The competitiveness of Arctic shipping over Suez Canal and China-Europe railway

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A R T I C L E   I N F O

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A B S T R A C T

One of the advantages of Arctic shipping or the Northern Sea Route (NSR) over the traditional Suez Canal Route (SCR) is its comparatively shorter transport distance between the Atlantic and the Pacific, which makes North East Asia and North Europe seemingly closer geographically and economically. The economic development of the North-East Asia brings further potential for the commercial applications of the NSR. Meanwhile, China’s ‘Belt and Road’ Initiative (BRI), the Railway Transport between China and Europe (Railway) has also been developing rapidly. This has led to the possibility of route competition among the NSR, the SCR and the Railway in freight transport between East Asia and Western Europe. In this paper, the market shares of the three transport routes are analyzed using bootstrapped multinomial logit (MNL) model. Further, scenario analysis is provided to examine the change of market share of the NSR under varying development trends related to economic conditions, natural conditions, and shippers’ preference. Based on the results, policy implications and suggestions are discussed.

1. Introduction

Arctic shipping or the Northern Sea Route (NSR) has received increasing attention from scholars due to melting ice and extension of the navigation season caused by global warming. The presence of an ice-free season in summer allows using NSR as a direct link between Asia and Europe (Tseng and Cullinane, 2018). The NSR is now approximately 40% shorter than the Suez Canal Route (SCR) for such trade. Furthermore, rich resources that are yet to be discovered in NSR is making it a new hot spot. NSR will increase its significant role on global shipping since SCR is blocked due nature disasters and piracy, and war (Gao and Lu, 2019).

However, there are several challenges in developing the NSR as a viable shipping channel. First, ship capital investment for using the NSR is higher compared with that for traditional routes; it is expensive to build or charter ice class ships required to navigate the NSR. Similarly, regarding operating costs, training and hiring crew who are proficient in operating this type of ship further adds to investments, and maintenance costs. Also, uncertainties exist in voyage cost. Although the NSR can decrease sailing distance and hence fuel cost in theory, its adverse environmental conditions such as low visibility and temperature, which are likely to reduce ships’ sailing speed and thereby increase fuel consumption. High and volatile tariffs further increase the uncertainty. In addition, the discontinuity of navigation seasons for the NSR presents an obstacle in ship scheduling for a shipping company. For instance, a shipping company that invests in ice class ships for NSR will experience high operating and voyage costs when the NSR is not passable.

Meanwhile, the sensitivity of the transport environment limits the types of freight shipped via the NSR. In 2014, 53 ships sailed through the NSR, including cruise ships and icebreakers. Cargo ships mainly transport crude oil and refined oil products. If the oil leaks, the arctic marine environment will be polluted, and the related countries such as Russia and Canada will suffer huge financial losses. Furthermore, commercial use of the NSR has a negative impact on the Arctic’s marine environment. Carbon dioxide released by ships will accelerate the melting of sea ice. Moreover, the navigational challenges in the NSR can affect ships’ schedule. Therefore, the prospects for operating liner shipping on NSR routes are not bright.

In addition, the implementation of the Belt and Road (B&R) Initiative of the Chinese government has brought further challenge to the

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commercial application of the NSR. With the implementation of the B&R Initiative, the Railway is developing fast (Jiang et al., 2018). The Railway refers to the international railway container transport service that runs between China and European countries according to fixed schedule and lines. On the one hand, the Railway is experiencing substantial growth in freight volume especially for last year (Yang et al., 2019). In addition, it provides a new transportation corridor for Sino-European trade and solves the awkward fact that shipping by sea needs a long time whereas shipping by air is expensive. It competes with NSR, which has a negative impact on the development of the NSR route. On the other hand, the Railway transportation network focuses on the northern and central regions of China. Gradual improvement of the transport system in the northern region can stimulate economic development, increasing demand for the NSR and promoting commercial applications of the NSR.

This paper studies the commercial prospects and potential of the NSR in the Northeast China, East China, and South China shipping regions, considering economic and natural factors as well as the impact of the B&R Initiative. The rest of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the multinomial logit model, and Section 4 presents the experimental design and coefficient calibration. Section 5 analyzes various scenarios, by varying the navigable time of the NSR, competition among different regions in China and transport preferences of shippers. Section 6 presents the conclusions.

2. Literature review

The extension of the summer ice-free season has brought new opportunities for commercial application of the NSR. It can potentially result in savings in both time and costs for shipping companies (Raza & Schayen, 2014). According to the statistics report of Northern Sea Route Information Office, the country that most often carries cargo through the NSR is Russia. From 2013 to 2015, the proportion of Russian ships passing through the NSR are 64.7%, 88.6% and 55.6%. The main types of cargo include oil, gas, frozen fish or meat. Except for Russia, the others transported cargo between the Far East and Europe include but are not limited to Norway, Panama, Liberia and China. However, their utilization rate is low. As for the types of cargo shipped, they are mainly general cargo and bulk. For instance, the three trial shipments undertaken by COSCO’s ‘Yongsheng’ contain general cargo (2013), coils and project cargo such as windmill tower and blades (2015), and Ore and steel (2016). In the past, shipping activities in the NSR have caused a wide range of concerns. Consequently, scholars have discussed the NSR’s prospects from various perspectives.

Due to the peculiarity of its environment, the NSR’s navigation season is concentrated in the summer. Among the studies that only considered using NSR during the summer, most scholars believe that, compared with the SCR, the NSR is competitive in bulk cargo shipments (Pierre and Olivier, 2015). To avoid high stranded costs associated with using ice-class ships in the non-summer season, the strategy of using ice class ships on ordinary routes during other seasons has been discussed. For instance, Liu and Kronbak (2010) compared the annual profit of two operating modes: regular service by a non-ice class ship via the SCR for the entire year and NSR service by an ice class ship during NSR navigable months with Suez Canal service for the remainder of the year. The latter case was found to be not economically feasible. Lasserre (2014) researched and compared 26 models on the feasibility of the NSR published between 1991 and 2013. The intention of the research is to define credible parameters to build a model that could assess the profitability of Arctic shipping. He built a new model on the basis of this research, considering the Rotterdam-Shanghai and Rotterdam-Yokohama routes to analyze the transportation costs for each container traveling the NSR and the Northwest Passage (NWP) and conduct sensitivity analyses. He concluded that the NSR is cost-competitive compared with Rotterdam–Yokohama routes, but not Rotterdam–Shanghai routes. Further, he proposed that being cost-competitive depends on many other conditions, such as tariffs and fuel cost. At present, tariffs for plying the NSR are high.

Meanwhile, the same applies to ice-breaking fees. When the sea ice reaches a certain thickness, ice-breaking aid is mandatory. The ice-breaking fee fluctuates and depends on ship sizes, routes, and the level of support required. Tariffs and ice aid costs strongly impact on the economic viability of the route. Pierre and Olivier (2015) considered ice-breaking fees in their analysis, arguing that the NSR holds an advantage on daily cost provided that the ship sails at an optimal speed and only requests one ice-breaking aid.

Apart from the costs of operations, shipping companies also faced the constraints of external policies and pressure from the international community regarding environmental protection. Many international multilateral institutions have been closely following the environmental protection of the Arctic, such as the International Maritime Organization (IMO) and the Arctic Council. The agencies might affect the commercial application of the NSR. In particular, many multilateral agencies have been emphasizing the environmental risks posed by commercial application of the NSR, including ship collision with whales, oil spills, and long-term pollution (Lee and Kim, 2015; Fu et al., 2018; Fedi et al., 2018). These have increased the risk and pressure for the shipping companies interested in using the NSR. For shipping companies, dealing with these risks requires strong financial resources to support long-term development business and is also influenced by the company’s leadership.

As for the Railway, it extends from Chongqing to Europe. At the end of 2017, a total of 57 railway routes have been opened between 35 Chinese cities and 34 cities from 12 European countries. Since the first Railway route began operating in 2011, the annual freight volume of the Railway has increased from 1404 TEU to 97400 TEU, from 2011 to 2016. At the beginning, the Railway mainly transported information technology products manufactured in Chongqing. Later, according to the industrial situation of the cities that opened the Railway, the types of goods transported were expanded to clothing, general merchandise, auto spare parts, medical instruments and so on.

With the rapid development of the Railway, relevant researches have gradually emerged. Most researches not only focus on qualitative analysis about key problems that affect the sustainability of the Railway (Gang et al., 2017), but also the quantitative aspects about network design. For instance, Sheu and Kundu (2018) consider the forecast of time-varying logistics distribution flows in the OBOR strategic context. Others focus on solving the consolidation problem of the Railway considering factors such as distances, costs and train speed (Jiang et al., 2015). To solve problems of the Railway such as low load factor and profit margin as well as high governmental pressure to subsidize the trains, Zhao et al. (2018) use the TOPSIS model and cargo rates to comprehensively evaluate the networks and select 10 cities as optimal consolidation centers using a mixed integer programming model. However, the existing researches have yet to examined the potential competition among the SCR, NSR and Railway while considering the climate change of sea ice melting in the Arctic and the promotion of the B&R Initiative. The competition among these three transport modes will have a great impact on the development of China’s regional economics and Sino-European trade in the future.

3. Methodology

In this paper, we combine quantitative and qualitative analyses to explore the potential market shares of the three transport modes. First, a mathematical model is built to describe the probability that the shipper will choose a certain transport route. Subsequently, we perform scenario analysis. With the background of the possible changes in natural conditions, economic conditions, and types of cargo, we analyze the

development of different transport routes in different regions.

3.1. Adjusted bootstrapped multinomial logit (MNL) model

We try to discuss market share changes of the SCR, Railway and NSR in different regions of China. In essence, market share depends on shippers’ choice of travel mode which is known as modal split. Normally, shippers are utility-oriented when choosing transport routes. The probability that an individual shipper will choose route $i$ can be approximated with the observed relative frequency. It can be approximated as or considered equivalent to the modal share of route $i$. In terms of characterizing the probability, the method used most commonly in the transportation sector is the logit model (Stamatopoulou and Psarafitis, 2013).

The three routes we studied are the SCR, Railway, and NSR. The SCR and the NSR are both marine routes; however, due to the great difference in their transport environment, characteristics and service frequencies, these two routes can be regarded as independent of each other. The Multinomial logit (MNL) model has the characteristic of independence of irrelevant alternatives (IIA), meaning that adding or deleting alternative outcome categories does not affect the odds among the remaining outcomes. In other words, alternatives are independent of each other and have no similarity. Therefore, this paper chooses the MNL model, which is one of the most widely used discrete choice models and has the advantage of a closed form mathematical structure (Ben-Akiva et al., 1997). In addition, an in-and-out sample bootstrap method is employed to ensure the reliability of estimation.

The basic form of a multinomial logit model is as follows:

$$P_i = \frac{\exp V_i}{\sum_{m=1}^{K} \exp V_m}$$  \hspace{1cm} (1)

where $V_i$ is the utility function expressing the shipper’s choice of transport route. Particularly, each utility function is defined as a function of all aspects and attributes influencing the choice between alternative routes.

A utility function can be expressed in various functional forms; to account for the uniformity of result interpretation and the expression of the coefficients, the linear function form is widely used.

$$V_i = \sum_{k=1}^{K} \beta_k X_{ki}$$  \hspace{1cm} (2)

where $X_{ki}$ represents the set of relevant factors considered by shippers when they consider route $i$, $K$ is the number of factors considered, $\beta_k$ is the coefficient of the corresponding factor $X_{ki}$ to be estimated.

Shippers that transport different types of cargo hold different preferences regarding the factors. They will choose the most suitable transportation mode according to its characteristics. For instance, shipping is affected by many natural conditions such as weather and sea condition. However, rail transportation is hardly affected by natural conditions. Rail transport has greater reliability and security because damage risk caused shipping is high. (Tuzkaya and Omit, 2008). The natural conditions for arctic shipping routes are the worst. Besides, the Railway generally takes 6–23 days for trains to travel from China to Europe, which is half of the time required for sea cargo (Zhao et al., 2018). Therefore, comparing the SCR with the NSR, the Railway holds advantages in speed and security. Therefore, cargoes whose arrival is time-sensitive or are valuable are more likely to be transported via the Railway. Conversely, the SCR is more likely to attract ordinary goods that are relatively time-insensitive due to its lower freight rates.

Accordingly, this paper introduces the shipper’s preference coefficient for different factors in the above utility function. The preference index $r_k$ increases as the shipper’s preference for factor $k$ increases. For example, when a shipper plans to transport high-value goods, that shipper will tend to prefer security of the transport route over convenience and speed which increases the safety preference index. The utility function can thus be expressed as follows.

$$V_i = \sum_{k=1}^{K} \beta_k r_k X_{ki}$$ \hspace{1cm} (3)

The shipper’s selection behavior is influenced by many factors such as the level of service, the characteristics of the goods, and so on. To limit the number of model variables to a reasonable level, we need to determine specific influencing factors. Based on a survey of 93 logistics companies located in the Autonomous Region of Madrid, Arencibia et al. (2015) analyzed the importance of each factor influencing the choice of transport provider. According to the results, the most important criteria were the transport cost, transit time and punctuality.

Considering the characteristics of the SCR, Railway, and NSR, the differences between the three routes and the difficulty of data acquisition, we mainly consider the freight rate, transportation time, safety, and convenience index (i.e. service frequency). To accurately characterize the shipper’s choice behavior, we also consider the shipper preference coefficient. Thus, the specific expression of the utility function $V_i$ is as follows.

$$V_i = \beta_{r,c} r_i p_i + \beta_{r,t} r_i t_i + \beta_{r,s} r_i s_i + \beta_{r,c} r_i c_i$$ \hspace{1cm} (4)

where $p_i$ represents the freight rate of route $i$, and $t_i$ is the transportation time of route $i$. The safety index $s_i$ for route $i$ is related to the cargo damage rate. $c_i$ is the convenience index of route $i$.

The concept of the convenience index is abstract. In this paper, convenience refers to the shipping schedule being frequency intensive and convenient for the shipper to arrange transportation. Hence, we use service frequency to express the concept of convenience. High service frequency will broaden the scope of the shipper’s choice and help the shipper to arrange transportation activities more conveniently. The convenience index in the model is equivalent to the number of trips per year.

Substituting eq. (4) into eq. (1), the choice probability of each transport model can be computed once the parameters are estimated in advance using regression.

$$P_i = \frac{\exp \beta_{r,c} r_i p_i + \beta_{r,t} r_i t_i + \beta_{r,s} r_i s_i + \beta_{r,c} r_i c_i}{\sum_{i=1}^{K} \exp \beta_{r,c} r_i p_i + \beta_{r,t} r_i t_i + \beta_{r,s} r_i s_i + \beta_{r,c} r_i c_i}$$ \hspace{1cm} (5)

3.2. Scenario analysis

Scenario analysis is often used to make assumptions or predictions about the future of the forecasting object, to predict the situation or the consequences of the forecasting object on the assumption of a certain phenomenon, or to predict whether a trend will continue in the future (Postma & Liebl, 2005). In this paper, factors influencing the trend include natural conditions, economic conditions, and shipper preferences. The scenario can be described by changing the variable or coefficient in the MNL model. In this paper, the use of scenario analysis is aimed at analyzing the market potential of the NSR under different trends. Therefore, the simulation verification and strategy development in the traditional scenario analysis are replaced by data analysis. Then, changes in the market share of the NSR are analyzed accordingly.

4. Example design and coefficient calibration

This paper analyzes the market share of the NSR which competes with the SCR and Railway and dissects the market conditions in East China, South China, and Northeast China. The Port of Hamburg is selected from the European ports as an example. We divide the large-capacity ports of China into three geographical groups represented by circles in Fig. 1: east, south and northeast. The throughput of the region
is the sum of each port throughput in the circle. For each circle, a representative route is selected. For East China, the Shanghai–Hamburg route is the best choice. For South China, we choose the Shenzhen–Hamburg route. For Northeast China, the Dalian–Hamburg route is appropriate.

4.1. Data processing

Two types of data, characteristics and historical data of market shares of three types of transport modes, were collected and processed according to data source and availability. The coefficients in the model are estimated by regression of quarterly data relevant to the period between 2011 and 2015. For the shipping price, we refer to the quotation provided by Jincheng Logistics, an online trading platform for a third-party logistics company. On this platform, the shipping companies that provide the quotation includes but not limited to MSK, COSCO, MSC, CMA. We collected quotation of three route (Shanghai, Shenzhen, Dalian to Hamburg) in 2015. The freight rate involved in the model is the average price of the quotations for corresponding time periods. The quotation from 2011 to 2014 is estimated by applying the China Container Freight Index (CCFI) on the quotation of 2015.

At present, the NSR is not a commercially operating route in China. Therefore, the freight rate used is referenced from Stamatopoulou and Psaraftis (2013). The freight rate from to Shanghai to Hamburg is derived from Stamatopoulou and Psaraftis (2013) and Verny and Grigentin (2009). Combining the NSR shipping cost (Furutichi and Otsuka, 2014; Lasserre, 2014) and the CCFI, the freight rates are obtained. For Shenzhen and Dalian, a reasonable estimate based on the sea freight rate from Shanghai to these two cities is made.

The price of Railway we refer to “imsilkroad.com”, an international information service platform of the Belt and Road, and official website “YUXINOU” (Chongqing) Logistics Co., LTD. We select the Railway originating from Chongqing, because Chongqing is the first city to open a Railway from China to Germany, and keeps important position in the Railway market from China to Germany. As for the price from three regions to Chongqing, freight rate and distance data are obtained from National Railway Administration of China.

The freight rate was obtained from information provided by the shipping companies and the Railway Corporation. The convenience index for the SCR is estimated based on the number of ships traversing the route during the whole year of 2015. Regarding the Railway, the number of annual trips is estimated according to the frequency of weekly trips between China and Europe. The number of shipments of the NSR includes both cargo and non-cargo ships. The data of the NSR is provided by the Russian NSR Administration. Regarding the safety index, compared with seaborne shipping, the Railway transport is with higher level of security (Tuzkaya and Omur, 2008). Considering the factors affecting navigation, the complexity of the real situation in the arctic is far beyond imagination. The research in weather and ice forecasting in Arctic region is progressing, and data sharing and navigational warning systems are gradually establishing (Meng et al., 2017). According to Kitagawa and Buixade Farre et al., the damage risk to vessels along the transarctic is increasing. Based on the natural conditions, the arctic shipping route is less safe than general shipping route. Hence, we used directly the safety index of Railway, SCR and NSR as 100, 85 and 65 to represent the safety levels of the three routes from a report on the Euro-Asian Transport Links Project (Inland Transport Committee, EU, 2018). Relevant data, taking 2015 as an example, is shown in Table 1.

The overall container volume of the SCR can be obtained through the relevant official website data, but the volumes for specific origins and destinations cannot be obtained directly. Therefore, the relevant data are obtained by indirect derivation. As an example, Fig. 2 depicts the specific data processing used to estimate the volume of freight from South China to Germany via the SCR.

Presently, Railway transport is in its early stages, and the large number of Railway lines between China and Germany increases the difficulty of data collection. Therefore, we indirectly derived the target data based on the foreign trade cargo throughput of Railway ports (Fig. 3).

Shipping and rail freight data are mainly derived from the China Statistical Yearbook and the statistical yearbooks and statistical communiques of provinces or cities. Although the NSR is not yet in commercial operation, COSCO has conducted commercial trial operation estimation for the route. Further, it has held “COSCO shipping arctic route customer promotion meeting” in Norway. Therefore, the freight data of the NSR are obtained from the data released by the Russian NSR Administration and COSCO.

The time range for data selection is 2011–2015. We collected the quarterly freight volume (TEU) between China and Germany of three routes to estimate their market shares. We calculate the statistics based on the quarterly data, and the annual market share of three routes from 2011 to 2015 (Table 2). According to the statistic information, 95.58% and 4.42% of cargoes are transported by SCR and Railway respectively, whereas the NSR mainly relies on the three trial voyages of COSCO’s “Yongsheng”. From a regional market perspective, South China’s shipping market share has remained above 97.5%, due to its geographical advantage (close to the Suez Canal). East China is the earliest area to develop the Railway. Therefore, the market share of Railway is ahead of the other two regions. However, the fastest-growing market share of the Railway is Northeast China, from 0.18% to 7.66% within 5 years.

In terms of shipper preference index, Tao et al. (2015) analyzed 61


literature related to the modeling of freight service choice behavior. To control the number of factors affecting the choice behavior at a relatively reasonable level, they counted the frequency of occurrence of the factors in the literature. The frequency of transportation charges is the highest in the relevant literature followed by the safety and convenience index and the frequencies. We believe that shipper preference index can be calibrated by frequencies. Thus, the preference index is set to 
\[
4 r_t + 3 r_s + r_c = 1.
\]
Table 4
Estimated results of bootstrapped coefficients.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Bootstrapped Coefficients</th>
<th>Standard error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>δ</td>
<td>0.720032</td>
<td>0.590216</td>
<td>1.079453</td>
<td>0.024063b</td>
</tr>
<tr>
<td>βₚ</td>
<td>0.00037</td>
<td>6.74E-05</td>
<td>3.19066</td>
<td>0.002306b</td>
</tr>
<tr>
<td>βₙ</td>
<td>0.04981</td>
<td>0.034215</td>
<td>2.22356</td>
<td>0.045000b</td>
</tr>
<tr>
<td>βₖ</td>
<td>0.067521</td>
<td>0.039095</td>
<td>1.30468</td>
<td>0.030578b</td>
</tr>
<tr>
<td>βₐ</td>
<td>0.006598</td>
<td>0.001537</td>
<td>4.29345</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

Note: a. Unless otherwise noted, bootstrap results are based on 2000 bootstrap samples; b. Based on 1999 samples.

4.2. Coefficient calibration

Considering that the sample size is only 60 for the parameters estimation, in order to ensure the reliability of estimation results, a bootstrap regression method was employed. The bootstrapped coefficients obtained by regression are shown in Table 3 and Table 4.

The overall percentage in Table 3 is 86.7%, which reveals that the estimated coefficients have a high level of stability. The estimated results can be seen from the results that the complex correlation coefficient of this multiple linear regression is high. The complex correlation coefficient R is 0.87. F examination shows a highly significant value for the regression equation (F-test, p 2.50E-14 < 0.05), and the bootstrapped regression coefficient passes the significance test (p < 0.05). And there are little changes of the coefficients after the bootstrap test.

5. Scenario analysis

In this section, we discuss the market potential of the NSR in the future under the influence of some factors. The factors that can affect the trends are natural conditions, economic conditions, and shippers’ preference. According to the environmental characteristics of the NSR and the development of each region, possible future scenarios include: First, the extension of the ice-free season in the Arctic in the summer, which means the navigable time will be longer. Second, economic development of the northern region brought about by the construction of the transportation system in North China, which will create growth in freight volume in the region. Against this backdrop, we consider the competition between different regions and analyze changes of market share. The third is the preferences of shippers. Shippers of different cargo have different preferences, which affects their choice of transport mode. Thereafter, we analyze the development potential of the NSR and its attractiveness to the three regional markets in Northeast, East, and

Fig. 4. Current market shares of three regions.

Fig. 5. Market shares of the NSR in three regions versus NSR convenience index.
5.2. The extension of the ice-free season in the Arctic

Since 1996, the area of ice melting in the Arctic has increased rapidly. Now, an ice-free season has emerged; this term refers to a period in which continuous sea ice cover is absent. In light of global warming, the ice-free season might be extended; thus, there is a high potential for increased traffic convenience of the NSR. High convenience or high service frequency can greatly enhance the scope of the shipper’s choice, providing good service experience. It also reduces the waiting time before the departure of cargo, thereby reducing inventory pressure of shippers.

With the extension of the ice-free season, the convenience index of the NSR will increase. We describe this scenario by adjusting the convenience index in the model. As the service frequency of the NSR is low presently, the maximum growth rate is fixed at 20 times. And the market shares of the NSR in three regions are shown in Fig. 5.

The horizontal line coordinates in the figure represent the rise in the NSR convenience index compared to the present value. Initially, East China holds the upper hand, with a slight advantage; although the northeastern region is more geographically advantageous, the economic prosperity of East China is sufficient to compensate for the geographical disadvantage in the early stages. However, when the convenience index increases above 15 times its present value, the northeastern region’s location advantage begins to play a role, and its market share increases beyond that of East China. Although the market share of the NSR is low, its growth rate is very impressive as the convenience index increases. When the NSR’s convenience index increases to 20 times its present value, its market share is 86.84 times the original.

As for the other two transport routes, although the impact is weak, we find that changes in the market share of the NSR to have different effects on the other two transport routes. We subtract the NSR market share from the original values to produce Fig. 6.

As the market share of the NSR rises (as shown in Fig. 5), marker shares of SCR decreases whereas the market shares of the Railway remain stable. The SCR’s share declines at nearly the same rate as the NSR’s rise. It can be deduced that, with rising NSR convenience index, some cargoes originally belonging to the SCR shift to the NSR. Hence, changes in the NSR share have a greater impact on the SCR than rail transport.

Regarding the regional markets, the share of the SCR in East China is most affected initially. However, when the convenience index increases to around 15 times its present value, the NSR’s service frequency is similar with the current service frequency of the SCR, and the rate of decline of SCR from the Northeast region surpasses that of the East region.

However, on the whole, the prospects for increasing the NSR market share seem poor. Even if the convenience index rose to 20 times its present value, the market share of the NSR would reach only 0.3%.

5.3. Growing freight volume brought by economic development of northern China

In the competition for market share, the biggest weakness of the NSR is its high freight rate. Two of the main reasons for the high freight rate are the low volume and the inability of shipping companies to reduce the cost of transport by economies of scale.

China intends to build a Northeast Asian transport system. Dandong Port in Liaoning province has the advantages of location, advanced infrastructure and can effectively open up the markets of China, Japan, Russia, and Europe. In terms of land transportation, Hunchun City of Jilin Province, with its unique geographical advantages, has constantly implemented internal and external channel construction to build a land, sea, and air transportation network. Improvements to the transportation system and the development of local economies each promote the other: economic development requires the transport system to improve, and gradual improvements on the transportation system provide a good basis for economic development. In this case, the economic center of China is likely to move northward. Economic development of northern China will bring the growth of freight volume in northern region, which will bring new opportunities for the NSR.

In general, the increasing freight volume is accompanied by a rise of load factor. High load factor also means excellent utilization of economies of scale and higher profit margins. At present, the load factor of the ships on the NSR still remains low. In most articles that analyze transportation costs on the NSR, the load factor in the example is generally set lower. In the case of Lasserre, for example, the load factors of travel and return between Yokohama and Hamburg were 70% and 45%, respectively. The essence of improving the load factor is to enhance the volume. The northward movement of the economic center is likely to increase the volume of the NSR.

In this way, such growth of the freight volume presents a good opportunity to replace small ships with large ones, increasing the amount of cargo on a single ship. This will further reduce costs, achieve lower tariffs, and thus allow the route to attract more shippers by virtue of its lower prices. The same effects will be observed on the other two routes from the northeastern region.

If the freight rate of the Northeastern China region decreases, to prevent market share decline, it is very likely that East China and South China will take measures to cut their freight rates. As the Northeast and
East China are geographically closer, the cargo origins overlap each other. In order to compete for cargo supply, the reduction of freight rate of the East China region may well be greater than that of Southern China, where there is almost no competition with the northeastern region. Based on this speculate, we provide 5 possible schemes of freight rate reductions for three regions are listed in Table 5.

After adjusting for these changes, the market share of the NSR is shown below (Fig. 7):

The market share of the NSR is not sensitive to freight rate. Even in the northeastern region, where the price cut is the largest, the NSR market share remains flat and low. In the northeastern region, for example, if the current freight rate reduction is 50%, the market share is about doubled. However, in practice, it is almost impossible to reduce the current price of the NSR by half in a limited time. The relatively stable NSR market share means that changes in market share mainly occur between the other two routes. We subtract the market share from the original value and produce the chart below (Fig. 8):

![Fig. 7. Market share of the NSR under competition.](image1)

![Fig. 8. Changes in market share of the SCR and Railway.](image2)

![Fig. 9. Changes in market shares of East China.](image3)
After the cuts on freight rates, the share of railway transport in the three regions increases. The rise of Railway market share in Northeast China is the greatest, followed by that of East China. If economic prosperity increases in the north (mainly in the northeastern region), routes departing from the northeast will attract cargo supply of neighboring areas. Due to their adjacent geographical positions, part of the cargo supply hinterlands of the Northeast and East China regions overlap. In this scenario, the northeastern region will attract some of the cargo supply of East China, which is very obvious from the perspective of rail transport. In terms of shipping, the dominant position of East China is not easy to disrupt at present; East China includes the top two ports in terms of throughput, namely the Ningbo–Zhoushan and Shanghai ports. In terms of marine transport, the northeast region cannot rival East China. However, the situation with Railway transport is different. Although there is some difference in Railway transport between East China and Northeast China, the gap is surmountable. This is one of the reasons that the rising share of Railway transport in East China is no match for Northeast China.

The shares of the SCR in the three regions are declining. The southern part of China is far from the northern region and is close to the SCR. Hence, the northward movement of the economic center does not have much impact on the region, both for rail transport and the SCR. In Northeast China and East China, the decline in market share of the SCR’s is similar to the increase in rail transport. It can be seen from Fig. 9 that, in this scenario, the movement of market share occurs mainly between the SCR and the Railway route. The change in NSR market share is very small.

5.4. Shippers’ preference

Shippers will have different preferences regarding route selection. For example, when transporting fresh and refrigerated goods, a shipper will prioritize the transport time, whereas transportation of electronic products, precision instruments, or other high-value cargo will prioritize safety. A shipper will prioritize freight rate when planning to transport general cargo without special time requirements. This section analyzes the market changes of the three routes considering the transport of different cargoes, corresponding to different preferences. We adjust the corresponding shipper preference index in the model according to the shippers’ preferences. To model the selection of shippers who prioritize safety, for example, the owners of high-value cargoes, we increase the safety index \( r_s \) in fixed intervals and observe the resulting changes in market share. Fig. 9 illustrates the market share changes in East China, where we increase value of relevant preference from 0 to 4.

As shipper dependence on time and security increases, the advantages of the Railway in terms of speed and safety will increase, resulting in capturing more market share from the SCR. The share of the NSR has no significant impact on market share. East China is a more economically developed region in China, with regards to maritime transportation due to the two super ports which are Shanghai and Ningbo–Zhoushan. The Railway is also more mature in this region. The NSR is unable to compete with the other two routes in East China.

Due to South China’s closer proximity to the SCR, the SCR’s transport time is smallest when departing from South China compared to departures from East and Northeast China. The Railway takes longer than the SCR when departing from South China, so it does not offer any time advantage. Thus, for cargoes which are sensitive to transport time, the market shares that the Railway can be captured from the SCR in the South China region is less than that in East China. However, in terms of security, the Railway still has advantage over other two routes; with increasing security preference index, high-value cargo becomes concentrated on the Central European routes (Fig. 10).

Among the three regions, the competitiveness of the NSR is the weakest in southern China, mainly due to geographical location. In South China, the changes in market share occur solely between the SCR and the Railway route.

The basic situation in the northeastern region is similar to the other
two markets; market share changes occur between the SCR and the Railway route. However, although the overall market share of the NSR is small, its market share grows the fastest when shippers prioritize shipping times. When the time preference index is 4, the NSR market share increases to 7 times its original value (Fig. 11).

6. Conclusions

This paper investigated the commercial prospects and potential of shipping via the NSR from the Northeast China, East China, and South China regions in the context of the B&R Initiative. Our method combines the MNL model and scenario analysis. We collected relevant data from the three major markets for analysis and arrived at the following conclusions.

Among the three regions, the development of the NSR is most attractive for the Northeast region, which has closer geographical proximity. But this attraction is limited. Even in a noncompetitive environment, the NSR market share remains low. The rapid development of the Railway and its brand system will lead to increasing competition, and the advancement of the B&R Initiative will accelerate this competition. Taking competition into account, the projected share of the NSR is even smaller.

In the face of the difficult-to-change adverse natural conditions of the NSR and the rapid growth of competitors, this study suggests that the Arctic route has little prospects for commercial development.

The correlation coefficients used in the present model were obtained by regression using real data. However, because the NSR is not used commercially at present, the available data are mostly trial data or from the Russian coastal transport data. Compared to the SCR and the Railway routes, which have been in commercial use for a long time, the share of the NSR is very low.

This paper analyzed the commercial application potential of the NSR from a market point of view and put forward a new research perspective for the study of the NSR. We consider the competition of the traditional SCR and also new factors brought about by new competition and opportunities. This paper not only considered the competitiveness of the Railway, but also the potential cargo supply brought by the B&R Initiative to the NSR. This article denies the possibility of commercial applications of the NSR in the short term, but the unknown and uncertain factors of the NSR should be studied in greater depth in the future.

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