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Analyzing the trade transportation and its demand on multimodal transportation system between China and Koreas

Shanhua Wu, Yu Sun and Zhongzhen Yang
Faculty of Maritime and Transportation, Ningbo University, Ningbo, China; National Traffic Management Engineering and Technology Research Centre, Ningbo University Sub-centre, Ningbo, China and Center for Collaborative Innovation on Port Trading Cooperation and Development (Collaborative Innovation Center of Port Economics), Ningbo University, Ningbo, China

Abstract

Purpose – This paper aims to understand the trade transportation situation between China and Koreas, and to explore the possibility of establishing the surface transportation corridor between China and Koreas in the future. Moreover, the paper also intends to find out the mode choice behaviors of shippers, which can be used to analyze the substitute effects of the surface modes on the water one.

Design/methodology/approach – The paper first analyzes the Sino-Korean bilateral trade and the corresponding trade transportation between China and Koreas. Secondly, it presents the surface transportation network between China and Koreas, and analyzes the warming relations between the North and South. Finally, the modal split of trade transportation between China and Koreas is estimated by establishing a mode choice model based on a questionnaire survey.

Findings – With the increasingly stable political environment and the physical highway and railway connections, the surface transportation network would become possible. Moreover, the shippers need the multimodal transportation system between China and Koreas, and many shippers would select road or rail mode if a suitable road or rail network were available. Especially, between China and South Korea, the road, rail and water mode may be used evenly, while the road mode may play a more important role between China and North Korea. The surface modes would have a huge substitute effect on the water mode.

Originality/value – The existing literature conducted research mainly from the perspective of economy and geopolitics, while the topics of transportation between China and Koreas are rarely concerned. This paper intends to throw some light on the situation of the trade transportation between China and Koreas, consider the potential of relation improvement on the Korean Peninsula proactively and study the surface transportation issues between China and Koreas.

Keywords Bilateral trade, Korean Peninsula, Multimodal transportation network, Shipping and surface transportation

Paper type Research paper

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1. Introduction

The Korean Peninsula is one of the regions where great powers (such as the USA, China, Japan and Russia) compete for the strategic benefits, and thus plays an extremely important role in the geopolitical pattern of Northeast Asia. Therefore, the situations in the Korean Peninsula, especially the bilateral relation between South Korea and North Korea, as well as the relations between the peninsula and the great powers, have always attracted the global attention. Compared with other great powers, China has more prominent geographic advantage relative to the Korean Peninsula. China adjoins the peninsula in both land and sea with a long history of diplomatic relation dating from ancient times. Since the beginning of the new century, under the trend of economic globalization and regional economic integration, the relations between China and Koreas have been continuously consolidated and developed. The bilateral economic and trade cooperation has been further strengthened, resulting in a substantial increase in the trade volume and the related freight volume.

Because of some historical reasons, there is a long-term confrontation between North Korea and South Korea, which results in the cut-off of the surface transportation on the peninsula. Therefore, though China adjoins the peninsula, the transportation between China and Koreas now mainly relies on shipping. With the gradual easing of the situations on the peninsula as well as the good development trend of economic and trade relations between China and Koreas, the establishment of the coordinated multimodal transportation system, especially the stable surface transportation, becomes possible and even would be a realistic demand. It is of great significance to establish such a multimodal transportation system, as it would not only facilitate the trade development between China and Koreas, but also contribute significantly to a coordinated transportation network in Northeast Asia.

2. Literature review

Many studies have focused on the analysis of the geopolitical and economic relations between China and Koreas. For example, Kim (2016) reviewed the South Korea's China policy since the Korean War and discussed the implications of evolving Sino-Republic of Korea relations for East Asian security. He contended that South Korea is likely to keep pursuing the deepening of the strategic partnership with China, as it is necessary not only for South Korea's future economic prosperity but also for coping with North Korea's growing threats. Ye (2016) examined the economics-politics nexus in China–South Korea relations. He used the vector autogression models to test the Granger causality between Sino-South Korean bilateral trade and political relations and examined the two states' economic and political ties with other regional powers in Northeast Asia. Li and Pang (2002) reviewed the development of Sino-South Korean trades as well as the direct investments with related contemporary issues, and put forward possible approaches of bilateral cooperation in the near future, that is, deepened cooperation in selected sectors of industry and transportation and coordinated development among major cities. Besides the studies on the Sino-South Korean bilateral relation, the research studies on the China–North Korea relation also attracts the scholars' interest. For example, Lee and Hong (2015) analyzed the Sino-North Korean economic relations, and revealed the high degree of North Korea's economic reliance on China and the potential problems of the current Sino-North Korean economic ties. Lee (2016) conducted a regression analysis on the panel data consisting of cross-section data from 30 provinces in China and quarterly time series data from 2000 to 2015, to examine what determines the trade volume between China and North Korea in the 2000s. Lee and Gray (2017) analyzed the impact of financial sanctions on the Sino-North Korean border economy and proposed a more comprehensive understanding of the shortcomings of financial sanctions as a tool of foreign policy. Some scholars have also

focused on the impact of China's policies on the Korean Peninsula. For example, Cha (2018) reviewed the historical background behind the "One Belt, One Road" initiative and analyzed the initiative's strategic significance as well as the implications it may have for the Korean Peninsula.

The existing literature conducted research mainly from the perspective of economy and geopolitics, while the topics of transportation between China and Koreas are rarely concerned. The transportation related studies are certainly interesting and meaningful, as the development of transportation would be influenced by the factor of economy and geopolitics, and would also influence the economy and geopolitics in turn. This paper intends to throw some light on the situation of the trade transportation between China and Koreas, and obtain some implications for the future development.

The trade transportation is generally supported by a multimodal transportation system where the major transportation means compete with each other, and thus the mode choice problem would be involved. The modal split model is usually used to solve such mode choice problem, which can be classified into two categories, i.e. the aggregate model and the disaggregate model. For the aggregate model, it has been studied earlier and is relatively easy to use, but the accuracy is not that satisfactory. Therefore, the disaggregate model has been applied more often. The disaggregate model was analyzed based on the pursuit of utility maximization by the decision-maker involved. In the 1970s, McFadden first introduced the utility theory in economics to the disaggregate model and proposed the "Random Utility Model." Later Ben-Akiva introduced the random utility model into the field of transportation demand forecasting (Ben-Akiva and Lerman, 1985). The disaggregate model presumes that the probability of individual choosing a given option would be affected by the characteristics of the individual and the attributes of the option. The revealed or stated preference surveys are needed to calibrate the model. The disaggregate model is thus more realistic, and up to now an extensive study of the disaggregate model is still in progress.

Dalla Chiara *et al.* (2008) applied the logit model to estimate the influence of the new European ro-ro service on the distribution of freight transport between Italy and France for the traditional road transport. In the model, the service frequency and the total shipment time were taken into account in the modal split for freight transport. Danielis and Marcucci (2002) extended the two-mode model developed by Tabuchi (1993) to explore the efficiency of different road pricing regimes in reducing the total travel costs when a competing railroad service is available. Sivakumar and Bhat (2002) proposed a fractional split model for commodity flow distribution, and applied the model to analyze inter-regional commodity flows in Texas. Ferrari (2014a, 2014b) developed a dynamic model of modal split in a multimodal freight transport system with the assumption of the change of transport demand and transport modes, and later he extended the research to examine the characteristics of the evolution of modal split for a multimodal transport system (Ferrari, 2014a, 2014b). Arencibia *et al.* (2015) conducted advanced choice experiments where the prior information was used to analyze the freight shippers' preferences for the main attributes from a methodological point-of-view. Hong *et al.* (2016) examined the effectiveness of five policies including the modal shift reinforcement that the South Korean Government has imposed on the transportation sector. Zis and Psaraftis (2017) applied a nested modal split model to estimate the modal shifts between maritime and land-based modes, and further to examine the impact of Sulfur Emission Control Areas regulation on maritime routes. Meers *et al.* (2017) conducted a choice-based conjoint experiment to analyze the preference of modal choice decision-makers in Belgium. Their findings suggest that the maritime operators should try to provide daily services at a competitive price and more

reliable services than road transport. Liu *et al.* (2018) proposed a "Remote P&R" service mode where a car park is located in a suburban area and is connected with a nearby train station by the dedicated express bus service. They evaluated the impact of the new service on the network flows by developing a combined cross-nested logit model and traffic assignment model. Dong *et al.* (2018) analyzed a joint modal split transport and inventory control problem, and developed a modal split transport policy that enables volume allocation into two transport modes and integrate inventory controls. Humphreys and Ahern (2017) examined the interaction between travel choices and household location decisions based on data collected through a postal survey, and found that the travel-based residential self-selection is a contributory factor to modal split characteristics.

The paper follows the paradigm of random utility and applies the modal split model to analyze the attractiveness of different means of transportation in the trade transportation system between China and Koreas. In the paper, the current trade transportation system between China and Koreas is described first, and then the possibility of establishing the surface transportation corridor in the future is proposed based on the analysis of the infrastructure and the bilateral relation development, and finally the mode choice behaviors of the shippers are explored supposing that they are faced with the multimodal transportation system to verify the necessity of opening the surface transportation corridor.

The remainder of the paper is organized as follows. Section 3 and 4 describes the bilateral trade and the corresponding trade transportation between China and Koreas (South Korea and North Korea, respectively). Section 5 presents the surface transportation network between China and Koreas, and analyzes the warming relations between North and South to demonstrate the possibility of future establishment of the surface transportation corridor between China and Koreas. Section 6 studies the modal split of trade transportation between China and Koreas by establishing a mode choice model. Section 7 presents a sensitivity analysis and the implication for future development. Conclusions are drawn in Section 8.

3. Trade and transportation between China and South Korea

3.1 Trade situation between China and South Korea

China and South Korea formally established diplomatic relations in 1992. Since then the trade and the economic cooperation between China and South Korea has developed rapidly. The trade volume increased from USD5.03bn in 1992 to USD108.31bn in 2005, and realized the projected target of USD100bn for the year 2008 (Zhang, 2002) three years ahead of the schedule.

The "Research Report on Long and Medium Term Developing Plan of the Cooperation between China and South Korea," which was published in November 2005 and is regarded as a guide for the economic and trade cooperation between the two countries, projected the cooperative objectives and the key fields. It forecasted that the trade volume in 2010 would reach USD150bn, and in 2012 (20 years anniversary of the normalization of the bilateral relation) would be USD200bn (Zhang, 2010). In fact, in 2010 the trade volume has reached USD188.62bn (China Statistical Yearbook, 1994-2018), indicating that the actual volume has already overtaken the projected one.

At present, South Korea has become the fifth biggest trade partner of China after the European Union, the USA, the Association of Southeast Asian Nations and Japan (China Customs Statistics Yearbook, 2018). In 2017, the trade volume further increased to USD261.14bn (China Statistical Yearbook, 1994-2018). Table I shows the trade situation between China and South Korea. It can be seen that Chinese side has a big adverse trade balance and the trade deficit increases continuously.

Based on the above analysis, it can be known that the trade and the economic cooperation will be promoted further between China and South Korea, and the good bilateral relationship

Year	Trade quantum Billion USD	Trade quantum Increment (%)	Export from China to South Korea Billion USD	Export from China to South Korea Increment (%)	Import from South Korea to China Billion USD	Import from South Korea to China Increment (%)	Balance
1993	8.26		2.98		5.28		−2.3
1995	15.22	84.26	6.04	102.68	9.18	73.86	−3.14
2000	32.28	112.09	11.20	85.43	21.08	129.63	−9.88
2005	108.31	235.53	34.09	204.38	74.22	252.09	−40.13
2010	188.62	74.15	66.83	96.04	121.79	64.09	−54.96
2015	299.72	58.90	102.31	53.09	197.41	62.09	−95.1
2017	261.14	−12.87	98.85	−3.38	162.29	−17.79	−63.44

Table I.
Trade quantum between China and South Korea

Notes: The number in the table denotes the quantum of foreign trade between China and South Korea instead of the value of foreign trade, i.e. quantum of export (import) = value of export (import)/price index of export (import)(%), to remove the factor of price changes (e.g. inflation) and make the number comparable for different years
Source: China Statistical Yearbook

will induce large amount of transportation demand. Therefore, the sea transportation and the surface transportation will have a big market.

3.2 Trade transportation between China and South Korea

Shippers in China and South Korea rely on shipping lines to conduct trade transportation. China has 16 companies operating container liners between China and South Korea, and with 38 vessels they operate 41 voyages and supply the capacity of 160,000 TEU per week (Yeo *et al.*, 2008; Li *et al.*, 2008). South Korea has 14 companies operating container liners, and with 31 vessels, they operate 36 voyages and supply the capacity of 150,000 TEU per week (Yeo *et al.*, 2008; Li *et al.*, 2008). There are only two vessels of the third party that operates two voyages weekly (Yeo *et al.*, 2008; Li *et al.*, 2008). A total of 14 Sino-South Korean joint ventures operate roll-roll liners between China and South Korea whose shipping lines are shown in Figure 1.

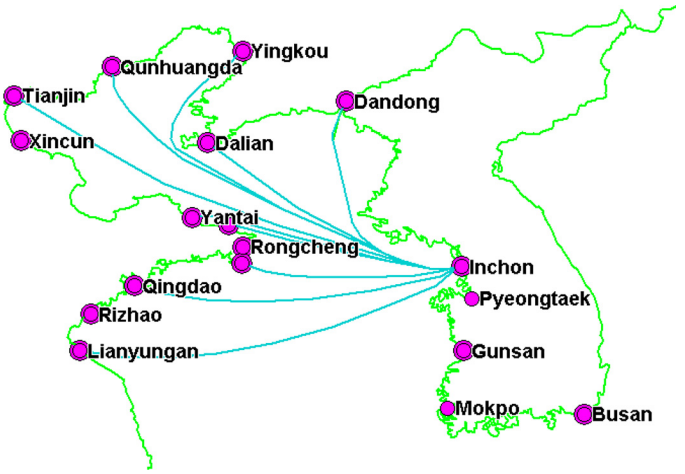


Figure 1.
Ro-ro lines between China and South Korea

In the first half of 2019, a total of 153, 4,606 TEU containers were shipped on the shipping lines between China and South Korea, among which 964,061 TEU are east bound and 570,545 TEU are west bound. Ports of Shanghai, Qingdao, Tianjin, Ningbo and Dalian are top five in terms of the operated containers. In the first half of 2019, they dealt with 413,676 TEU, 226,788 TEU, 220,731 TEU, 126,858 TEU and 101,733 TEU, respectively (Wuliubashi, 2019).

4. Trade and transportation between China and North Korea

The Sino-North Korean economic relation has been enhanced in recent years. China has increasingly participated in Noth Korea's economic activities, which can be manifested in the rapid growth in bilateral trade and Chinese investment in North Korean natural resources and cross-border infrastructure.

4.1 Trade situation between China and North Korea

China is the top country in terms of the foreign trade volume with North Korea. The bilateral trade volume of China and North Korea was USD4.98bn in 2017, among which North Korea imported USD3.25bn from China and exported USD1.73bn (China Statistical Yearbook, 1994-2018). Since the economic policy adjustment of "7.1" in 2002 of North Korea, many Chinese enterprises began to invest in North Korea.

4.2 Trade transportation between China and North Korea

China adjoins North Korea, and there are two surface routes between China and North Korea, located at Hunchun in Jilin province and Dandoing in Liaoning province, respectively. Because the trucks in Chinese side can only reach the supervision zones of North Korea near the border, most of the trucks used for trade transportation between China and North Korea are from North Korea (Wang, 2001). Therefore, the surface transportation is very inconvenient for China, and the shippers in China have to rely on shipping lines.

Shipping lines between China and North Korea are mainly operated between the ports in Liaoning and Port of Nampo. For example, a vessel with a capacity of 400 TEU jointly own by Liaoning Danxing, Korean Trans and Germany Mill Cooperation runs between Dalian and Nampo twice a week. Another line between Dandong and Nampo is operated by Shifeng Shipping of North Korea twice a week with a vessel capacity of 180 TEU (Wang, 2004). To quicken the delivery speed and improve the logistic system in Dadong, and alleviate the congestion in Yalujiang Pass, Donggang Developing Zone Shipping Co. Ltd operates a line from Dadong to Nampo every Thursday.

Liaoning and Sinuiju are separated only by a small river (YaluJiang). In recent years, trade transportation across the river reaches 3 million tons, while 1.7 million tons are passed by vessels. After about 20 years of construction, the two sides have 168 vessels and 6 docks for boundary trade delivery. The shipping lines of boundary trade delivery have the attributes of fixed lines, fixed vessel, short distance (4-40 nautical mile), short voyage time (0.5-5 h), small capacity (capacity of 10-100 tons) and short annual operating period (no operation during January-March).

5. Surface transportation network between China and Koreas

The Korean Peninsula is located in the south of China's North-East area. From ancient times, there had been a convenient surface transportation route between the peninsula and the North-East area of China. Even in modern times, the passengers and freights had been transported through the land route at Liaoning and Jilin in China to North Korea rapidly.

However, since the Korean War, the peninsula has been divided into two countries. The North Korea is a closed country that only keeps normal bilateral relations with China and Russia, and thus the surface transportation channel between China and the Korean Penisula is no more effective. Especially the surface transportation between China and South Korea is completely cut off. Even between China and North Korea, the Chinese trucks cannot enter the far area in the other side and can only enter the truck terminals at the boundary area. Moreover, the custom clearing efficiency is so bad that the clearance costs are huge because of the over-long time.

International agencies always make efforts to encourage the surface transportation between China and Koreas. As early as 1959, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) proposed an international highway network that connects all Asian countries. In November 2003, the ESCAP passed the "Governmental Agreement on Asia Highway Network" in Bangkok. A total of 32 member states agreed to enter the Asia highway network. In April 2004, 23 member states signed the agreement formally in the 60th convention of the ESCAP in Shanghai (Yang, 2008).

The Asia highway network mainly connects the national capitals, industrial and agricultural centers, main airports, water ports, main container depots and tourism spots in Asia. It is the base and physical facility to encourage the integration of the Asian countries. The aim of the construction of Asia highway network is to harmonize and push the road transportation among Asian countries, to encourage the bilateral trades and boom the tourism, and then stimulate the economic growth in Asia and facilitate the international economic and cultural exchanges.

The No. 1 Asia highway (AH1) is the longest line in the network. It starts from Japan (Tokyo, Fukuoka, etc.), passes South Korea (Busan, Seoul etc.), North Korea (Pyongyang, Sinuiju etc.), China (Dandong, Shenyang, Beijing, Guangzhou etc.), Vietnam, Cambodia, Laos, Thailand, Burma, India, Pakistan, Afghanistan, Iran, Turkey and ends at the boundary of Bulgaria. The No. 6 Asia highway (AH6) starts from South Korea (Busan), passes North Korea (Pyongyang, Chongjin etc.), Far East Russia, China (Suifenhe, Manzhouli etc.), Russian (Chita, Moscow etc.) and reaches the boundary of Belarus. Figure 2 shows the location and routes of the two lines.

The AH1 and AH6 lines connect China and the Korean Peninsula closely. The surface distances between Seoul and Pyongyang, Pyongyang and Dandong and Dandong and Shenyang are all about 200 km, indicating that the surface transportation would have obvious advantages. According to the plan of the ESCAP, to realize the objective of connecting all countries and promoting transportation in Asia, the member states should cooperate in the aspects of delivery of containers, traffic management and international freight transportation. All member states should actively sign the agreement of bilateral truck usage to determine the openness of the transportation market to each other. The railway system between China and the Korean Peninsula is similar to the highway system. The physical railway connection exists. However, because of the political issue, the transportation channel is cut off between South Korea and North Korea.

It should be noted that North–South relations have improved significantly in the past two decades. Up to now, the top leaders of the two sides have successfully had five historic meetings, and signed several important and guiding declarations. These would be devoted to the sustainable development of bilateral relations, the nation's reconciliation and cooperation, as well as the peace and prosperity on the peninsula. The first historic meeting took place in June 2000 in Pyongyang. The important achievement of the meeting is the signing of the "North-South Joint Declaration," which started the process of reconciliation and cooperation between the two sides. In October 2007, the heads of the two sides had a

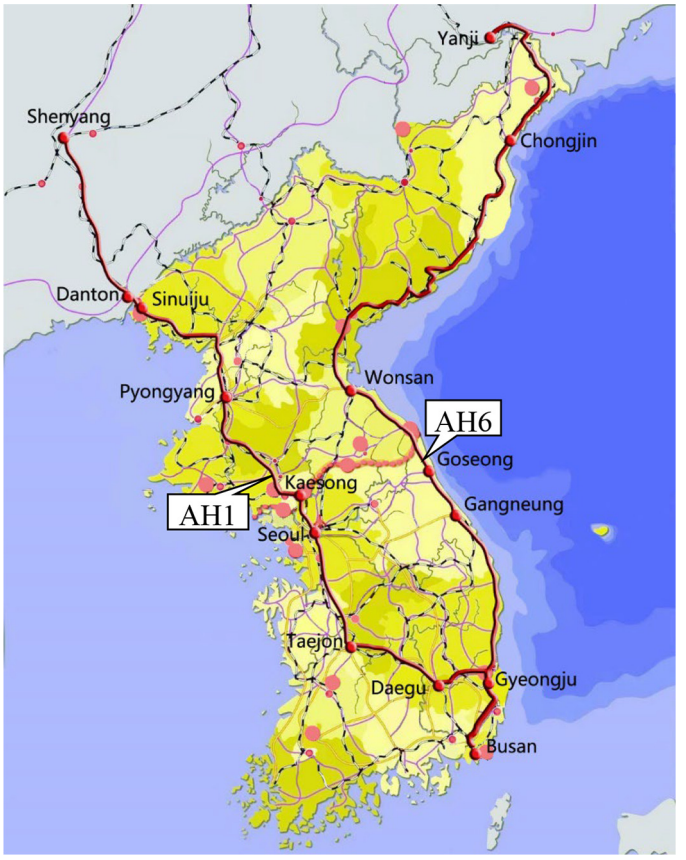


Figure 2.
Routes of AH1 and AH6 in China and Koreas

second important meeting in Pyongyang and issued "the Declaration for Development of North-South Relations and Peace and Prosperity," whose main purpose is to put an end to the Korean War and lay the foundation for permanent peace on the Korean Peninsula. Even though the relations of the two sides had stagnated since then, in recent years, the relations have shown a trend of easing and warming up. In 2018, the two sides had three meetings, and signed "Panmunjom Declaration" and "Pyongyang Joint Declaration" in which both sides would undertake to improve the bilateral relations and strengthen the cooperation in various fields.

With the efforts of the official side in improving the relations, the communication and cooperation of the folk side has become more active and in-depth. For example, in August 2000, a delegation of about 100 separated family members crossed the 38th parallel to reunite with their families. In September 2000, the sports delegation of the two sides participated in the opening ceremony of the Olympic Games together with the Korean Peninsula Flag for the first time. In June 2003 the Kaesong industrial complex began to be established, which revealed the real economic cooperation between the two sides. In December 2005, the first direct telephone line between North and South was opened and in May 2007 the first batch of railway connections crossing the military demarcation line

started the trial operation. In February 2018, the "sports diplomacy" was once again used to relieve the tension between the two sides.

Therefore, it is held that the peace and stability on the peninsular would become possible with the reinforcement of the desire for the reconciliation and the nation's unity from both sides. As the situation on Korean Peninsula gets stable, the safety of the rail and road transportation between China and South Korea can be guaranteed, and thus China, South Korea and North Korea may sign the accord of making full use of the highways and the corresponding railways. A transportation network consisting multi modes such as waterway, railway and highway will be available. Moreover, when all transportation modes could be used, the situation of over relying on the shipping lines between China and Koreas would change.

The physical highway and railway connections, as well as the increasingly stable political environment, makes the surface transportation network possible. Then we need to analyze the behaviors of the shippers and the substitute effects of the surface modes on the water one.

6. Modal split of trade transportation between China and Koreas

Sea transportation is the main mode for the long-distance inter-continental transportation, while it has some obvious disadvantages, such as the over-long time, being easily affected by the weather and needing transshipment at the terminals. Especially the transportation cost of roll-roll vessels is expensive because of the adoption of some safety equipment and measures. The surface transportation has the advantages of the rapidness, better safety and feasibility, and especially the road transportation can offer door-to-door service. Therefore, the surface transportation is more suitable for the short distance and small batch deliveries. Moreover, because the rail transportation is very safe and weather resisting, it is at an advantageous position for the transportation between 300 and 800 km (Shen, 2003).

To analyze the modal splits in the context of having a good surface transportation system between China and Koreas and offer the evidence for constructing an integrated transportation network between China and Koreas, we did questionnaire surveys at Dalian, Dandong and Yanji in China in 40 companies, which are doing trade business with Koreas. During the survey, under the assumption of existence of a good surface transportation system and unchanged water transportation system, the respondents were asked to answer their choices when transporting containers from China to Koreas corresponding to different surface transportation price and time. Part of the used questionnaire is shown in Figure 3.

The survey aims to understand the evaluation of the shippers on the modes. The evaluation may be determined by the price, timeliness, convenience and safety of the mode. And it also relates to the perception of the users on the attributes of the modes (Maja, 1999). It means that the utility of a mode is determined by the attributes of the mode and the users and can be expressed with equation (1):

$$\begin{aligned} U_{ij} &= V_{ij} + \varepsilon_{ij} \\ V_{ij} &= \alpha_{ij} + \sum\nolimits_k \beta_{ijk} x_{ijk} + \sum\nolimits_s r_{is} z_{is} \end{aligned} \tag{1}$$

Where:

U_{ij} = utility of service j perceived by user i;
V_{ij} = deterministic term of U_{ij};
α_{ij} = constant term;
x_{ijk} = preference of client i to attribute k of service j;
z_{is} = attribute s of user i;
β_{ijk}, r_{is} = parameter; and
ε_{ij} = random term (Ben-Akiva and Lerman, 1985).

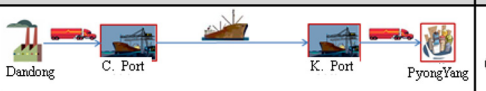
In three supposed situation, indicate your favorite one with √ respectively			Answer
①	Container Vessel	 Cost: 4,063 RMB Time: 36 hours	( )
	Container Truck	 Cost: 5,250 RMB Time: 6 hours	( )
	Container Train	 Cost: 1,375 RMB Time: 18 hours	( )
②	Container Vessel	Cost: 4,063 RMB Time: 36 hours	( )
	Container Truck	Cost: 6,825 RMB Time: 8 hours	( )
	Container Train	Cost: 1,788 RMB Time: 23 hours	( )
③	Container Vessel	Cost: 4,063 RMB Time: 36 hours	( )
	Container Truck	Cost: 3,675 RMB Time: 10 hours	( )
	Container Train	Cost: 963 RMB Time: 28 hours	( )

Figure 3.
Part of the questionnaire in the survey

The utility determines the chance that a mode is chosen, and the greater the utility the bigger the chance. When the random term ε_{ij} follows the distribution of Gumble, the chosen probability can be calculated with logit model as shown in equation (2) (Ben-Akiva and Lerman, 1985):

$$P_{ij} = \mathrm{E}xp(V_{ij}) / \left(\sum_{k=1,\ldots,K} \mathrm{E}xp(V_{ik})\right) \tag{2}$$

In this study, the size of the companies, the price and needed time of the mode are used as the variables in the utility function and the detailed formation is as equation (3):

$$V_{ij} = \alpha_i + \beta_1 S_j + \beta_2 C_i + \beta_3 T_i \tag{3}$$

Where:

S_j = company scale of respondent j (classified by the number of the employees);
C_i = price of mode i (RMB/TEU); and
T_i = time of mode i (hour).

With the surveyed data, the utility model is calibrated and the results are shown in Table II. It can be seen that the parameters have good statistic qualities and the R-square values of the two calibrated models indicate a relatively good fit (both are larger than 0.6), and thus the calibrated model can be used to analyze the modal splits between China and Koreas.

Here we use the averaged values of the supposed surface transportation cost, time and company size in the questionnaires to analyze the modal splits. The detailed values and the estimated modal splits are listed in Table III. It indicates that when a Chinese company with

the size of 1.5 (1 = with less than 100 employees; and 2 = with 100-500 employees) will send its trade goods to South Korea by road, sea and rail with the ratio of 30 per cent, 30 per cent and 40 per cent, respectively, while it will send its trade goods to North Korea by road, sea and rail with the ratio of 48 per cent, 18 per cent and 34 per cent, respectively, when the prices and time of transporting a container to Koreas by the three means are as shown in Table III.

7. Discussion

The sensitivity analysis is further carried out to explore the influence imposed on the modal splits by the changes in price and time of each mode. The following three scenarios are analyzed.

7.1 The decline in the freight rates

Supposing that with the continuous improvement of bilateral relations between North and South, the trade among China and Koreas would become more and more prosperous. The unit transportation cost would thus be lowered because of the economies of scale. Supposing that the freight rates decline by 5 per cent for each mode, the re-estimated modal splits are shown in Table IV. The results indicate that, in the Sino-South Korean trade, the modal

Table II. Calibrated results of the model

	China–South Korea			China–North Korea			
Constant and variables	Parameter	*T*-value	R^2	Parameter	*T*-value	R^2	Sample no.
Constant	−0.3215049	−2.57	0.65	0.0177014	2.04	0.71	35
Size	−0.4512816	−3.54		−0.9329969	−4.42		
Cost	−0.0000970	−2.28		−0.0000295	−3.96		
Time	−0.0025686	−2.81		−0.0321566	−2.29		

Table III. Average value of the price, time and company size and the modal splits

	Dandong–Seoul			Dandong–Pyongyang		
Variables and modal splits	Road	Sea	Rail	Road	Sea	Rail
Price (RMB/TEU)	4,860	4,063	1,448	3,388	4,063	907
Time (hour)	8	36	23	5	36	19
Company size	1.5			1.5		
Modal splits (%)	30	30	40	48	18	34

Table IV. Sensitivity analysis for modal splits in different scenarios

	China–South Korea			China–North Korea		
Scenarios	Road (%)	Sea (%)	Rail (%)	Road (%)	Sea (%)	Rail (%)
Modal splits in original scenario	30	30	40	48	18	34
Modal splits in Scenario A (decline in freight rates by 5% because of the economies of scale)	30	30	40	49	18	33
Modal splits in Scenario B (increase in delay and time lost at ports by one day)	31	28	41	54	9	37
Modal splits in Scenario C (improvement in efficiency of customs clearance)	30	30	40	45	20	35

splits would remain generally even and the freight rates would have little impact on the market share of the three major modes, while in the Sino-North Korean trade, the road transportation would still play a major role and the rail transportation would become its major competitive mode.

7.2 The increase in the delays and time lost at ports

Supposing that with the continuous increase in trade among China and Koreas, the possibility of port congestion would rise if the port capacity remains limited and the port would become the bottleneck of sea transportation. Supposing that the delays and time lost at ports increase by one day for the sea transportation, the re-estimated modal splits are shown in Table IV. The results indicate that, for both the Sino-South Korean trade and the Sino-North Korean trade, the market scope of sea transportation would be further reduced, and roads and railways would equally acquire the lost market share of sea transportation. To maintain the competitiveness of sea transportation, the port operation efficiency should be improved and the waiting time at ports should be shortened as much as possible.

7.3 The improvement in the efficiency of customs clearance

Supposing that the effective regulation and policies among the three countries are proposed to further promote the trade development. For example, the customs, the inspection and quarantine authority, as well as the border inspection authority carry out the inspections separately in the past, but now they exercise the joint inspection to improve the efficiency of customs clearance and shorten the delivery time. Supposing that the transit time is reduced by 1/5 because of the acceleration of customs clearance speed, the re-estimated modal splits are shown in Table IV. The results indicate that in the Sino-South Korean trade with the reduction of transit time for all modes, there is no evident change in the competitiveness of each mode, while in the Sino-North Korean trade, the competitiveness of sea transportation would be enhanced but the road transportation would still play the major role.

Based on the above-mentioned stated preference survey and the model results as well as the sensitivity analysis, it is found that shippers actually need the multimodal transportation system between China and Koreas, and many shippers will choose road and rail if suitable road or rail transportation is available. In fact, establishing such multimodal transportation system would be a good supplement and improvement to the current trade transportation situation, which would in turn facilitate the development of trade between China and Koreas. Then how to promote the establishment of the multimodal transportation system and achieve a better interconnection between China and Koreas would be a major concern. Here is our reflection for this concern.

First, one of the most important premises of promoting the multimodal transportation system is to create a stable and peaceful political environment. Any incident affecting the mutual political relations would become a disruption and obstacle to promoting the development of trade transportation between China and Koreas. For example, North Korea's nuclear test has brought a serious threat to the sensitive and complex Sino-North Korean and North-South Korean political relations, and caused sustained tension on the Korean Peninsula. To promote the interconnections, China and Koreas have to resolve the disputes and disagreements through peaceful negotiations and work together to create a secure and stable external environment.

Second, the infrastructural development is the basis for promoting the multimodal transportation system especially the surface transportation system between China and Koreas. The feasible ways include building the railway and highway border inspection facilities, accelerating the railway and highway construction, increasing the railway and

highway mileage, setting up the clear signboards, operating the scheduled railway container lines etc. The infrastructural development needs huge funds, so great efforts should be made to introduce the capital, such as the national financial funds and the funds from international institutions such as World Bank.

Third, many efforts should also be made to enhance the service level of the multimodal transportation system especially the surface transportation system from the management perspective. For example, the cooperation of customs clearance between China and Koreas should be enhanced to reduce the transportation time and thus increase the service utility of each mode. Agreements and protocols among the three parties can be signed by drawing lessons from relevant international standards, uniform rules and technical standards when necessary to ultimately establish a harmonious, stable and prosperous environment for border trade.

8. Conclusion

From the analyses, it can be induced that there is a great deal of trade transportation demand between China and Koreas. At present, almost all cargos are transported by waterway, but this kind of transportation pattern is not reasonable. With the increasingly stable political environment and the physical highway and railway connections, the transportation network consisting of multi-modes especially the surface modes becomes possible. From the survey on the companies in China, it is found that shippers need the multimodal transportation system, and many shippers will select road and rail if suitable road or rail transportation is available, and market share of sea transportation would be thus largely reduced. Especially, between China and South Korea, the road, rail and sea transportation may be used evenly, while the road transportation may play a more important role in the trade transportation between China and North Korea. The surface transportation would have a huge substitute effect on the water one.

The following sensitivity analysis compares the impact of the freight rates and the transit time on the competitiveness of each mode in the Sino-South Korean and Sino-North Korean trade, respectively. Three scenarios are proposed, including the decline in the freight rates, the increase in the delays and time lost at ports and the improvement in the efficiency of customs clearance. The re-estimated modal splits in the three scenarios indicate that the mode competitiveness is less sensitive to the changes in the freight rates and the transit time in the Sino-South Korean trade, while in the Sino-North Korean trade, the changes in the freight rates and the transit time would have an obvious effect on the market share of each mode.

Establishing a multimodal transportation system incorporating the road, rail and sea transportation would be a good supplement and improvement to the current trade transportation situation, which would in turn facilitate the development of trade between China and Koreas. Several suggestions are offered to better promote the establishment of the multimodal transportation system and achieve a better interconnection between China and Koreas, including creating a stable and peaceful political environment, promoting the infrastructural development between China and Koreas, as well as enhancing the service level of the multimodal transportation system from the management perspective.

The major contribution is made in analyzing the current situation of the trade transportation between China and Koreas, and proposing both the possibility and the necessity of establishing a multimodal transportation system through the analysis of the infrastructure and the bilateral relation development as well as the questionnaire survey and the modal splits model. The topic of how to optimize the multimodal transportation network would be a future study interest.

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Corresponding author
Zhongzhen Yang can be contacted at: yangzhongzhen@263.net