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Coal containerization: will it be an alternative mode of transport between north and south China in the future?

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Abstract

Shaanxi, Shanxi province and Inner Mongolia in north China are the nation's leading producers of coal. In the past decades, a huge amount of coal has been transported from these areas to the central and south China via ports in Hebei Province and Port of Tianjin. Traditionally, coal is transported in bulk shipment. However, in recent years, an interesting phenomenon is that the lump coal is sorted out in the north and then moved in containers to the south. This paper aims to ascertain whether the coal containerization will become an alternative transport mode for moving lump coal from the north to the south of China. Based on extensive field investigation and data analyses, it is found that although the container mode appears to be more expensive than the bulk shipping mode, the cost difference between the two modes is not as significant as our expectation if we also take into factors like fragmented demand, environment pressure, geographic distribution characteristics of customers and so on.

Keywords: Coal containerization, Coal logistics chain, Economic decision model

1. Introduction

Containerization has developed from the specialization to generalization in terms of product transport. Technological advancements and market innovations have significantly reduced service barriers and costs once prohibitive for movement of lower-value commodities (Vacha et al., 2007). Traditionally, container transportation model is mainly applied for high-value manufactured commodities, such as electronic device, furniture, toys, apparel, sports equipment, works of art and so on. The majority of low-value products like grain, iron ore and coal are basically transported via bulk shipment. However, with the development of technology, for example, mega container ship, multiple-function container, the scale and scope of containerized intermodal transportation have expanded rapidly. Since the 1990s, an increasing volume of grain produced in North America has been delivered in container to export markets. Similarly, Australia has witnessed a growing amount of wheat transported to Indonesia via the container shipment. The extension of container transport to traditional bulk cargoes, such as food, is largely driven by the imbalance of cargo flows. As a case, there are 14.8 million TEUs shipped from Asia to USA while only 5 million are shipped in the opposite direction with traditional containerization cargos.

Shaanxi, Shanxi and Inner Mongolia in north China are the major three national coal provinces. To decades, a huge amount of coal has been transported from these areas to central and south China via ports in Hebei Province and Tianjin. According to the coal size, coal can be divided into two categories including lump coal (>50 mm) and powdered coal (<50mm). Powdered coal has been generally used by coal-fired power plants while the lump coal with a higher calorific value has been largely used for firing ceramic products and even for steelmaking due to the rise of oil price and improvement of steel-making technology. In the past, coal was transported in bulk shipment. However, one recent phenomenon is that the lump coal is sorted out from the northern ports and then transported in containers by liner to the south in China.

It is obvious that the grain or wheat containerization have already been regarded as a promising complement to traditional bulk model, especially in Canada, US and Australia. However, rather limited attention has been paid to the coal containerization. Against this background, this study aims to investigate the emergence and development of containerized transport of coal in China. It is expected that this study will contribute to a better understanding of the operation mechanism of coal containerization, and more importantly help decision-makers to take into consideration relevant factors and ascertain whether the coal containerization can grow up to be an alternative transport mode between the north and south of China in the near future.

The rest of the paper is organized as follows. Section 2 reviews relevant studies concerning the bulk containerization. Section 3 provides an overview of the current development of coal containerization in China as well as a critical review on the network of coal transportation, demand and supply, logistics chain of containerized coal, logistics costs, customer characteristics, local policies and so on. Based on the review results in Section 3, Section 4 firstly figures out the driving force of coal containerization; then the development of coal containerization is discussed while its logistics structure is under analysis. The transport costs and time required between the bulk and container modes are also estimated and compared in this section, so as to determine whether the two modes are economically comparable. The paper finally summarizes the profile of the coal container industry in China.

2. Literature Review

A number of works have been conducted on the food containerization since 1980s. Prentice (1980) firstly examined the economic potential in improving the Canadian grain handling system through containerization. Later, Prentice studied on re-designing the grain logistics chain in Canada by replacing bulk handling with containerization, and concluded that technological advances in information collection and transmission have already made container shipment a rival to the bulk handling of grain.

Vachal and Reichert (2002) and Vachal et al. (2003) explored the trends in the containerized movement of grain and general logistics information, in an attempt to find out factors for successful container shipment, such as costs, services, and logistical alternatives. Vachal et al. (2007) then studied the export of containerized grain and oilseed in U.S., and proposed that technological advances, privatization of foreign markets and the declining transaction costs on the global market have facilitated the diversification of container industry in niche markets, such as the development of small-volume containerized products. They suggested that an established and growing shipper population in U.S. is active in marketing containerized grain and oilseed products.

Barber et al. (2008) discussed the application of container shipping to grain identity preservation (IP) systems and found that bulk container could be considered as an attribute to potential IP system. Gurning and Grewal (2007) analyzed the costs and time for carrying out wheat container transport between Australia and Indonesia. It was found that the alternative mode of container transport can reduce freight costs and transit time significantly during the booming dry bulk shipping market.

Although a large number of studies have been conducted on the analysis of food containerization, the literature on the coal containerization is rather limited. Zhang and Zhang (2008) explored the coal container handling technology, and found that coal container is free of the pollution that coal bulk transportation may cause. You (2010) and Lu (2011) both conducted economic analyses on coal containerization and found that the container mode is more expensive than the bulk mode. However, the two studies keep a positive attitude towards the development of coal containerization since the cost difference is still acceptable according to their estimation. Xu (2012) expressed an opposite opinion that coal containerization is only a short–lived phenomenon and would disappear with the recovery of China’s container shipping market..

In summary, although the major focus has been placed on the food containerization, the coal containerization is still a new thing and has attracted only limited attention. This paper is making an initial attempt to profile the phenomenon of coal containerization in China. This attempt is believed to not only enrich the literature of coal containerization, but also support the literature of bulk containerization.

3. Current Development of Coal Containerization in China

Coal reserves in Shanxi, Shaanxi and Inner Mongolia in the north of China account for 64.1% of the whole nation. The coal production in these provinces is close to 60%

of the total amount of coal produced in China in 2012, and these regions contribute over 80% to the increase in China's annual output. The volume of coal transported outside these provinces takes up over 90% of the total cross-province transport volume in 2012. As shown in Fig. 1, in domestic trade, the majority of coal is shipped from the north to the south of China via the port of Tianjin and a cluster of ports in Hebei province, e.g., Qinhuangdao, Huanghua, Caobeidian, Jintang and so on. In 2012, 410 million tons of coals were loaded at the three ports of Qinghuangdao, Huanghua and Tianjin. Major customers of the coal concentrate in the eastern and southern coastal regions of China. It was reported that five regions including Shanghai, Jiangsu, Zhejiang, Fujian and Guangdong provinces purchased 88.5% of the coal from the northern China in 2012. In particular, more than 50% of the coal was unloaded in three ports including Shanghai, Ningbo and Guangzhou.

Insert Figure 1 about here

Fig. 1 Coal transport network in China
Source: CEIC Deutsche Bank

As mentioned above, only lump coal is found being shipped in containers and only a small quantity of lump coal is sorted out in the north of China before being shipped to the south in containers. According to the data collected from Chinese ports, the total lump coal loaded at ports of the north China was around 11.2 million tons in 2011. Among these ports, Tianjin Port handled the largest amount of coal (9.8 million lump coal in total), followed by Qinhuangdao Port (0.6 million), Huanghua Port (0.6 million) and Jintang Port (0.4 million). Among all lump coal shipped from the north, 5 million tons (50% of the total) was unloaded or transferred at Guangzhou Port, followed by Shantou (1 million), Jiangxi (2 million), Fujian (1.2 million), Guangxi (1 million) and Hunan (1 million).

Table 1 represents the coal container throughput at the Qinhuangdao Port. It can be seen from the table that the coal container throughput at the Qinhuangdao Port has seen big fluctuations in the past five years. It reached the peak in 2009 when almost 40,000 TEUs were loaded. However, this figure continued declining in the following three years and finally fell to around 9,000 TEUs in 2012. Two possible reasons might explain this sharp drop: one is that the Qinhuangdao Port is now upgrading its port facilities in response to pressure from environment authorities; the other lies in the competition from the nearby ports like the Huanghua Port and Jintang Port.

Table 1 The throughput of coal container at the Qinhuangdao Port (TEU)

Insert Table 1 about here

Source: Own realization based on Investigation to Qinhuangdao Port Group

Fig. 2 depicts the existing three modes of coal container transportation in the north of China.

Insert Figure 2 about here

Fig. 2 Coal container logistics chain in north China
Source: Author's own composition

(i) Tianjin Mode (sorted in the central): a certain amount of coal is firstly carried by trains from where it is mined to a coal distribution center named Xiahuyuan in northwest Hebei. The lump coal is sorted out there and loaded into containers, and then transported by trailers to the Tianjin Port.

(ii) Jintang/Qinhuangdao Mode (sorted at the port): coal is carried by train or trailers to the port of Jintang and Qinhuangdao directly from coal mines. The sorting and boxing are conducted at the ports.

(iii) Huanghua Mode (mixed mode): A part of the coal is directly carried to the Huanghua Port by trains and sorted there. The other part is sorted and boxed in Hejian (the south of Hebei) before being carried to the Huanghua Port.

The customers of lump coal are basically small ceramic factories that spread over the hinterland of Guangzhou Port, in particular around Foshan city. It is found that the total demand of lump coal from these factories together cannot be ignorable (around 5 million ton per year) but each of the ceramic factories only has small volume of demand. Traditionally, the coal is unloaded in Nansha area of the Guangzhou Port from bulk ships of 30,000 to 50,000 dwt, and then lump coal is sorted out at the port and carried by trailers to customers. After the container coal transport is introduced, lump coal sorted out is packed in containers at ports in the northern China and then delivered by 5000-7000 TEU container ships to Nansha where container barges transfer these containers to small ports along the Xi River. Xi River is shallow and ports along the river periodically suffer floods in rainy seasons. Thus, it is impossible for big bulk ships to sail on the river. In addition, because of the seasonal floods, few ports along the river have coal stockpiles and most of the ports are container ports.

Last but not least, these ports are much closer to customers than Nansha Port in distance.

Insert Figure 3 about here

Fig. 3 Coal container logistic chain in the south of China

In 2012, as the most prominent coal enterprise in China, Shenhua Group decided to invest in the construction of a large-scale coal port and coal distribution center at the Gaolan Port, which is located in the very south of Guangdong province and far from any big cities, shown in Fig. 3. Some insiders within the transport industry believe that this project will bring positive impacts to the lump coal logistics chain of China in the future.

Although the transport via container ships costs more than that by bulk ships, using containers to transport lump coal has certain advantages. According to an internal report provided by Qinhuangdao Port Group, in the process of loading and unloading, about 10% of the lump coal will break into powder, which is apparently a significant loss. Also, to serve small and dispersely distributed customers, coal container shipments work better because the just-in-time inventory management system can be of great use in reducing financing costs and inventories by ensuing a more constant flow of small tonnages. Besides, additional trailer cost will be spent by the bulk transportation because the big bulk ships cannot navigate on the Xi River and Nansha port is far away from customers. Furthermore, container transport is supposed to be less time-costly than bulk transport if the scheduling and sailing speed of container liners are both taken into consideration.

4. Discussions

To offer a better understanding of the coal containerization in China, three key issues are discussed in this section. The first is the driving force of the coal containerization, which sheds light upon how the coal containerization began and whether it will sustain in the future. The second is the evolution of coal container logistics structure, which gives a clue to the potential development of the coal containerization. The last part is about the cost and time differences between container transport and bulk transport. The feasibility of coal containerization heavily relies on whether the cost difference is acceptable to customers/shippers/traders and whether there is any other advantage, for example, shorter transport time.

4.1. Driving force

Five factors are believed to have contributed to the emergence and development of coal containerization in China.

(a). Different coal trading prices.

For local authorities and ports in Hebei Province, the difference of coal trading price between lump coal and powdered coal means additional benefits. Hence, they have built the coal-sorting centre in hinterlands and purchased sorting devices at the port to encourage coal traders/forwarders to sort lump coal there. To avoid coal breakage and preserve its value during the transportation period, container is then introduced.

(b). Unstable bulk shipping freight.

Fig. 4 shows the freight index of China's domestic trade container transport and bulk transport along the shipping route between the Tianjin and Guangzhou Ports between 2007 and 2013. Coal containerization in China emerged at the end of 2007 when the bulk shipping freight reached the peak. Market behaviors are always driven by the market price. When the bulk shipping freight rises to almost as high as the container freight, naturally coal traders/forwarders would consider using containers as an alternative to transport lump coal. It should also be pointed out that the bulk price index is much more fluctuant compared to the container price index. Given this analysis, the incentive to use containers is more than apparent.

Insert Figure 4 about here

Fig. 4 Comparison between China's domestic trade container freight index and bulk index (Tianjin to Guangzhou) issued by Shanghai Shipping Exchange
Source: Author's composition based on data collected from Shanghai Shipping Exchange

(c). Customer characteristics.

Most of the ceramics factories are of small scale and dispersely distributed in the deep hinterland of Guangdong Province, which means fragmented demand. Moreover, ports along the Xi River, which extends through hinterland, are mostly container ports. It is understandable that customers prefer purchasing dozens of containers to hiring a bulk ship. With containers bought, transshipment would be no longer necessary, more importantly, with a more constant flow of small tonnages, financing risks and inventories can be reduced. Meanwhile, the coal containers are often used by customers to transport ceramic tiles, ceramic products and other products back to the north of China, which reduces the container relocation costs. Nowadays, carriers are always ready to adjust to individual requirements of these ceramics factories. For example, as one of Chinese leading shipping companies, the China Shipping Company has designed special containers for lump coal and built container-washing spots.

(d). Environment prevention.

Pollution is now a national concern in China. The coal transportation has been the focus of concern as substantial coal dust finds its way into the air during the logistics process, especially when the coal is being loaded and unloaded. Many local governments have issued policies to reduce the pollution from coal transportation. For example, the city of Foshan in Guangdong Province requires that raw and processed materials, like coal and fuel, be transported in an enclosed space, so as to prevent them from falling off in transportation. Coal containers, as an enclosed box, fully conform to the requirement.

(e). Chinese port upgrade.

Many ports in Hebei Province have been under operations for decades, featuring low efficiency and heavy pollution. With the potential development of new energy and power conversion technology and the increasing pressure for environmental protection, the government of Hebei is planning to upgrade its port system. Specifically, the government intends to move coal terminals away from big cities and at the same time transform the old coal terminals that were close to residential communities to container terminals. Container terminals, clean,and future-oriented, are thought to be more contributive to the local economic development and thus preferred. For example, coal terminals built in the west basin of Qinhuangdao Port have been officially closed in 2013, and a new coal terminal with a capacity of over 50 million tons is now under construction in Caobeidian Port, a port near Qinhuangdao but with a much lower population density. Meanwhile, construction of new container terminals in Qinhuangdao in the next few years is under consideration. It is worth noting that to ensure the utilization of new container terminals and promotion of container throughputs in Hebei, the local government has offered great policy and technology support in relation to coal containerization.

To sum up, the coal containerization in China arose from multiple factors and expands under a series of favourable conditions. As these driving forces are likely to sustain and even further develop in the near future, it is inappropriate to take the coal containerization as a temporary phenomenon.

4.2 Evolution of logistics structure

The Ministry of Railways (MOR) of China stipulates that the coal transported via rail should be placed in an opened space to ensure that the coal will not spontaneous combust. To avoid the trouble of relocating empty containers (specially-designed train containers), the MOR also regulates that train containers are not allowed to be loaded in ships. Under these rules, coal sorting only takes place in three segments of the coal logistics chain—hinterland distribution centre close to loading ports (north China), loading ports (north China), and unloading ports (south China). However, the location of coal sorting is now transferring, from which two trends can be identified.

Firstly, sorting is moving from ports to the sparsely populated inland. In Hebei Province, coal sorting at Qinhuangdao Port is now moving to a nearby Port of Caobeidian. Container coal loaded at Tianjin Port is almost all sorted at Xiahuayuan (a dry port of Tianjin). Similar cases are found in the south of China. A large-scale coal base is now under construction at Gaolan Port, a port in the very south of Guangdong and far from any city. Three possible reasons can explain these location transfers. First, pollution in the port city will be relieved. Secondly, land is cheap in sparsely populated regions. Third, the scale of economy will be achieved because of more land available and less policy restraints at the new location.

Second, sorting may move from north China to the south. Because coalmines concentrates in north China, several ports have been built there as coal bases in early years, so as to easily distribute the coal from north to other coastal areas. Yet, as a huge investment has been made in constructing a coal base at Gaolan Port of Guangdong, the traditional coal transport network might well be changed in the future. Part of coal sorting and distribution may gradually move to the south. Two facts support this change. First, in spite of the constant changes in the bulk freight, container transport is ultimately more expensive than bulk transport in a long-time period. Thus, transporting coal in bulk ships to the south and having the coal sorted there still costs less, especially when the transshipment is arranged in a proper manner and the economy of scale is achieved. Second, in contrast to the north, the weather in the south of China is more humid and rainy. This means less dust spreading in the air and less costs for dust leakage prevention.

The transfer of coal sorting from ports to inland coal distribution center in Heibei Province will help relieve the pressure on environment and achieve economies of scale, thus believed contributive to maintaining a portion of coal containers in the north. However, it cannot rule out the possibility that with the construction of Gaolan Port in the south, more coal would be sorted there, which turns out a potential threat to the development of coal containerization in the north of China.

4.3 Economics analysis

Because bulk containerization, coal containerization in particular, is still a novel phenomenon emerged given its scope and scale, it is still impossible to collect enough customer data for a study in the traditional "modal-shift" model. Alternatively, spreadsheet model, simulation, cost comparison, and economic decision models are employed to illustrate the cost differences between transportation modes in previous studies.

For example, Barry (1998) developed a spreadsheet model and simulation to analyze the effects of individual costs of wheat trading on the choice of container shipping mode. The advantages and disadvantages of wheat bulk transportation versus containerization were discussed in terms of the cost of physical handling and container transfer, pipeline storage costs and use of containers, economics of shipping and inventory holding costs, empty backhauls and tare weight of containers, low freight costs/average quality and freight premiums/exact quality. It was found that freight costs, communication costs and price/quality considerations are the key factors affecting the choice of the containerization of wheat. Another finding from the study of Barry (1998) was that the container system could shorten the transport time significantly compared to the bulk system.

Reichert and Vachal (2003) applied an economic decision model to illustrate potential cost differences in the identity preserved and generic marketing of raw grain. The economic decision model is based on a spreadsheet simulation of individual transportation and marketing costs. Factors considered in the model include storage, handling, transportation, marketing and special charges. Gurning and Grewal (2007) employed an economic decision model to evaluate the grain container transported from Australia to Indonesia by comparing segment costs from various parties, such as farmer, handler, processor, distribution center, wholesaler, sub-wholesaler, retailer and consumers. Lirn and Wong (2013) investigated the behaviour of grain shippers' and importers' freight transport choice. They ascertained the importance of the service attributes by applying a questionnaire survey and the fuzzy analytic hierarchy process (AHP) technique.

In this section, the economic decision model based on a spreadsheet simulation of individual transportation is also employed to explore the cost and time difference between container and bulk transport on the route from Tianjin to customers in Guangdong. The shipping cost, trailer cost, breakage loss, container cost, and time and storage cost all are taken into consideration. All the data were collected from ports, carriers, traders and logistics forwarders. A container of lump coal is used as the comparison unit. Averagely, a 20-feet container can hold 30-ton lump coal. A formula of calculating the cost can be expressed as follows:

Total cost = Shipping cost + Trailer cost + Breakage cost + Container cost + Storage cost (1)

Shipping cost. By the price issued in January 2014 by China Shipping Company, a container shipped from Tianjin Port to a port along the Xi River, all shipping and port costs included, would cost 3,650 Yuan. In contrast, based on the price issued by Tianjin Port, one ton of coal carried by bulk ships from Tianjin to Nansha (Guangzhou) costs 35 Yuan, 30 tons added up is 1,050 Yuan.

Trailer cost. The distance from the bulk terminal in the Guangzhou Nansha Port to lump coal customers distributed in Foshan is around 100 to 200 km which will cost the customers averagely 1,500 Yuan to hire a coal trailer. If the coal is transported from container ports along Xi River to customers, the distance can be reduced to 20 to 100 km, for which a trailer trailer only costs averagely 500 Yuan.

Breakage loss. As mentioned earlier, 10% of lump coal will break into powder during either the loading or unloading process. By the price published in the January of 2014 by Qinghuangdao Coal Information Exchange Center, lump coal per ton is 165 Yuan more expensive than powdered coal. Suppose that at least two more times of loading and unloading occurred during the bulk transportation, 940 Yuan would then be lost as 6 ton of lump coal broke into powdered coal.

Container cost. Coal containers are generally stuffed with ceramic products by customers after being cleaned up. As the container washing in Foshan city has already developed into scale, the cleaning costs per box is as low as 20 Yuan. If the bulk mode is chosen, customers need to pay about 100 Yuan to relocate a container and have it filled with ceramic products.

Storage cost. According to the investigation, the monthly transport demand of the ceramics factories is averagely 2,000 to 5,000 ton. The period of storage can be as long as 15 days, which means the demand is around 1000 to 2500 ton per shipment. As for a bulk ship of 30,000 to 40,000 dwt, if the total demand cannot reach its freight volume, additional storage costs will be charged by the port. According to the charging standard issued by the Ministry of Transportation of China in 2010, the storage fee is 0.2 Yuan/ton for the first 10 days and 0.3 Yuan/ton afterwards. Thus, suppose 30 ton of coal need to be stored at the port for 30 days, 240 Yuan would be charged.

Time. The waiting time for a domestic trade container to be loaded in a ship at Tianjin Port is around 3 days while the time of bulk is very uncertain and approximates to one week. It averagely takes 7 days to reach the customers after the container cargo is on board. Container ships basically sail faster than bulk ships, Based on their speed difference, another 2 days can be saved by container ships when sailing in the sea. Thus, the transportation time saved by using containers shipping is approximate 6 days.

Table 2 summarizes the transport cost and time of bulk and container mode. The total cost of transporting a container from Tianjin to customers in Guangdong Foshan is around 4,170 Yuan while the cost of bulk mode is only 3,830 Yuan. However, given the time, service quality and financing costs, the costs of the two modes is almost on a par.

Table 2 The cost comparison between bulk mode and container mode

Insert Table 2 about here

* All the prices are calculated according to the weight of one container (30 ton)

5. Conclusions

Although food containerization has been found very popular, coal containerization is still a novel thing and only found in China. After all, the price difference between container and bulk transport is supposed to be greatly large while the value of coal is relatively low. This paper aims to profile the coal containerization in China and determine whether it is a counter-intuitive phenomenon.

To reach this objective, this paper firstly reviewed the current development of coal containerization by looking into the coal transport network in China, the demand and supply of lump coal, the coal container logistics chain, the characteristics of customers and so on. The driving force of coal containerization, the evolution of coal container logistics chain and the cost and time difference between container and bulk transport modes were then discussed so as to explore the underlying mechanism and the development prospect of coal containerization in China. With the analyses, the paper comes to the conclusion that coal containerization is a fairly competitive alternative for lump coal transportation after we take into account some factors like freight rate fluctuations, distribution characteristics of customers, environment protection pressure, and etc.

In general, the transfer of coal sorting from ports to inland in Heibei Province will help relieve the pressure on environment and achieve economies of scale, thus contributive to maintain a portion of coal containers in the north of China. However, the construction of Gaolan Port in Guangdong Province may bring limited but negative effects to the coal containerization. Although the container mode appears to be more expensive than the bulk mode, the price difference is not as large as our expectation if the additional costs of transshipment, breakage, storage, financing and time required for the bulk transportation are considered. It is noted that the paper supposed that a container ship with 5,000 to 7,000 TEU capacity are fully loaded with coal container. In practice, this may lead to stability problem and the coal container is normally loaded with other types of containerized cargoes. Further research will be conducted on the application of the “modal-shift” model, for example logistic model, after sufficient data are collected.

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