Research on the Economic Effect of "Polar Silk Road" on China and Arctic Countries Based on GTAP Model

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Abstract. The accelerated melting of sea ice in the Arctic makes the potential value of the Arctic increasingly significant. The exploitation and utilization of the "Polar Silk Road" has important influence on the economic cooperation between China and the Arctic countries along the "Polar Silk Road". This paper uses GTAP model to simulate and analyze the economic and trade impact of the "Polar Silk Road" on the Arctic countries along the "Polar Silk Road" and China. The results show that the construction of "Polar Silk Road" will have a positive impact on the import and export trade between China and Canada, USA and some Nordic countries, and the GDP and trade structure within the region. China should seize the opportunity to expand the width of "Polar Silk Road" and further promote the construction of the "Polar Silk Road".

1. Introduction
During the state visit to Russia in July 4, 2017, China's president Xi Jinping responded to the Russian proposal to build the "Polar Silk Road" invitation. He welcomed and actively participated in the proposal put forward by the Russian side for the joint development and construction of coastal international transport corridors, and hoped that the two sides will jointly develop and make use of sea lanes, especially the Arctic routes, to build the "Polar Silk Road". When Xi Jinping met with Russian Prime Minister Dmitry Medvedev on November 1, 2017, he reaffirmed the cooperative intention of China and Russia to jointly build the "Polar Silk Road". The construction of the "Polar Silk Road" will have a great impact on the world economy.

At present, there are few studies on the impact of the "Polar Silk Road" on the world economy. Many current studies have focused on the Arctic routes. The study of the Arctic routes has certain reference significance for the future research on the "Polar Silk Road". He et al. (2013)[1] quantitatively evaluated the impact of the Arctic routes on China's trade potential through a stochastic frontier gravity model. Li et al. (2015)[2] used the improved trade gravity model to study the trade growth potential of China and its affected regions due to the opening of the "Arctic routes". Li et al. (2015)[3] calculated the intensity of economic ties between China and countries along the Arctic routes through the gravity model. On the basis of the basic trade gravity model, Wang (2017)[4] depicted the impact of the opening of the northeast Arctic routes on the bilateral trade volume of the Arctic countries along the route. Scholars have made abundant research achievements on the trade potential of the Arctic routes, which can provide reference for the research on the economic impact of the "Polar Silk Road" on China. However, because the above research on the economic and trade potential of the Arctic routes ignores the complex mechanism of interaction between different
industries, it can not provide an accurate judgment for the effective cooperation between China and the Arctic countries along the "Polar Silk Road".

Cong (2017a,2017b)[5-6] used the self-developed computable general equilibrium simulation system to simulate the impact of the Arctic northeast channel and the northwest channel on the global economy, and draws the conclusion that the use of Arctic routes will promote global economic growth, but the benefits of different countries or regions are different. It provides a train of thought for this paper to study the economic and trade effects of the construction of the "Polar Silk Road" on China and the Arctic countries along the "Polar Silk Road". Unlike the previous article, which studies the impact of the Arctic routes on the economy of various regions of the world, this paper turns the research object into countries rather than regions, and studies the economic and trade effects of the "Polar Silk Road" on China and the Arctic countries along the route.

Therefore, this paper chooses to use the economic model GTAP model for prior simulation. Taking the construction of the "Polar Silk Road" as an external shock on the transportation technological progress, this paper studies the economic effects of the construction of the "Polar Silk Road" on China and the Arctic countries along the "Polar Silk Road", so that providing decision-making reference for more accurate trade exchanges between China and the Arctic countries along the "Polar Silk Road". This article defines the Arctic countries along the "Silk Silk Road" as eight Arctic countries, namely the United States, Canada, Denmark, Iceland, Norway, Sweden, Russia and Finland.

2. GTAP model of "Polar Silk Road"

2.1. GTAP model

Global Trade Analysis Project (GTAP) is a multi-region, multi-sector, comparatively static and computable general equilibrium model developed by Purdue University in USA. Its modeling foundation is derived from the Computable General Equilibrium (CGE) theory of Walras. The GTAP model establishes a set of equation relations that can reflect the economic operation laws of closed economies by quantitatively modeling a single economic system and describing the behavior of the main economic agents, including government, residents, and enterprises. On this basis, the introduction of interregional investment mechanisms and international trade links will connect the various subsystems into a global system. The GTAP model has a detailed description of economic and trade exchanges between countries, and it has become a powerful tool for analyzing international economic and trade policies [7-9].

At present, the application of GTAP is mostly based on tariff reduction, carbon emissions and other aspects, while the research results of its application in the field of transportation are still relatively few. Based on this, this paper uses this model to simulate the economic and trade effects of the construction of the "Polar Silk Road" in this paper.

The GTAP model includes a virtual international transport sector, which is used to provide the necessary transport services for international trade. Among them, the mode of transport of the international transport sector includes three parts: sea, air and other transport. In the GTAP model, the regional CIF price is affected by the change of technological progress parameters of transportation, which in turn affects the trade and transportation demand. The construction of the "Polar Silk Road" will greatly shorten the shipping distance from China to Canada, USA and the Nordic countries, and the shortening of the shipping distance is essentially the technological progress of transportation, so the policy effect caused by the progress of transportation technology can be evaluated by the GTAP model. The influence of technological progress parameters of transportation on regional CIF price in GTAP model is expressed by the following formula:

\[
pcif(i,r,s) = FOBSHR(i,r,s) \times pfob(i,r,s) + TRNSHR(i,r,s) \times [pt(m) - atmfsd(m,i,r,s)]
\]

\[
\text{atmfsd}(m,i,r,s) = atm(m) + atf(i) + ats(r) + atd(s) + atall(m,i,r,s)
\]
Among them, $pcif$ is the rate of change in the CIF price, $pfof$ is the rate of change in the FOB price, $FOBSHR$ and $TRNSHR$ are the proportion of the FOB price and freight in the CIF price respectively. $pt$ is the compound price change rate of providing transport services for various regions, and $atmfsd$ is the change rate of transportation technology progress. $atm(m)$ is the traffic technology progress rate of transportation mode $m$ in the world; $af(i)$ is the traffic technology progress rate of transportation i in the world; $ats(r)$ is the traffic technology progress rate shipped out of area $r$; $atd(s)$ is the progress rate of traffic technology transported to $s$; $atall(m,i,r,s)$ is the rate of transportation technology progress that transports $i$ from $r$ to $s$ by means of transport mode $m$. In this paper, the transportation technology between the two regions has made some progress due to the shortening of shipping distance, so this paper takes the change rate of marine traffic technology in the change rate of comprehensive traffic technology as the impact of transport services between all regions. Because the shock involved in this article is in the specified areas, the impact variable is set to $atall$.

2.2. Model setting

2.2.1. Area setting.
This study uses GTAP8 database, which includes 129 countries and regions and 57 industrial sectors. According to the needs of the simulation, using GTAPAgg software, the 129 countries and regions in the database are divided into China (only Chinese mainland), Russia, Canada, USA, Denmark, Norway, Finland and Sweden (because Iceland is not listed separately in the GTAP database, Iceland is not included in this paper during the impact) and other countries in the world, a total of 9 regions.

2.2.2. Industrial department setting.
In this paper, the transport department is divided into three categories: air transportation, sea transportation and other transportation, and the rest are classified according to the default classification in GTAPAgg software. The industrial sectors are divided into 12 departments shown in Table 1.

| Number | department                                      |
|-------|------------------------------------------------|
| 1     | Grains and crops                               |
| 2     | Animal husbandry and meat products             |
| 3     | Natural resources                              |
| 4     | Processed food                                 |
| 5     | Textile and garment industry                   |
| 6     | Light industry                                 |
| 7     | Heavy industry                                 |
| 8     | Public utilities and architecture              |
| 9     | Other services                                 |
| 10    | Air transport                                  |
| 11    | Water transport                                |
| 12    | Other transportations                          |

Data source: Organized according to GTAP database

2.2.3. Reduction of transportation distance.
In the simulation calculation, the shortening of transportation distance is essentially the technological progress of transportation. This technological progress in turn reduces the cost of trade transportation as well as the CIF price of exports. Therefore, the technological progress parameters of transportation can be exogenously set as the reduction of the transportation distance. In this paper, when calculating the reduction of sea transportation distance, important ports such as Shanghai, Anderma, Vancouver, Toronto, Seattle, New York, Copenhagen, Oslo, Helsinki and Stockholm represent the distance
measuring points of China, Russia, the west coast of Canada, the east coast of Canada, the west coast of USA, the east coast of USA, Denmark, Norway, Finland and Sweden. The BLM-Shipping software is used to estimate the shipping distance from Shanghai, China to the destination port through the traditional Suez Canal route or the Panama Canal route, and the http://www.freemaptools.com/software is used to describe the shipping distance to the destination port through the "Polar Silk Road". (Russia, Denmark, Norway, Finland and Sweden use the Suez Canal route or the northeast channel of the "Polar Silk Road", while Canada and USA use the Panama Canal route or the Northwest route of the "Polar Silk Road") Based on this, the shipping distance is calculated, and the results are shown in Table 2.

Table 2 Calculation results of transportation distance (nautical mile)

|                       | Sea transportation distance (Suez Canal / Panama Canal) | Sea transportation distance ("Polar Silk Road") |
|-----------------------|--------------------------------------------------------|-----------------------------------------------|
| Russia                | 12517.52                                               | 5849.64                                       |
| Canada                | 7367.96                                                | 6224.81                                       |
| USA                   | 6880.29                                                | 6071.58                                       |
| Denmark               | 10799.34                                               | 7787.00                                       |
| Norway                | 10943.71                                               | 7556.00                                       |
| Finland               | 11446.65                                               | 8321.00                                       |
| Sweden                | 10885.74                                               | 7757.00                                       |

Data source: The BLM-Shipping software

Regarding the reduction of distance in Russia, the transportation method of the land continental bridge is not considered. In addition, the economically developed region of Russia is northwestern Russia. Therefore, the port in the northwest of Russia is selected as the distance measuring point of Russia.

3. Analysis of simulation results

3.1. Impact of the "Polar Silk Road" on CIF prices between China and Arctic countries

Setting different impacts of transportation technological progress will affect the CIF prices of regional trade between China and the Arctic countries along the "Polar Silk Road". The impact of the "Polar Silk Road" on the CIF prices of the above-mentioned inter-regional trade is shown in Table 3.

Table 3 Impact of the "Polar Silk Road" on CIF prices between China and Arctic countries (%)

| department                      | China and Russia to Russia | Russia to China | China and Canada to Canada | Canada to China | China and USA to USA | USA to China | China to Denmark | Denmark to China |
|---------------------------------|---------------------------|----------------|---------------------------|----------------|----------------------|--------------|------------------|------------------|
| Grains and crops                | -0.494                    | -0.123         | -2.125                    | -1.146         | -0.903               | -1.687       | -0.806           | -1.135           |
| Animal husbandry and meat products | -0.108                  | -0.258         | -0.368                    | -1.118         | -0.358               | -0.709       | -0.133           | -1.789           |
| Natural resources               | -3.008                    | -2.423         | -2.030                    | -3.746         | -1.838               | -3.397       | -2.971           | -2.104           |
| Processed food                  | -0.257                    | -0.427         | -0.990                    | -1.285         | -0.700               | -0.861       | -0.465           | -1.944           |
| Textile and garment industry    | -0.202                    | -0.612         | -0.547                    | -0.690         | -0.473               | -0.644       | -0.499           | -0.598           |
| Light industry                  | -0.293                    | -1.042         | -0.875                    | -1.267         | -0.691               | -0.396       | -0.819           | -1.735           |
| Heavy industry                  | -0.490                    | -1.501         | -0.383                    | -0.605         | -0.279               | -0.368       | -0.456           | -0.833           |
The development and utilization of the "Polar Silk Road" has reduced the regional CIF prices between China and Russia, Canada, USA and Nordic countries, among which the decline of grain and crop industry, natural resources and processed food industry is larger than that of other industries, which is consistent with the proportion of the above-mentioned corresponding industries in CIF prices. The decline in the natural resources industry between China and the four Nordic countries was particularly pronounced, with a drop of as much as 5 per cent. As the "Polar Silk Road" reduces the transportation distance between China and the Arctic countries along the "Polar Silk Road", the CIF prices between China and the corresponding countries have dropped. On the other hand, the CIF prices of China and other parts of the world have also declined, which is not due to the price adjustment caused by the development and utilization of the "Polar Silk Road", but due to the passive decline caused by the price shocks of other countries, this decline is weaker than the direct impact of the construction of the "Polar Silk Road".

3.2. Changes in export volume from China to Arctic countries along the "Polar Silk Road"
Due to the decline of regional CIF prices between China and the Arctic countries along the "Polar Silk Road", the interregional export volume has changed accordingly, as shown in Table 4.

| department | China and Russia | China and Canada | China and USA | China and Denmark |
|------------|------------------|-----------------|--------------|------------------|
| Grains and crops | -0.901 | -0.008 | -2.881 | -3.104 | -1.215 | -4.394 | 0.132 | -0.018 |
| Animal husbandry and meat products | -0.198 | -1.742 | -0.345 | -0.393 | 0.075 | -1.822 | 0.166 | -0.022 |
| Natural resources | -5.111 | -2.666 | -4.214 | -3.149 | -2.994 | -2.506 | -0.071 | -0.004 |
| Processed food | -0.639 | -1.721 | -2.463 | -2.055 | -1.806 | -3.085 | 0.120 | -0.021 |
| Textile and garment industry | -0.535 | -1.847 | -1.206 | -0.946 | -1.354 | -1.310 | 0.142 | -0.015 |
| Light industry | -0.807 | -1.828 | -1.736 | -1.897 | -2.128 | -1.772 | 0.130 | -0.020 |
| Heavy industry | -0.508 | -1.133 | -0.504 | -0.545 | -1.169 | -0.843 | 0.086 | -0.015 |
| Public utilities and architecture | 0.144 | -0.011 | 0.144 | 0.007 | 0.144 | 0.001 | 0.144 | -0.023 |
| Other services | 0.215 | -0.009 | 0.215 | 0.016 | 0.215 | 0.009 | 0.215 | -0.028 |

Data source: simulation results from GTAP

Table 4 Changes in export volume between China and Arctic countries along the "Polar Silk Road"(%)
### Results of the Interregional Trade Flow Between China and Other Countries

| Department                        | China to Norway | Norway to China | China to Finland | Finland to China | China to Sweden | Sweden to China | China to the rest of the world | the rest of the world to China |
|-----------------------------------|-----------------|-----------------|------------------|------------------|----------------|----------------|-----------------|------------------|
| **Grains and crops**              | 4.4256          | -1.2461         | 14.2483          | 14.199           | 5.952          | 20.633         | -0.6871         | -1.1954          |
| **Animal husbandry and meat products** | 1.3753          | 11.8939         | 2.4731           | 2.067            | -0.5961        | 12.4807        | -1.325          | -0.6433          |
| **Natural resources**             | 59.7886         | 28.3416         | 50.3364          | 33.9728          | 35.6468        | 26.4771        | 1.0615          | -2.7263          |
| **Processed food**                | 2.7477          | 7.4002          | 10.7465          | 8.865            | 7.786          | 13.3944        | -0.6087         | -0.0714          |
| **Textile and garment industry**  | 2.9303          | 14.0891         | 7.5419           | 7.3725           | 8.5195         | 10.0856        | -0.9253         | 0.4352           |
| **Light industry**                | 5.0928          | 12.0024         | 11.0238          | 12.4634          | 13.5615        | 11.6366        | -0.9451         | 0.027            |
| **Heavy industry**                | 3.5421          | 8.1246          | 3.3217           | 3.8553           | 8.205          | 6.0192         | -0.6698         | 0.0037           |
| **Public utilities and architecture** | -0.6857         | 0.4269          | -0.6543          | 0.3439           | -0.6899        | 0.37           | -0.7384         | 0.4807           |
| **Other services**                | -0.8519         | 0.429           | -0.7963          | 0.3348           | -0.8178        | 0.361          | -0.9033         | 0.5              |

Data source: simulation results from GTAP

The "Polar Silk Road" makes the international trade between China and the Arctic countries along the "Polar Silk Road" show obvious price advantages, expands the scale of trade, and leads to a series of changes in the export volume of different sectors in different regions. The scale of exports between China and the Arctic countries along the route has increased to varying degrees. From the perspective of regional flow, the export scale of Russia, Canada and USA to China is larger than that of China to the corresponding three countries, while the export scale of the other four countries and China is the opposite. From the perspective of different industrial sectors, the change in the export volume of natural resources is the most significant. The export volume of natural resources from Canada and USA to China increased by 42.88% and 38.78% respectively. Compared with USA, the location conditions of Canada determine that the transportation distance of Canada using the "Polar Silk Road" is greatly reduced, so the increase of its exports to China is higher than that of USA. As the trade between China and Russia is mainly completed by land transport, the impact of the technological progress of maritime transportation on the export volume between the two countries is less than that of USA and Canada. For the manufacturing industry, exports to China also increased slightly, and the growth rate of exports to China from most countries was higher than that from China. Most of the
products exported by USA and Canada to China increased, of which natural resources products increased the most. The export volume between China and the Nordic countries has increased to varying degrees. In addition to the obvious increase in natural resources, the textile and clothing industry and light industry have also increased greatly. This will improve China's high trade dependence on Russia and USA in the Arctic countries along the "Polar Silk Road", and at the same time enhance China's trade dependence with other Nordic countries and promote trade between China and the Nordic countries.

4. Main conclusions
By impacting the traffic technological progress parameters of transportation in the GTAP model, this paper simulates and analyzes the economic and trade impact of the construction of the "Polar Silk Road" on China and the Arctic countries along the "Polar Silk Road". The main conclusions are as follows.

First, the "Polar Silk Road" will increase trade dependence between China and USA, Canada and Nordic countries. The development and utilization of the "Polar Silk Road" will reduce the shipping distance between China and Canada, USA, and the Nordic countries. Due to the reduction of the distance, the cost of economic cooperation between the two places will be significantly reduced and the obstacles to economic cooperation will be reduced, it will reduce the CIF price of exports and increase the volume of exports. The positive impact on grain, crops, natural resources and other industries is particularly obvious. The use of the "Polar Silk Road" will improve the price terms of trade between China and Canada, USA and Nordic countries, highlight the comparative advantages of their respective products, increase the scale of trade between them, and deepen their trade interdependence, especially increase the trade dependence of Canada, USA and Nordic countries on China.

Second, the "Polar Silk Road" will accelerate the process of Arctic cooperation between China and Russia, which will help China to fight for more Arctic rights and interests. As most of China's trade with Russia depends on land transport, compared with other countries that mainly rely on sea transportation with China, Russia does not have the advantage of price reduction because of the reduction of maritime transport distance with China, resulting in a negative impact on Russia's GDP and residents' welfare. In order to prevent this negative impact, Russia will step up its Arctic cooperation with China.

Third, the "Polar Silk Road" has significant economic value for China. From the changes of export trade, trade pattern, residents' welfare and other economic indicators, we can see that the "Polar Silk Road" is of great value to China's economy. From the perspective of different industrial sectors, the change in the export volume of natural resources is the most significant. The export volume of natural resources from Canada and USA to China increased by 42.888% and 38.788% respectively.

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References
[1] He Shufeng, Ping Ying, Zhang Weihua. (2013). Influence of Arctic Passage on China’s Trade Potential: An Empirical Research Based on Stochastic Frontier Gravity Model. Journal of International Trade, 08, 3～12. (in Chinese)
[2] Li Zhen, Hu Maixiu. (2015). The Impact of Using the Arctic Route on Trade in China and Its Accessible Areas. Chinese Journal of Polar Research, 27(04), 429～438. (in Chinese)
[3] Li Zhenfu, Ding Chaojun. (2015). Research on Potential of Cooperation between China and
Regions along Arctic Route. International Business, 06, 125～135. (in Chinese)

[4] Wang Dan, Zhao Yuan, Zhang Hao. (2017). Influence of the Northern Sea Route on bilateral trade volume. Journal of Dalian Maritime University, 43(02), 81～88. (in Chinese)

[5] Cong Xiaonan. (2017a). Potential Influence of the Northwest Passage on Global Economics and China’s Countermeasures: Based on Global Multi-Regional CGE. World Economics and Politics, 02, 106～129+159. (in Chinese)

[6] Cong Xiaonan, Wang Mou. (2017b). CGE Analysis of Potential Influence of the Arctic Northeast Passage on Global Economics and Its Strategic Implications. China Soft Science, 08, 21～33. (in Chinese)

[7] Walmsley T, Hertel TW, Ianchovichina E. (2016). Assessing the Impact of China’s WTO Accession on Investment, Pacific Economic Review, 11(3), 315-339.

[8] McDonald S, Robinson S, Thierfelder K. (2014). Asian Growth and Trade Poles: India, China, and East and Southeast Asia, World Development, 36(2), 210-234.

[9] Verburg R, Stehfest E, Woltjer G, et al. (2009). The Effect of Agricultural Trade Liberalisation on Land use Related Greenhouse Gas Emissions. Global Environmental Change, 19(4), 434-446.