Spatial-Temporal Evolution Characteristics and Influencing Factors of the China-Black Sea Economic Cooperation Trade

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Abstract. ArcGIS was used to analyze the spatial-temporal evolution characteristics of trade between China and Black Sea Economic Cooperation (BSEC). From 2006 to 2017, the panel data of China and BSEC were used to construct gravity model to analyze trade-influencing factors. The analysis shows that, (1) there are obvious differences in the spatial distribution of trade within the organization. The trade volume of Russia, Turkey and Ukraine is relatively large, but it is affected by geopolitical and social stability. (2) China's trade with the BSEC countries has been increasing year by year, with obvious spatial differences. Its trade with Russia, Ukraine and Turkey accounts for 87.1% of the total, but its trade with other countries is growing at a considerable rate. (3) There are significant differences in the spatial distribution of the annual trade dependence between China and BESC. China has the highest trade dependence with Albania and Russia, and the weakest trade dependence with Moldova and Serbia. (4) Geographical distance, GDP of each country, consumer price index, degree of openness and absolute difference of GDP per capita between China and BSEC member countries are the main factors affecting the trade between China and BSEC.

1. Introduction

Turkey initiated the Black Sea Economic Cooperation, or BSEC, in 1992. It has 12 pan-black sea countries, including Turkey, Bulgaria, Romania, Greece, Moldova, Armenia, Azerbaijan, Georgia, Russia, Ukraine, Albania and Serbia. As of 2017, the organization had an area of 28.9 million square kilometers and a population of 376 million. The countries along the black sea have been strategically important since ancient times and the centre of east-west power rivalry. According to Engels, the ports of the black sea, including Constantinople, are at least two-thirds. The whole rapid growth of trade depends on the reliability of the two black sea choke points, the Bosporus and the Dardanelles. Whoever controls these two straits is free to open and close the road to this distant corner of the Mediterranean [1].

Since the reform and opening up, China has been opening wider to the outside world. China put forward the Belt and Road Initiative in 2003. Chinese President Xi Jinping announced at the opening ceremony of the second One Belt and One Road summit for international cooperation that China would adopt a series of major reform and opening-up measures to promote opening-up at a higher level on April 26, 2019. The 12 member states of the organization have a long history of economic and trade cooperation with China, and all of them belong to Belt and Road Initiative. On June 7, 2019, when attending the 23rd St. Petersburg International Economy Forum in Russia, President Xi Jinping said that China will adhere to the principle of extensive consultation, joint contribution and shared benefits, jointly build an open and diversified world economy. This paper attempts to analyze the
economic and trade issues with the geographic spatial structure, use ARCGIS and gravity model to analyze and the spatial-temporal evolution characteristics and influencing factors of the trade between China and BSEC.

2. Methods and Data

2.1. Methods

2.1.1. Spatial Geographic Model. Geographic information system (GIS) is a computer system for collecting, storing, processing, managing, analyzing, displaying and applying geospatial information [2]. Through the combination of geographical information and trade data, ARCGIS visualizes the temporal and spatial evolution of China, BSEC and its intra-organization trade.

2.1.2. Trade Share Index. The simple trade share index mainly reflects the dependence of exports on an economy by the proportion of its total exports to that economy. While this index is easy to calculate, it ignores imports and reflects only one-way dependence [3]. So use the composite share of trade index, calculate the proportion of total import and export of economy $a$ to economy $b$ in total trade of economy $a$ and the sum of the proportion of total import and export of economy $b$ to economy $a$ in total trade of economy $b$, so as to comprehensively analyze the absolute degree of interdependence between economy $a$ and economy $b$.

$$S_{ab} = \frac{I_{ab} + E_{ab}}{I_a + E_a} \times \left( \frac{I_{ba} + E_{ba}}{I_b + E_b} \right)$$

$S_{ab}$ is the share of trade index of economy $a$ and $b$. The value of $S_{ab}$ represents the absolute degree of dependence between economies. In other words, the higher the value is, the greater the degree of mutual dependence between them, and vice versa. $I_{ab}$ and $E_{ab}$ represent the amount of imports and exports from economy $a$ to economy $b$ respectively. $I_{ba}$ and $E_{ba}$ represent the import and export amount of economy $b$ to economy $a$ respectively. $I_a$ and $E_a$ represent the total import and export of economy $a$ respectively. $I_b$ and $E_b$ represent the total import and export of economy $b$ respectively.

2.1.3. HM Index. Hubness Measurement index (HM) was first constructed by Baldwin (2003), and is an indicator to measure the degree of inter-economy trade dependence, reflecting the asymmetry of inter-economy trade dependence [4].

$$HM_{ab} = \frac{E_{ab}}{E_a} \times (1 - \frac{I_{ab}}{I_a}) \times 100\%$$

$HM_{ab}$ represents the dependence of economy $a$’s exports on economy $b$’s market. $E_{ab}$ represents the exports of economy $a$ to economy $b$. $E_a$ represents the total exports of economy $a$. $I_{ab}$ represents the imports of economy $a$ from economy $b$, and $I_a$ represents the total imports of economy $a$. The value of HM index is between 0 and 1, and the closer it is to 1, the stronger the dependence of economy $a$’s exports on economy $b$ is, and the closer it is to 0, the weaker the dependence of economy $a$’s exports on economy $b$ is.

2.1.4 Gravity Model. Tinbergen (1962) first used the gravity model to study the determinants of bilateral trade. He found that the flow of bilateral trade was in direct proportion to the two countries and inversely proportional to the distance, thus confirming the feasibility of studying bilateral trade with the gravity model [5]. After that, a large number of scholars used gravity model to study bilateral
trade issues under the framework of general equilibrium, and reached a conclusion consistent with empirical facts [6]. The basic form of trade gravity model is as follow.

\[
T_{ab} = \frac{A(GDP_a \times GDP_b)}{D_{ab}}
\]  

(3)

In the Equations (3), \(T_{ab}\) represents the total amount of trade between country \(a\) and country \(b\); \(A\) is a constant; \(GDP_a\) is the gross domestic product of country \(a\), \(GDP_b\) is the gross domestic product of country \(b\); \(D_{ab}\) is the distance between country \(a\) and country \(b\).

2.2. Research Data

From 2006 to 2017, trade volume between China and BSEC countries, within the BSEC, and trade volume by commodities are obtained from the International Trade Center Database and the UN Comtrade Database. GDP, population, per capital GDP and CPI of all countries come from the World Bank Database. The distance between countries of the black sea economic cooperation organization and China comes from CEPII Database.

3. Spatial – Temporal Evolution Characteristics of the China-BSEC Trade

3.1. China-BSEC Trade Profile

The total trade volume between China and BSEC reached US $130358.571 million in 2017, up nearly 2.3 times from US $56993.251 million in 2006, with an average annual growth rate of 10.03% (shown in figure 1). Among them, China’s import from the BSEC increased from 19232.291 million US dollars in 2006 to 52126.399 million US dollars in 2017, with an average annual growth rate of 11.03%. The import volume of BSEC from China increased from 37760.96 million US dollars in 2006 to 78232.172 US dollars in 2017, with an average annual growth rate of 9.94%. The overall trade volume of China and BSEC has shown an obvious upward trend, but in 2009, both the import value and the export value showed an obvious decline, mainly due to the global financial crisis in 2008 and the global economic recession. The total trade in 2015 also appeared back slightly, there are many reasons. The global economic recovery is slow, the appreciation of the RMB at the same time and the international crude oil prices fall. China import and export volume, the volume of trade with Japan, the European Union and other major trading partners have decreased.

![Figure 1](image)

**Figure 1.** 2006-2017 Trade Volume between China and the BSEC

3.2. The Spatial Distribution of China-BSEC Trade

By using ArcGIS software, the geographic coordinates of capitals of various countries are taken as nodes, and the weight of total bilateral trade is taken as the weight, without considering the flow direction of trade, the geographic spatial structure chart of China-BSEC trade network is constructed by selecting three time sections in 2006, 2011 and 2017 (shown in Figure 2).
From 2006 to 2017, the spatial distribution of trade among the member countries within the organization was uneven and did not change much. Most of the 12 member states have bilateral trade relations, and trade is high between countries like Russia, Turkey and Ukraine, but almost none between other countries like Armenia and Albania and Moldova. In 2006, the trade volume between Russia, Ukraine and Turkey was relatively large. However, due to the outbreak of Ukraine crisis in 2013, the trade volume between Russia and Ukraine dropped from 48951.911 million dollars in 2011 to 12876.605 million dollars in 2017. It can be seen that the trade within BSEC is affected by geopolitics and the social stability of countries.

The volume of trade between China and the BSEC is on the rise. The total trade volume between China and Russia has always been the highest, and the proportion of total trade volume has tended to stabilize. Meanwhile, China's trade volume with Turkey, Ukraine, Romania and other countries has significantly increased. In 2017, China’s trade with Russia, Turkey and Ukraine accounted for 87.1 percent of the trade with BSEC, while China's trade with Romania, Greece and Bulgaria increased year by year. Although China's trade volume with Azerbaijan, Moldova and Armenia is relatively low, the average annual growth rate with them is 12.48%, 16.00% and 28.06% respectively. The natural resource endowments of China and BSEC countries are quite different, and the trade between China and BSEC countries is highly complementary. Meanwhile, under the Belt and Road Initiative, the trade volume between China and other BSEC countries has increased and the spatial distribution of the region has been rationalized.

![Figure 2. Evolution of the Spatial Structure of Trade between China and the BSEC](image-url)
3.3. Analysis of Trade Dependence between China and BSEC

3.3.1. Composite Trade Share Index. Based on the comprehensive trade share index, the absolute trade dependence between China and the BSEC is analyzed and evaluated. Shown as Figure 5, from 2006 to 2017, the absolute trade dependence between China and BSEC increased year by year, from 8.72% in 2006 to 11.99% in 2017. As shown in the Figure 3, from 2006 to 2017, the annual average spatial distribution of trade dependence between China and the BSEC was significantly different. China’s combined share with Albania and Russia was the highest, followed by Ukraine, Georgia and Turkey. The smallest are the Republic of Moldova and Serbia. This shows that China is most dependent on trade with Albania and Russia, while least dependent on trade with Moldova and Serbia.

The average annual change rate of the comprehensive trade share of BSEC was mostly positive, shown as Figure 4, indicating that the trade dependence between BSEC and China was gradually increasing. Among them, China's annual growth rate with Romania and Bulgaria is negative, indicating that their trade dependence with China is decreasing. Armenia and Georgia, on the other hand, have seen rapid growth, averaging 21.00% and 18.88% respectively. Since 2009, China has become Armenia's second largest trading partner. Its main exports to Armenia are electric motors, electrical appliances and audio-visual equipment. Boilers, machinery and appliances and steel are growing fast. The main commodities imported by China from Armenia are mineral raw materials such as ore and slag. Trade volume between Georgia and China has grown rapidly. In 2014, China became Georgia's third largest trading partner and the fastest growing country with Georgia. On the whole, China's trade share with the BSEC countries has been growing at a relatively high annual rate, and there is huge potential for bilateral trade.

![Figure 3. Average of Share of Trade between China and BSEC during 2006-2017](image)

![Figure 4. Average Growth Rate of the Share of Trade between China and BSEC during 2006-2017](image)

3.3.2. Symmetry of Trade Dependence. The calculation of HM index between BSEC countries and China (Figure 5.) shows that the trade dependence asymmetry between BSEC countries and China is very obvious, and BSEC’s dependence on China is significantly higher than China's dependence on
these countries. After a slight decrease from 2006 to 2008, the dependence of the organization on trade with China increased year by year, especially after China put forward the Belt and Road Initiative in 2013. China's trade dependence on the organization hit its lowest point in 2015, but the overall trend remained stable.

From the perspective of spatial distribution (Figure 6), China's dependence on the countries of the BSEC is asymmetrical, and China's dependence on Russia and Turkey is significantly higher than that of other countries, 1.92% and 0.78% respectively, followed by Ukraine and Greece. However, on the whole, China's trade dependence on the countries of the BSEC is relatively low, while the dependence on China of the countries of the BSEC is much higher than that of China. Shown as Figure 8, HM index of Russia to China is at the highest of 6.74%, which indicates that the trade dependence of China and Russia on each other is relatively balanced. China-Russia bilateral trade mainly consists of China's exports of labour-intensive commodities such as light industrial products, while Russia's exports of resource-intensive commodities such as oil, timber and non-ferrous metals are mainly. However, the proportion of high-tech and high value-added commodities in the import and export of China and Russia is very low. Both countries are major economic and trading countries, and there is huge potential for bilateral economic and trade cooperation. Armenia and Albania depend on China for trade by more than 6%, while Ukraine depends on China by 4.25%. The dependence of the above three countries on China shows a strong asymmetry. Armenia is a landlocked European country, and Russia has always been its most important economic and trade partner. After the Belt and Road Initiative, the economic and trade cooperation between China and Armenia has developed rapidly. In 2010, China surpassed Germany to become Armenia's second largest trading partner, and in 2014, China became Armenia's second largest export market [7]. Meanwhile, the trade volume between China and Albania is growing rapidly, mainly exporting capital-intensive and labour-intensive products such as machinery, electronics and clothing to Albania, and importing resource products such as oil and coffee from Albania [8]. In 2017, Ukraine exported the most resource-based products to China, such as mineral products, animal and vegetable oils and fats, and mainly imported mechanical and electrical products, base metals, chemical products and plastics from China [9].

From 2006 to 2017, the trade dependence of the member states of BSEC on China showed a rapid growth trend (shown as Figure 9), among which Azerbaijan, Serbia, Georgia and Armenia showed an average annual growth rate of more than 50%, and Russia maintained the lowest rate of 6.72%. At the same time, China's annual growth rate of dependence on Georgia and Armenia is also high. Although the current HM value is low, it shows great potential under the high annual growth rate. However, China's negative average annual growth rate to many BSEC countries is mainly due to the low HM value of China's dependence on BSEC countries, so the numerical fluctuation has a greater impact on the average annual growth rate, which cannot fully explain the trend of China's trade dependence on these countries (Figure 7). Meanwhile, the average annual growth rate of China, Russia, Turkey and other countries is relatively stable, and the degree of trade dependence has risen steadily.

Figure 5. Share of Trade Index between China and BSEC during 2006-2017
Figure 6. Average of HM Index of China’s Export to BSEC

Figure 7. Annual Growth Rate of HM Index of China’s Export to BSEC

Figure 8. Average of HM Index of Export of BSEC to China
4. Factors Affecting Trade between China and BSEC

4.1. Model Specification and Variable Selection

Combined with the actual situation of trade between China and the BSEC, the traditional gravity model was modified and expanded. The heteroscedasticity and multicollinearity problems were eliminated by taking logarithm, and the model was obtained as follow.

\[
\ln t r a d e_{abt} = \beta_0 + \beta_1 \ln g d p_{abt} + \beta_2 \ln d i s_{ab} + \beta_3 \ln p o p_{abt} + \beta_4 \ln p g d p d_{abt}
\]

\[
+ \beta_5 \ln c p i_{abt} + \beta_6 \ln o p e n_{bt} + \beta_7 \ln l a n d_{b} + \epsilon_{abt}
\]

(4)

In the Equations(4), \( a \) is China, \( b \) is the BSEC countries, \( b = 1, 2, \ldots, 12 \); \( \beta_0 \) is a constant term, \( \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 \) and \( \beta_7 \) are regression coefficients, indicating the influence degree of each influencing factor on the explained variable; \( t r a d e_{abt} \) is the volume of trade between China and country \( b \) in BSEC in the year \( t \); \( g d p_{abt} \) is the product of GDP of China and country \( b \) in the year \( t \); \( d i s_{ab} \) is the geographical distance between China and country \( b \); \( p o p_{abt} \) is the product of the population of China and country \( b \) in the year \( t \); \( p g d p d_{abt} \) is the difference between the per capital GDP of China and country \( b \) in year \( t \). \( c p i_{abt} \) is the ratio of price index of China and country \( b \) in year \( t \); \( o p e n_{bt} \) is the degree of openness of country \( b \), the proportion of trade volume in GDP; \( l a n d_{b} \) is the landscape size of country \( b \); \( \epsilon_{abt} \) is the residual term. Specific variables are described in Table 1.
Table 1. Variable Declarations

| Variable     | Implication                  | Expected sign | Remark                              |
|--------------|------------------------------|---------------|-------------------------------------|
| $gdp_{abt}$  | Gross domestic product       | +             | Economic scale and production capacity |
| $dis_{ab}$   | Geographic distance          | -             | Trade barriers which increase the cost of trade |
| $pop_{abt}$  | Population                   | +             | The market demand                   |
| $pgdpd_{abt}$| Per capital GDP difference   | *             | Different demand                    |
| $cpi_{abt}$  | The ratio of price indices   | +             | Different demand                    |
| $land_b$     | Land area                    | +             | Economic scale and demand           |
| $open_b$     | Trade as a proportion of GDP | +             | Trade power                         |
| $trade_{abt}$| Volume of trade              |               |                                     |

4.2. Empirical Analysis

4.2.1. Model Test. Using the panel data of trade between China and BSEC during 2006-2017, data analysis and processing in Stata15. Usually, mixed regression, fixed effect and random corresponding methods are used to process panel data. The Hausman test showed that the $P$ value of the data was 0.0995, indicating that the null hypothesis could not be rejected at the level of 5%, that is, data consistent with random effects could not be excluded. In the test of mixed regression and random effect, $P$ value is 0, which means the null hypothesis is strongly rejected and random effect exists. In the test of whether there is time fixed effect, the $P$ value is 0.0573, so the null hypothesis cannot be rejected at the level of 5%, that is, there is no time fixed effect.

4.2.2. Regression Analysis of the Model. Mixed regression, random effect and fixed effect are used for regression respectively, and the empirical results can be analyzed by combining random effect and fixed effect through the test of the model. The fitting degree of the model to the trade influencing factors between China and BSEC is relatively high, and the result is basically consistent with the expectation.

Among them, the trade volume is positively correlated with the GDP of the economic scale of China and the BSEC, that is, the larger the economic scale and the stronger the production capacity of China and the BSEC, the larger the trade volume between the two countries is. The coefficient of fixed effect and random effect is close to 0.582. There is a strong negative correlation between geographical distance and trade volume between countries, with a coefficient of -2.435. The farther the distance is, the higher the transportation cost of goods will be, and the greater the trade resistance will be. The population is positively correlated with the trade volume, with a coefficient of 0.866, that is, the trade demand of countries with larger population increases. The difference of per capital GDP and the ratio of consumer price index are positively correlated with the trade volume, with coefficients of 0.0923 and 0.618 respectively, which means that the greater the difference in consumer demand between the two countries, the easier trade is likely to occur (most of China and BSEC are inter-industry trade). Openness is positively correlated with trade volume, coefficient 0.497, that is, the higher the openness, and the greater the trade volume between the two sides. The results show that the land area is not significant, mainly because the land area and population number, GDP and other factors may have a correlation.
Table 2. Regression Results

|        | (1)  | (2)  | (3)  | (4)  |
|--------|------|------|------|------|
|        | OLS  | MLE  | RE   | FE   |
| gdp    | 0.813*** | 0.566*** | 0.582*** | 0.507*** |
|        | (0.0602) | (0.0409) | (0.0384) | (0.0435) |
| dis    | -1.787** | -2.506** | -2.435** | .    |
|        | (0.610) | (1.188) | (1.016) | .    |
| pop    | 0.567*** | 0.904*** | 0.866*** | 1.759*** |
|        | (0.0936) | (0.164) | (0.139) | (0.598) |
| pgdgd  | 0.0877 | 0.0912*** | 0.0923*** | 0.0850*** |
|        | (0.0635) | (0.0233) | (0.0244) | (0.0238) |
| cpi    | 1.333*** | 0.579*** | 0.618*** | 0.513*** |
|        | (0.373) | (0.157) | (0.159) | (0.159) |
| open   | 0.626*  | 0.506*** | 0.497*** | 0.537*** |
|        | (0.281) | (0.137) | (0.140) | (0.147) |
| land   | -0.0690* | -0.152  | -0.140  | .    |
|        | (0.0357) | (0.104) | (0.0883) | .    |
| _cons  | -35.16*** | -26.99** | -27.24*** | 79.91*** |
|        | (6.435) | (11.33) | (9.728) | (21.45) |
| N      | 132   | 132   | 132   | 132   |
| R-sq   | 0.969 | 0.740 | .    | .    |

Standard errors in parentheses * p<0.1, ** p<0.05, *** p<0.01

5. Conclusions

Through a comprehensive review of the development status, temporal-spatial evolution characteristics and influencing factors of China-BSEC trade from 2006 to 2017, the conclusion can be drawn.

① There are obvious differences in the spatial distribution of trade within the organization. The trade volume of Russia, Turkey and Ukraine is relatively large, but it is affected by geopolitical and social stability.

② China’s trade with countries of the BSEC has been increasing year by year, with obvious spatial differences. China’s trade with Russia, Ukraine and Turkey accounts for 87.1 percent of the total, but trade with other countries is growing fast. The natural resource endowments of China and BSEC countries are quite different, and the trade between China and BSEC countries is highly complementary.

③ There are significant differences in the spatial distribution of China’s trade dependence with the BSEC. China’s trade dependence with Albania and Russia is the strongest, while its trade dependence with Moldova and Serbia is the weakest. China’s dependence on BSEC countries is asymmetrical, and China and Russia have more balanced dependence on each other than China.

④ GDP, geographical distance, consumer price index, degree of openness and absolute difference of GDP per capital between China and BSEC are the main factors which affecting their trade. The geographical distance represents the negative correlation between trade resistance and trade volume, while other factors are positively correlated.
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