The Impact of Northern Sea Route on Sino-European Trade Potential Based on Gravity Model*

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Abstract—The NSR navigation will have significant impacts on global maritime transport pattern and Sino-European trade. Based on the analysis of impact mechanism of NSR navigation on maritime trade, this paper establishes a gravity model and uses regression analysis to measure the trade potential between China and Europe. The assessment results show that China's trade potential to European countries has increased significantly after NSR navigation. The northern European countries are the most obvious, and the countries that have larger trade scale with China also show greater growth space, while the southern European countries do not show obvious superiority because of their geographical location.

Keywords—northern sea route (NSR); trade potential; Sino-European trade; gravity model; regression analysis

I.   INTRODUCTION

According to PIOMAS data, the volume of Arctic sea ice reached the lowest record with 12,900 km^3 in 2017. The last record was 13,500 km^3 in 2012. In April 2018, the average volume of Arctic sea ice was 22,250 km^3, which was 32% lower than the lowest record in 1979 and 19% lower than the average between 1979-2017 (see "Fig. 1" and "Fig. 2"). The melting rate of Arctic sea ice is accelerating year by year, and the trend is very obvious. Northern Sea Route navigation has changed from a long-term expectation to a reality.
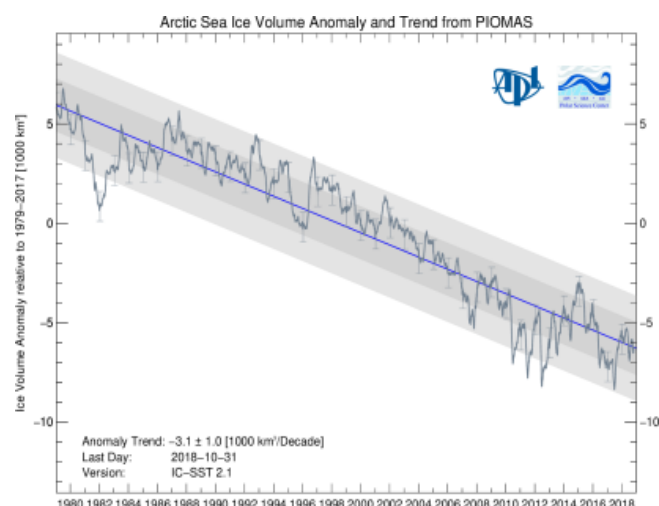
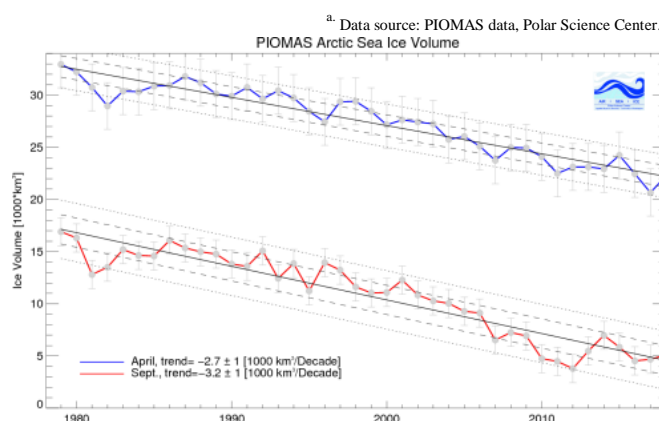Fig. 1.   Arctic sea ice volume anomaly.

a. Data source: PIOMAS data, Polar Science Center.

Fig. 2.   Monthly sea ice volume in April and Sept.

a.   Data source: PIOMAS data, Polar Science Center.

The realization of ice-free navigation on Northern Sea Route will have a significant impact on the strategy,

economy and resources of all countries in the world, especially for the countries along the Arctic route and the countries near the Arctic. In July 2017, China and Russia proposed to jointly develop and utilize Arctic routes to build a "Polar Silk Road". On January 26, 2018, Chinese government published the White Paper on Arctic Policy for the first time, China's Arctic Policy, which reflects the positive attitude of China towards participating in Arctic activities and cooperation.

So NSR navigation will make a significant change in the global maritime transport pattern, and will also have a far-reaching impact on maritime trade. Therefore, the analysis of impact of NSR navigation on maritime trade is helpful to define the development direction of maritime trade under the background of NSR navigation, and to provide a theoretical reference for making full use of logistics resources under the conditions of NSR navigation.

II. IMPACT MECHANISM OF NSR NAVIGATION ON MARITIME TRADE

The impact of NSR navigation on maritime trade is mainly based on the fact that the trade distance is shortened between the near-Arctic countries and the relevant trade countries. Therefore, NSR navigation can bring about the substitution effect of other routes to near-Arctic countries and the trade crowding-out effect to non-Arctic countries.

A. The Substitution Effect of Other Routes to Near-Arctic Countries

For different shipping routes, if the conditions of rate, navigation environment and route congestion are basically the same, the trading countries will definitely choose the shorter shipping distance and time. Therefore, in terms of shipping distance and time, NSR has a substitution effect of other routes to near-Arctic countries.

From the view of global trade, both the liquid cargo ship market and the dry bulk ship market are important contents of maritime trade. The liquid cargo market mainly includes oil and natural gas, while the rich resources of oil and gas in Arctic region will reduce the existing supply market, thus reducing the carrying capacity of the corresponding routes. The dry bulk market mainly includes iron ore, coal, cereals, bauxite/alumina, phosphate, etc., and the Arctic region is rich in iron ore and coal resources, which will also directly affect the route choice of the Arctic countries.

As an alternative choice to other routes such as the Suez Canal and the Panama Canal, NSR has its unique advantages. Compared with other politically unstable areas such as the Suez Canal and the Strait of Malacca, the geopolitical problems of NSR are relatively stable. Even though Russia is now dominant, the future navigation will eventually become normal. Moreover, China's relation with Russia is generally better than those with the United States, Japan and South Korea. Especially since Crimea declared its independence, western countries have imposed sanctions on Russia. China and Russia have carried out many cooperation projects, including cooperation projects in Arctic oil exploitation.

Russia's control over the Arctic region is a very favorable factor for China.

B. The Trade Crowding-out Effect to Non-Arctic Countries

The length of shipping distance will affect the trade efficiency of participating countries. Long-distance transportation may result in the decrease of trade efficiency due to its long completion cycle, which will affect the increase of total trade volume, and make the potential trade volume impossible to fully realize. While the NSR can shorten the distance of ocean trade, shorten the time and cycle of trade, and then shorten the capital turnover cycle of enterprises, accelerate the speed of capital turnover, thus produce the multiplier effect and further promote the improvement of trade efficiency.

For Germany, UK, Switzerland and other European countries, China, Japan, South Korea and other Northeast Asian countries, the NSR will significantly shorten the shipping distance between Asia and Europe, improve the trade efficiency, and contribute to the trade growth between them. To a certain extent, the improvement of trade efficiency and the growth of trade volume among these countries have led to the reduction of trade volume between these countries and other homogeneous countries, which has a crowding-out effect on the trade volume of other countries. The fluctuation of trade volume between countries may cause the change of trade trend and the carrying capacity between routes, which will result in the change of global maritime trade pattern.

Furthermore, the abundant oil and gas resources in the Arctic region will have an impact on the oil and gas supply structure of the global liquid cargo ship market and the original supplier countries, thus occupying the export trade of the original countries to a certain extent. Meanwhile, the rich resources such as iron ore, coal and precious metals, fisheries and other resources in Arctic region will also squeeze the share of the original supply market, resulting in the reduction of exports of corresponding countries, which will have an impact on the overall pattern of global maritime trade.

III. CONSTRUCTION OF TRADE GRAVITY MODEL AND VARIABLES SELECTION

A. Construction of Trade Gravity Model

This paper chooses the most basic form of trade gravity model to analyze the impact of NSR navigation on Sino-European trade potential. GDP and distance between ports are selected as the explanatory variables of the model. The basic form of trade gravity model can be expressed as follows:

$$Y_{ij} = K \times \frac{G_i G_j}{D_{ij}} \qquad (1)$$

Among them, Y_{ij} represents the bilateral trade volume, that is, the total trade volume, export volume and import volume between two countries or regions; G_i represents the GDP of country i; G_j represents the GDP of country j; D_{ij}

represents the distance between ports of two countries; K is a proportional constant.

The model is non-linear, so the logarithms are taken to the two ends of the equation and make it a linear equation. The corresponding variables are set according to the calculation of Sino-European trade potential. The regression equations of the trade gravity model are obtained as follows:

$$lnT_{cj} = \alpha_0 + \alpha_1 lnG_c + \alpha_2 lnG_j + \alpha_3 lnD_{cj} + U_{cj} \qquad (2)$$

$$lnE_{cj} = \beta_0 + \beta_1 lnG_c + \beta_2 lnG_j + \beta_3 lnD_{cj} + U_{cj} \qquad (3)$$

$$lnI_{cj} = \gamma_0 + \gamma_1 lnG_c + \gamma_2 lnG_j + \gamma_3 lnD_{cj} + U_{cj} \qquad (4)$$

Among them, lnT_{cj} represents the total trade volume including import and export between China and European country j, lnE_{cj} represents the export volume between China and European country j, lnI_{cj} represents the import volume between China and European country j, G_c represents China's GDP, G_j represents the GDP of European country j, D_{cj} representing the distance of ports between China and European country j, U_{cj} is a random error term.

G_c and G_j are the variables reflecting the import and export demand capacity of two countries. The larger of the economic scale, the stronger of the potential import and export capacity, and the bilateral trade volume of two countries would be larger. D_{cj} is the variable that reflects the size of shipping costs, which is an obstacle to bilateral trade.

B. Variables Selection and Data Source

This paper chooses the panel data of top 20 countries in China's trade volume from 1998 to 2017 to make a regression calculation, including total trade volume, export volume and import volume. The total observations are 400. The trade volume of selected countries with China accounts for more than half of China's total trade, and distributed all over the world, so they are representative. About 90% of China's foreign trade cargo is transported by sea, so the index of distance is chosen according to the distance between Shanghai port of China and representative ports of other trading countries. The selected countries and ports are shown in "Table I".

TABLE I.　　SELECTED COUNTRIES AND PORTS

No.	Country	Trade Volume	Port
1	USA	5847.7	Miami
2	Japan	3030.5	Kobe
3	Korea	2802.6	Busan
4	Germany	1680.7	Hamburger
5	Australia	1364.5	Adelaide
6	Vietnam	1219.9	Haiphong
7	Malaysia	961.4	Penang
8	Brazil	878.1	Santos
9	India	843.9	Mumbai
10	Russia	842.2	Vladivostok
11	Thailand	801.4	Bangkok
12	Singapore	792.7	Singapore
13	Britain	790.4	London
14	Netherlands	784.0	Amsterdam
15	Indonesia	633.3	Belawan
16	France	547.7	Bordeaux
17	Canada	518.0	Vancouver
18	Saudi Arabia	501.4	Dammam
19	Italy	497.0	Ancona
20	Mexico	477.1	Manzanillo

a. Unit: billion US Dollar

b. Data source: UN Comtrade Database

The data of export and import volume of China and other countries are derived from UN Comtrade Database, the unit is billion US Dollar; the data of GDP of each country come from the World Bank database, the unit is billion US Dollar; the shipping distance is measured by shipping distance calculation tool in the website of port.sol.com.cn, the unit is nautical mile.

IV. REGRESSION ANALYSIS

Based on the panel data of total trade volume, export volume and import volume of China and 20 trading countries from 1998 to 2017, EVIEWS 8.0 is used to estimate the parameters in the trade gravity model. The estimated results are shown in "Table II".

TABLE II.　　ESTIMATION RESULTS

Variables	lnT_{cj}	lnE_{cj}	lnI_{cj}
C	-16.095215*** （-19.416640）	-14.973701*** (-14.086465)	-18.323726*** (-21.932979)
lnG_c	1.625678*** (26.753771)	1.539247*** (19.753978)	1.688661*** (27.573983)
lnG_j	0.488614*** （16.791027）	0.475365*** （12.738983）	0.522738*** （17.823861）
lnD_{cj}	-0.312421*** (-10.314142)	-0.394849*** (-10.165290）	-0.272463*** (-8.924970)
Prob.	0	0	0
R-squared	0.752176	0.636407	0.764069
F-statistic	400.6363	231.0433	427.4856

a. *** represents 1% significant level, ** represents 5% significant level

The model estimation result shows that the regression coefficients of all explanatory variables are consistent with the theory of trade gravity model, that is, the volume of trade is positively correlated with the GDP of two countries and negatively correlated with the distance between two countries. The P values are all 0, which indicate that all three variables pass the significance test at 1% level. In addition, R-squared are 0.75, 0.76 and 0.63 respectively, which show a higher fitting degree of three equations. F-statistic values are 400.6363, 231.0433 and 427.4856 respectively, which show that the linear relationship between explained variables and explanatory variables in the model is significant in general.

Based on the results of model estimation, the regression equations of total trade volume, export volume and import volume between China and other 20 countries are established as follows:

$$lnT_{cj} = -16.095 + 1.626lnG_c + 0.489lnG_j - 0.312lnD_{cj}$$
$$(5)$$

$$lnE_{cj} = -14.974 + 1.539lnG_c + 0.475lnG_j - 0.395lnD_{cj}$$
$$(6)$$

$$lnI_{cj} = -18.324 + 1.689lnG_c + 1.523lnG_j - 0.272lnD_{cj}$$
$$(7)$$

Based on the results of model estimation and regression equations, the following conclusions can be drawn.

Firstly, the GDP variable, which reflects the economic scale of both countries, has significant positive elasticity and has a greater impact on bilateral trade volume. If other conditions remain unchanged, every 1% increase in China's GDP can increase by 1.626% in total trade volume, 1.539% in export and 1.689% in import of China. For every 1% increase in GDP of other 20 trade countries, China's total trade volume, export volume and import volume will increase by 0.489%, 0.475% and 0.529%, respectively.

Secondly, the coefficient of China's GDP in all the three regression models are larger than that of other 20 countries, which show that the change of China's economic scale is likely to have a greater impact on the trade scale of other 20 countries.

Thirdly, the shipping distance coefficient is significantly negative, the export distance elasticity is -0.395, the import distance elasticity is -0.272, the import and export distance elasticity is -0.312. These show that the variable of distance is an important factor hindering China's trade with other 20 countries, especially for China's export to other 20 countries, which is more sensitive to distance factor. From the results of regression model, it can be seen that if other conditions remain unchanged, when shipping distance reduce by 1%, China's total trade will increase by 0.312%, export will increase by 0.395%, and import will increase by 0.272%.

V. ASSESSMENT OF IMPACT OF NSR NAVIGATION ON SINO-EUROPEAN TRADE POTENTIAL

In order to measure the impact of NSR navigation on Sino-European trade potential, this paper selected seven European countries as the representative countries. Two

countries from northern Europe, Norway and Iceland; one country from southern Europe, namely Portugal; the remaining four countries are the top four European countries in trade with China, Germany in central Europe, Britain, the Netherlands and France in Western Europe.

Based on the relevant data in 2017, the trade potentials between China and seven European countries in traditional route and NSR can be calculated according to the above trade gravity model. When calculating the trade potentials between China and seven European countries through NSR, the variable of distance is replaced by the port shipping distance of NSR.

A. Export Potential

The results of China's export potential to seven European countries are shown in "Table III".

TABLE III.   EXPORT POTENTIAL

Country	Traditional route	NSR	Increase %
Norway	234.4	276.2	17.83
Iceland	47.9	55.4	15.66
Portugal	178.3	183.8	3.08
Germany	634.9	721.4	13.62
Britain	552.2	617.1	11.75
the Netherlands	324.0	365.6	12.84
France	564.0	618.7	9.70

a.   Unit: billion USD

The export potential of NSR has been improved obviously. China's export potentials to Norway and Iceland increase by more than 15%, to Germany, Britain and the Netherlands also increase by more than 10%, while the export potential to Portugal has the smallest impact, it only increases by 3.08%. This is mainly due to the geographical location, Portugal is in southern Europe, compared with other countries and the shipping distance of NSR is longer, so the promotion space is not so obvious.

B. Import Potential

The results of China's import potential to seven European countries are shown in "Table IV".

TABLE IV.   IMPORT POTENTIAL

Country	Traditional route	NSR	Increase %
Norway	344.9	386.3	12.00
Iceland	60.0	66.4	10.67
Portugal	248.9	254.2	2.13
Germany	1030.5	1125.1	9.18
Britain	879.1	949.0	7.95
the Netherlands	489.3	531.7	8.67
France	895.1	954.0	6.58

a.   Unit: billion USD.

From the results of China's import potential to seven European countries, after NSR navigation, the import potential also shows a certain degree of improvement, but not so significant as the export potential, and the promotion trend of import potential is similar to export potential.

China's import potentials to Norway and Iceland have increased by more than 10%, to Germany, Britain, the Netherlands and France increase by 6% to 10%, while Portugal is also smallest, only 2.13%.

C. Total Trade Potential

The results of China's import potential to seven European countries are shown in "Table V".

TABLE V.   IMPORT AND EXPORT POTENTIAL

Country	Traditional route	NSR	Increase %
Norway	640.4	729.4	13.90
Iceland	124.9	140.2	12.25
Portugal	476.4	488.0	2.43
Germany	1784.1	1973.3	10.60
Britain	1540.5	1681.9	9.18
the Netherlands	890.4	979.5	10.00
France	1569.7	1688.7	7.58

a.   Unit: billion USD

From the results of China's total trade potential to seven European countries, China's potentials have shown a relatively strong improvement space except Portugal. The China's total trade potentials to Norway, Iceland, Germany and the Netherlands all exceed 10%, to Britain and France also increase by more than 7%, and Portugal is 2.43%.

VI.   CONCLUSION

Generally speaking, the NSR has a greater impact on the trade potential between China and Europe. China's export, import and total trade potentials to northern European countries have increased significantly, which is mainly due to the advantage of shortening distance brought by NSR. The trade potentials to Germany, Britain, the Netherlands and France have also increased considerably. These four countries are China's largest trading partners in Europe. After NSR navigation, the trade potentials will also be fully enhanced. Because of the geographical location, Portugal does not have much space to improve its trade potential compared with other countries. For Portugal, the distance advantage of NSR is not prominent compared with the traditional route.

NSR navigation will play a great role in promoting trade between China and European countries, and the degree of promotion is different with the latitude of ports in China and European countries. The higher the latitude of ports, the more obvious the advantages of route are, and the greater the promotion of trade will be. It can be predicted that once the NSR is officially opened, due to the geographical advantages of Northern, Western and Central European countries, and their trade complementarity with China', their strategic position as trading partners will increase in Sino-European trade.

REFERENCES

[1] J C Comiso, C L Parkinson, Robert Gersten. Larry Stock, Accelerated decline in the Arctic sea ice cover [J]. Geophysical Research Letters, Vol. 35, 2008, pp: 1703-1724.

[2] Halvor S, Svein B. The Northern Sea Route versus the Suez Canal: cases from bulk shipping [J]. Journal of Transport Geography, Vol. 19, 2011, pp: 977-983.

[3] T S Rogers, J E Walsh, T S Rupp, L W Brigham, M Sfraga, Future Arctic marine access: analysis and evaluation of observations, models, and projections of sea ice [J]. The Cryophere, Vol. 7, 2013, pp: 321-332.

[4] Frédéric Lasserre. Case studies of shipping along Arctic routes. Analysis and profitability perspectives for the container sector [J]. Transportation Research Part A, Vol. 66,2014, pp: 144-164.

[5] Sung-Woo LEE, Ju-Mi SONG, Economic Possibilities of Shipping though Northern Sea Route [J]. The Asian Journal and Logistics, Vol. 30, 2014, pp: 415-430.

[6] Taedong Lee, Hyun Jung Kim. Barriers of voyaging on the Northern Sea Route: A perspective from shipping Companies [J]. Vol. 62, 2015, pp: 264-270.

[7] Yiru Zhang, Qiang Meng, Liye Zhang. Is the Northern Sea Route attractive to shipping companies? Some insights from recent ship traffic data [J]. Marine Policy, Vol. 73, 2016, pp: 53-60.

[8] Y Aksenov, E E Popova, A Yool, A.J. George Nurser, et al. On the future navigability of Arctic sea routes: High-resolution projections of the Arctic Ocean and sea ice [J]. Marine Policy, Vol. 75, 2017, pp: 300-317.