The Impact of Export Sophistication on Bilateral Trade Flow: a Gravity Model

Xiankun Li[1,a,*]

[1]Department of Economics, Shanghai University, Shanghai, China

[a] xiankun_95@163.com

[*]corresponding author

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Abstract: Based on the extended gravity model, this paper analyses the influence of export sophistication on bilateral trade. On the basis of the export sophistication measurement method proposed by Hausmann et al. (2007), this paper calculates the export sophistication of China and 56 trading partner countries in 2000-2017, and then uses cross-border panel data to empirically test the impact of export sophistication on bilateral trade. The results show that the increase of export sophistication has a positive impact on bilateral trade flows. The empirical results of this paper also confirm the previous scholars' conclusion that the trade scale between the two countries is directly proportional to their economic scale, and inversely proportional to their distance. Population and real exchange rate have uncertain impact on trade; the increase of trade freedom will expand the scale of bilateral trade; regional economic organizations and preferential trade agreements will promote bilateral trade. Finally, based on the empirical results, this paper puts forward some policy suggestions for China and other countries, especially for developing countries, to enhance the complexity of their exports, expand bilateral trade and open up international markets.

1. Introduction

Export is one of the important engines of economic growth. Since the 1950s, Japan, the "four Asian Tigers" and China have made great achievements in economic development through export-oriented strategy. In view of the role of export in promoting the economy, scholars have constructed a series of indicators, such as RCA and TC, to further study export competitiveness. In fact, these indexes only reflect the quantity of exports, while export competitiveness depends not only on the quantity of exports, but also on the product composition of exports, that is, the quality and technical structure of exports. With the technical content and added value of products playing an increasingly important role in international trade competition, the export sophistication can more reasonably reflect a country's position in the international division of labor compared with the traditional export competitiveness index.

On the research of export sophistication, Michaely (1984) first proposed the trade specialization indicator (TSI). Michaely assumes that the technological content of a country's exports is related to the country's per capita income level. Therefore, the TSI of an export is a weighted average of the per capita income of all export countries, with the export volume of this product of each country accounting for the total export volume of this product of the world as the weight. Hausmann et al. (2007) improved the weight of TSI to relative proportion, and put forward an index that can be used to measure the level of export technology of industries or exporting countries: export sophistication [1]. Rodrik (2006) used the export sophistication measurement method proposed by Hausmann and other scholars to measure the export sophistication of China and OECD countries, and found that the export sophistication of China has steadily increased, and the gap between China and developed countries has been narrowing [2]. Schoot (2008) also reached the same conclusion [3]. Jarreau and Poncet (2012), Poncet and Waldemar (2013) empirically studied the impact of export sophistication on economic growth based on provincial and municipal data in China, and found that export sophistication has a positive effect on economic growth [4,5].

Regarding the research of bilateral trade based on the gravity model, Tinbergen (1962) first introduced the law of gravitation in physics into the research of economic field. He compared the bilateral trade flow between the two countries to the gravitation between two objects, and concluded that the bilateral trade volume of the two countries is positively related to the economic scale of the two countries, and negatively related to the geographical distance of the two countries. Subsequently, scholars at home and abroad have carried out a series of optimization on the gravity model, introducing new variables, such as population (Bergstrand 1985; Oguledo and Macphee 1994; Martinez and Nowak 2003), exchange rate effects (Klein and Shambaugh 2006; Gil Pareja et al. 2007), institutional factors(Kucera and Sarna 2006; Rose 2007) and membership of some economic organizations, such as APEC (Rose 2004; Subramanian and Wei 2007), and the effects of preferential trade agreements (Ghosh and Yamarik 2004; Jordaan and Kanda 2011). [6-16]

In short, scholars have done a lot of empirical research on export sophistication and bilateral trade. Among them, the research on export sophistication mainly focuses on the measurement, influencing factors and the impact on economic growth of export sophistication. Few scholars combine export sophistication with gravity model to study its impact on China's bilateral trade. Therefore, this study assumes that a country's export sophistication will also promote the development of bilateral trade. The purpose and importance of this study is to test whether the increase of export sophistication will promote trade growth through panel data and extended gravity model. This paper studies the role of two factors in the gravity model: one is the export sophistication of China, the other is the export sophistication of trading partners.

2. Model and Data

2.1. Model

The theoretical framework of this paper is based on the gravity model. Based on the existing research, considering the economic scale, population, geographical distance, real effective exchange rate, trade freedom and other factors of exporter and importer, this paper constructs the basic regression model as follows:

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln D_{ij} + \beta_4 \ln P_{it} + \beta_5 \ln P_{jt} + \beta_6 \ln EXPY_{it} + \beta_7 \ln EXPY_{jt} + \beta_8 \ln REER_t + \beta_9 \ln TFR_t + \gamma_1 APEC + \gamma_2 PTA_t + \epsilon_{ijt} \quad (1)$$

Among them, the subscript i represents China, j represents China's trading partner country, and t represents the year. X_{ijt} represents the total trade volume of China and country j in t period; Y_{it} and Y_{jt} represent the GDP of China and country j respectively; D_{ij} represents the geographical distance between China and country j; P_{it} and P_{jt} represent the population of China and country j respectively; $EXPY_{it}$ and $EXPY_{jt}$ represent the export sophistication of China and country j; $REER_t$ represents the real effective exchange rate index of country j in t period; TFR_t represents the freedom of trade for country j in t period. APEC and PTA are two virtual variables. If country j is a member of APEC, APEC is 1, otherwise it is 0; if country j has a regional trade agreement with China, PTA is 1, otherwise it is 0.

2.2. Measurement and Descriptive Analysis of Export Sophistication

Based on the export sophistication measurement method proposed by Hausmann et al. (2007), this paper first measures the export sophistication of 98 chapters of goods with 2-digit HS code. The specific methods are as follows:

$$PRODY_j = \sum_i \frac{x_{ij}/X_i}{\sum_i x_{ij}/X_i} Y_i \quad (2)$$

Where, $PRODY_j$ is the export sophistication of product j, x_{ij} is the exports of product j of country i, X_i is the total exports of country i; Y_i is the per capita national income of country i, and its value is the constant price USD in 2010.

The second step is to bring the export sophistication of each product calculated by formula (2) into formula (3), and calculate the export sophistication of each country:

$$EXPY_i = \sum_j \frac{x_{ij}}{X_i} PRODY_j \quad (3)$$

In the above formula, $EXPY_i$ is the export sophistication of country i, x_{ij} is the exports of product j of country i, X_i is the total exports of country i, and $PRODY_j$ is the export sophistication of product j calculated by formula (2).

Because of the integrity of the data, 56 countries are selected as the research samples which include Australia, Austria, Belgium, Belize, Bolivia, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus, Côte d'Ivoire, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Macedonia, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Norway, Paraguay, Philippines, Poland, Portugal, Romania, Russia, Singapore, Slovakia, South Africa, South Korea, Spain, Sweden, Switzerland, Togo, Tunisia, Uganda, Ukraine, United Kingdom, United States, Uruguay, Zambia. The product and total export data of each country are from the UN COMTRADE database; the per capita GDP data is from the World Development Indicator Database of the World Bank.

In order to visually observe the trend of China's export sophistication and compare it with developed and developing countries, this paper draws the average export sophistication of China, the United States, Germany and the average of developing countries from 2000 to 2017 into a line chart, as shown in Figure 1.

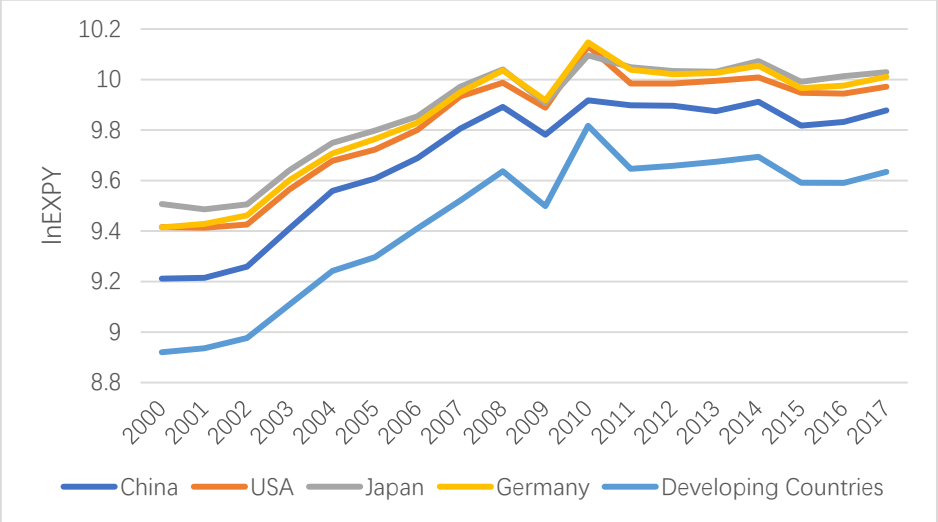

Figure 1 Export sophistication changes in 2000-2017.

As can be seen from Figure 1, the export sophistication of China and other countries is generally on the rise. China's export sophistication ratio rose from 9.21 in 2000 to 9.88 in 2017, up 7.2%, which is close to the level of developed countries. However, it is undeniable that there is still a certain gap between China's export sophistication and that of developed countries. In addition, compared with the average level of developing countries, China's export sophistication has certain advantages. On the whole, China's export sophistication still has some room to improve.

2.3. Data Source and Description

This paper uses panel data from 56 countries in 2000-2017 to examine the impact of export sophistication on China's bilateral trade flows. The variables involved in the model include bilateral trade flows (X), economic scale GDP (Y), geographic distance (D), population (P), export sophistication (EXPY), real effective exchange rate index (REER), trade freedom (TFR) and virtual variables (APEC, PTA). Among them, bilateral export data comes from the UN COMTRADE database; GDP (2010 constant price USD), population and real effective exchange rate index data come from the world development indicator database of the world bank; geographic distance comes

from the GeoDist database of CEPII; trade freedom data is from the Heritage Foundation of the United States (www.heritage.org).

3. Empirical Results and Analysis

In this paper, we use static panel data for regression analysis. According to the results of Hausmann test, we should use the fixed effects (FE) model. But as a robustness test, we show the random effects (RE) model and Poisson pseudo maximum likelihood (PPML) results at the same time. The fixed effect model adopts two-way fixed location and time. The regression results of time effect will not be shown in this paper, and the results are shown in Table 1.

Table 1 The estimation results of the gravity model.

Variables	Explained variable: ln exports		
	Fixed Effects (FE)	Random Effects (RE)	Poisson Pseudo Maximum Likelihood (PPML)
LnYi	3.039***	1.000**	0.0257
	(-0.499)	(-0.404)	(-0.105)
LnYj	2.015***	1.107***	0.0860***
	(-0.415)	(-0.172)	(-0.00453)
LnPi	-63.68***	-6.293	0.663
	(-8.561)	(-6.177)	(-1.703)
LnPj	-0.928	-0.159	0.0287***
	(-0.713)	(-0.208)	(-0.00501)
LnD		-0.2	-0.0200***
		(-0.173)	(-0.00621)
LnEXPYi	4.611***	1.765***	0.144***
	(-0.859)	(-0.249)	(-0.0401)
LnEXPYj	0.122	0.00836	0.142***
	(-0.334)	(-0.249)	(-0.0241)
LnREER	0.539**	0.840***	-0.0337
	(-0.253)	(-0.26)	(-0.0279)
LnTFR	0.0531	0.171	0.0392
	(-0.226)	(-0.234)	(-0.0313)
APEC		0.602*	0.0548***
		(-0.313)	(-0.00873)
PTA		0.452	0.0865***
		(-0.342)	(-0.0108)
Constant	349.2***	3.621	-6.947
	(-51.25)	(-38.64)	(-10.83)
Pseudo log-likelihood			-2025.3858
Wald chi2		1940.05***	
Adj. R2	0.915		
AIC	339.9		4074.8
N	1008	1008	1008

The regression results in Table 1 show that the GDP of China and its trading partner countries is significantly positively correlated with the bilateral trade flow, which is reflected in the increase of 1% in GDP in China, 3.309% in trade flow, 1% in trade partner countries and 2.015% in trade flow. As we can see from the RE and PPML regression results, GDP and trade flow are also positively correlated, and most of the results are significant. This shows that the larger the economic scale of the two countries, the larger the scale of trade between the two countries.

For the distance between the two countries, it is omitted in FE model, but observing the regression results of RE and PPML, we can find that the distance between the two countries is negatively related to bilateral trade. RE estimation is not significant, while PPML is significant. This is consistent with our expected results, but according to Marimoutou et al. (2010), the larger the economic scales of two trading countries are, the smaller the impact of the distance between the two countries on their trade flows is [17]. With the development of transportation technology and e-commerce, the influence of distance on the trade between the two countries is no longer as important as conventionally assumed.

With regard to the impact of population size on trade flows, the coefficients of China and trading partner countries are negative in both FE and RE estimates, and are not significant except for the coefficient of Chinese population. There are two explanations for the negative coefficient of population size in academic circles. One is that when the economic scale in a country is given, the level of per capita income depends on population. The more the population is, the lower the per capita income will be, so the diversity of individual consumption demand will be reduced, which thus reduce the demand for foreign products. The other is that the more population the country has, the larger the national scale it has, and the more abundant the industry the country will have. As a result, the country’s economic system will be more independent and the level of domestic supply and demand will be higher, for which the tendency of trade will be lower.

From the results, we can see that the impact of export sophistication of China and trading partner countries on bilateral trade is positive in FE, RE and PPML models. In the FE and RE models, only the coefficient of export sophistication of China is significant, while in the PPML model, both are significant. Specifically, in the fixed effects estimation results, when the export sophistication of China increases by 1%, the trade flow will increase by 4.661%; when the export sophistication of trade partners increases by 1%, the trade flow will increase by 0.122%. It can be seen that the domestic export sophistication plays a greater role in promoting trade flows than that of partner countries.

Next, we can see from the estimation results of FE and RE estimation results that the real effective exchange rate index has a significant positive impact on trade flows. But from the result of PPML, the coefficient of real effective exchange rate index is negative and not significant. This is consistent with most scholars' conclusions. There is no long-term stable relationship between real effective exchange rate and trade flow. In addition, this paper also analyzes the impact of two virtual variables on trade: the APEC and the PTA. They represent whether they are APEC member countries, and whether they have trade agreements with their own countries respectively. According to the results in Table 1, the coefficients of APEC and PTA are both positive, and are very significant in PPML. It can be seen that regional economic organizations and trade agreements can obviously promote the development of bilateral trade.

4. Conclusion

Based on the cross-border panel data of China and 56 countries from 2000 to 2017, this paper empirically analyses the impact of export sophistication of China and its trading partners on bilateral trade. The empirical results show that the export sophistication of China and its trading partners can promote the bilateral trade flows, and the role of China is more obvious. The empirical results of this paper also confirm the previous scholars' conclusion that the trade scale between the two countries is directly proportional to their economic scale, and inversely proportional to their distance. In the econometric model of this paper, population is also taken into account, but the

results show that the coefficient is negative. The reason is given above. In addition, this paper also explores the effects of real effective exchange rate index, trade freedom, regional economic groups and trade agreements on trade flows. The results show that: the impact of real effective exchange rate index on bilateral trade is uncertain; the increase of trade freedom will expand the scale of bilateral trade, but the results are not significant; regional economic organizations and preferential trade agreements will promote bilateral trade.

Under the trend of economic globalization and regional economic integration, the positive promotion of China's omni-directional diplomatic strategy and the proposal of "one belt and one road" initiative provide an opportunity for economic integration, development and prosperity of China and relevant countries. Combined with the above empirical analysis, this paper provides some policy suggestions on how to expand bilateral trade and further develop international market for China and other countries. First of all, from the perspective of key variables, the improvement of export sophistication of the two countries can promote the development of bilateral trade, so in order to promote the development of their own economy, China and trade partners should pay attention to the improvement of the complexity of export products. Among China's major trading partners, there are not only developed countries with advanced technology, such as the United States, Germany, Japan, etc., but also developing countries with relatively backward technology, such as some ASEAN countries. Due to the differences of market openness, infrastructure construction and system, these countries are in the high-end or low-end positions of the global value chain. To improve the technical structure of export products, each country needs to pay attention to the cultivation of high-quality talents and independent R&D capabilities, and improves their human capital and technical level. In addition, each country should optimize their trade structure and increase the proportion of high-tech intensive products in their exports. To optimize and adjust the trade structure, on the one hand, they need to maintain the advantages of low technology intensive products; on the other hand, they need to encourage and support the R&D and production of high and medium technology intensive products. For China and some developing countries, improving infrastructure, optimizing the environment for foreign investment, and actively undertaking the outsourcing of high-tech intensive products in developed countries will play a positive role in absorbing foreign advanced technology and improving the level of domestic production technology.

Secondly, as for other explanatory variables, economic scale, regional economic organizations, trade agreements and institutional factors all play a role in promoting bilateral trade scale. As far as the economic scale is concerned, the larger the economic scale of the country and its trade partner countries are, the larger the trade scale between the two countries is. Therefore, on the one hand, each country needs to strengthen its own economy, and on the other hand, it can choose the country with larger economic scale as its trade partner. The results of this study also show that the selective accession to some regional economic organizations and the signing of trade agreements are not only conducive to the decentralization of domestic exports and the expansion of export markets, but also let each country enjoy preferential trade arrangements and make full use of market resources, which will promote bilateral or multilateral economic as well as trade cooperation. In addition, from the institutional factor, China and its trading partners should improve their own economic and trade systems, remove institutional barriers to economic development and foreign trade to better attract foreign direct investment, improve industrial level and promote trade facilitation.

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