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Measuring aggregate trade costs and its empirical effects on manufacturing export composition in China

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Abstract

Background: This paper measures the aggregate trade costs from 2000 to 2013, and dicusses the impact of China's aggregate trade costs on comparative advantages and export share of 17 two-digit ISIC manufacturing industries.

Methods: This paper takes China's vertical specialization reality into account and establishes the panel data model which relates the aggregate trade costs with the export shares.

Results: We find that China's aggregate trade costs are declining, but it is still 1/3 higher than that of developed countries of 10 years ago; bilateral trade costs between China and some countries even risen instead; aggregate trade costs are the determinants, not only of "global" and "local" comparative advantages, but also of export share of China's manufacturing products, and its effect is stronger in industries with higher trade cost intensity.

Conclusions: We should consider the product composition on trade cost intensity and domestic value-added reseller (DVAR), and reduce trade costs in order to promote the export of products with higher domestic value-added rate, and to realize the substantial transformation of foreign trade growth mode.

Keywords: Aggregate trade costs, Manufacturing export composition, Trade cost intensity, Domestic value added

Background

Trade structure is an eternal topic in the theory of international trade. In 2013, China's trade volume ranked first in the world. But the trade structure is still not perfect with the high proportion of processing trade that reflects the vertical division as the outstanding characteristic. The proportion of processing trade in the total trade volume in 2012 and 2013 was 34.8 and 32.6%, respectively, and the added value of export goods is not high (Li 2014). To promote the export, especially the goods of higher added value, is the essential requirement of our country to accelerate the transformation of trade development model. Reducing trade costs is not only the important means to achieve the goal, but also to interconnect between countries in the strategy of the "Belt and Road" proposed recently.

The trade cost is the sum of all costs incurred from the beginning of production to the final consumption except the production cost (Anderson and Wincoop 2004). As the new trade theory that is ignored by the traditional trade theory, as well as the key concepts in heterogeneous firm trade theory and new economic geography, the issues of trade cost attract the academic study (Obstfeld and Rogoff 2000; Hummels 2007; Ullah and Kaliappa 2011; Jacks, Meissner and Novy 2008 and 2011; Novy 2013). These studies mainly focus on the measurement of countries' bilateral trade costs or its effect on trade volume. For example, Jacks (2011) used the trade data of 130 "country pairs" in the area of Asia, Europe and the USA from 1870 to 2000 and measured the bilateral trade costs, and illustrates that the trade costs constitutes the basis of prosperity and decline of international trade amount throughout this period. Ullah and Kaliappa (2011) used the trade data of Pakistan from 1999 to 2004 as well as the stochastic frontier law to show that the "implicit" and "explicit" trade cost of the outside border promote the export of Pakistan. Xu (2011; 2012), respectively, measured China's trade costs of manufacturing industry with 14 trade partners from 1997 to 2007, and that of agricultural industry with the USA, Japan, Europe, and ASEAN from 1996 to 2009, and their effect on trade development. Jia and Qin (2013) measured the trade cost of China's grain from 1996 to 2009, and its effect on trade growth. In addition, the relative literature also includes Fang (2010) and Xu and Liang (2010).

However, the research on the effect of trade cost with the complete meaning on the trade structure is less. Anderson and Wincoop decomposed the trade costs with the complete meaning into the transportation costs, tariffs and the policy barriers costs, information cost, contract execution cost, legal cost, regulatory cost, and local distribution cost in the export market caused by the non-tariff barriers. The retrieval found that only Greenaway, McGowan, and Milner (2009), Milner and McGowan (2013) explore the effect of trade costs with the complete meaning on trade structure. Most literature analyzed one component of trade costs to explore its impact on the comparative advantage. For example, Levchenko (2007), Huang (2013), Dai and Jin (2014) analyzed the system quality, one of the components of trade costs, and Nunn (2007) analyzed the implementation ability of contract.

It is obvious that the current literature mainly studies the measurement of trade costs and its effect on trade growth from the complete sense. But the literature that studies the measurement of trade costs and its effect on comparative advantage of trade cost and export structure from the complete sense is rare. There is no literature that studies the effect of Chinese aggregate trade costs on export structure. Then, as the largest developing country in the world and the largest trading nation, China's current literature merely studies the measurement of bilateral trade cost and its effect on the trade flow, which is not enough. Does the trade cost systematic affect the comparative advantage and trade structure? What is the particularity? The main contribution of the paper is. (1) based on the measurement of bilateral trade cost between China and 86 trading partners from 2000 to 2013, this paper measures the cost of Chinese aggregate trade cost. (2) The number of research objects is far greater than that in the domestic research. The large sample includes different types of countries as well as different regions, especially the countries along the "Belt and Road", which can not only make a comparison between the global comparative advantage and local comparative advantage, but also provide a reference for the trade development of countries that along the "Belt and Road". In addition, research with the large sample is also in line with the direction of mainstream literature. For example, the sample in the research of Milner and McGowan (2013) includes the trade data between 37 industrialized and transition countries with 213 countries. The sample in the research of Jacks (2011) includes the trade data of 130 "country pairs". (3) Based on the reality of higher proportion of Chinese processing trade, this paper empirically studies the effect of aggregate trade costs (rather than a component of trade costs) on export structure of 17 subsectors of Chinese manufacturing industry.

The theoretical basis of the effect of trade costs on export structure: an extension of Ricardo model[1]

The simple model of Ricardian assumed that there are two countries in the closed state of the economy producing two products respectively. The unit labor input of these two products produced in each country is different. a_{cg} represents the unit labor input of the product g in the country c (c = 1,2; g = 1,2). If the country 1 only produces and exports 1, then the following inequation was established:

$$a_{11}/a_{12} < a_{21}/a_{22} \quad (1)$$

The above inequation is the most original mathematical expression of the comparative advantage, which shows that the production 1 in the state 1 has a comparative advantage.

For the extension of the Ricardian model without the trade costs: in the situation that there is no trade cost, if the production g_1 in country c has the global comparative advantage to the other production g_2, and the production g_1 is exported to the other country o, then the following inequation would be established:

$$a_{cg1}/a_{cg2} < a_{og1}/a_{og2} \quad (2)$$

For the extension of the Ricardian model without the trade costs: in the situation that there is trade cost, if the production g_1 in the market of country c' produced by country c has the global comparative advantage to the production g_1 that produced in country o, then the following inequation is established:

$$\left(a_{cg1} + t_{cg1c'}\right)/\left(a_{cg2} + t_{cg2c'}\right) < \left(a_{og1} + t_{og1c'}\right)/\left(a_{og2} + t_{og2c'}\right) \quad (3)$$

In the above inequation, $t_{cgc'}$, $t_{ogc'}$ represents the trade cost if the production g produced in country c and country o exports to the country c' respectively. The trade cost is measured by the unit labor input, $g = g_1$, g_2. In can be seen that whether the production export or not determined by its comparative advantage, which means it is not only determined by production cost, but also by the trade cost. If the comparative trade cost is high enough, even the production cost is relatively low, then there would be no comparative advantage in some countries even all countries. In reality, there are lots of productions, such as cement, sand, etc., it is due to the high transport costs or trade costs that contributes to the nontrade goods.

Results and discussion

Measurement of aggregate trade cost and its analysis

Compared with the literature of specific trade cost's effect on trade, the literature about the trade costs in a whole sense of the country is little, especially the measurement methods. Limao and Venable (1999) are the earliest scholars that studied in this field. In order to quantify the international transportation cost, they measured the transportation cost of a standard container from the port of Baltimore to another foreign port and found there is a nonlinear relationship between transportation cost and distance, which indicates the significance of costs that are difficult to measure such as system, infrastructure. Based on the data from various sources, Anderson and Wincoop (2004) construct a measurement system of price trade cost with the combination method of direct and indirect metrics. With the value of CIF/FOB, Pomfret and Sourdin (2010) only calculated trade cost of five countries due to the limited data, and the trade cost from a whole sense would not be measured. Other scholars have used a more practical gravity model to measure. For example, Hiscox and Kaster (2008) set a simple gravity model with the GDP of import and export country, distance from one country to another and bilateral pair as the variable to analyze the trade policy barriers, and get the estimation of trade costs.

Novy (2013) constructed a mean value from a microeconomic foundation to solve the difficulties of direct gravity model in measuring the specific trade cost (distance, national boundaries, language, etc.) and the multilateral measuring resistance, which proves that the bilateral trade cost can be calculated by the relative amount of domestic trade and international trade, and the effect of multilateral resistance on trade cost is still controlled. No matter from the model of Eaton and Kortum (2002) based on the Ricardian comparative advantage theory or from the model of Chaney (2008) and Melitz, Ottaviano (2008) based on heterogeneous firms trade theory, Novy (2013) suggested all the derivation process could be established. Milner and McGowan (2013) used the method of Novy (2013) to measure the trade cost, and this paper also uses the model to estimate the bilateral trade cost between China and 86 trading partners. The formula is as follows:

$$\tau_{ij} = \left(x_{ii}x_{jj}/x_{ij}x_{ji}\right)^{1/2(\sigma-1)}-1 \tag{4}$$

Among them, τ_{ij} represents the bilateral trade cost between China and trade partners; x_{ii} is China's domestic trade. China's domestic trade = Chinese GDP-Chinese domestic total export (Wei 1996); x_{jj} is the domestic trade of trade partners. Domestic trade of trade partners = GDP of trade partners—total export of trade partners. The data of GDP is from World Bank; the data of total export data is from OECD database. x_{ij} and x_{ji} represent the mutual export volume between China and trade partners, and the data is from OECD database. Anderson and Wincoop (2004) concluded that the value of substitution elasticity is generally between 5 and 10. In this paper, the value of substitution elasticity σ is 8.

The trading partners selected in this paper are derived from OECD database. In order to guarantee the availability of data that includes the export data of sub industry between China and trade partners, the total export data of all countries or regions, bilateral export data and GDP, we collect relevant data of all countries or regions in the OECD database and search the available countries. Finally, 86 countries or regions are selected as Chinese trade partners: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, South Korea, Mexico, Luxemburg, Holland, New Zealand, Norway, Poland, Portugal, Republic of Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, UK, USA, Brazil, India, Indonesia, Russia, South Africa, Algeria, Benin Republic, Botswana, Egypt, Ethiopia, Ivory Coast, Madagascar, Mauritius, Morocco, Mozambique, Senegal, Tanzania, Tunisia, Uganda, Zambia Ethiopia, Argentina, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Jamaica, Nicaragua, Paraguay, Peru, Uruguay, Venezuela, Cyprus, Hong Kong, Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Malaysia, Oman, Philippines, Saudi Arabia, Singapore, Sri Lanka, Thailand, Vietnam, Bulgaria, Croatia, Latvia, Lithuania, Malta, Romania, and Ukraine.

Among them, the value of domestic trade in China, Hong Kong, and Singapore or the regional trade in the two counties is negative, which is due to their entrepot trade in export accounted for a relative large proportion, and influences the calculation of normal calculation of domestic sales. Therefore, in the data processing, the negative value is excluded from the total export, namely that the actual domestic trade = GDP − total export + re-export (the actual export in Hong Kong = total export—re-export). Among them, the data of re-export in China, Hong Kong is from the database of UN comtrade. Although the entrepot trade data in Singapore cannot be obtained directly, the data from 2002 to 2005 is from East Asian economic Blue Book (2000-2005) (the unit is billion Singapore dollar). The data from 2007 to 2010 is from East Asian economic Blue Book (2007-2010) (the unit is billion Singapore dollar). The entrepot trade data from 2011 to 2013 is from the Statistics Singapore - International Enterprise Singapore (unit is million dollar). We acquire the entrepot trade data of Singapore from 2002 to 2013 through the unit conversion of exchange rate between dollar and Singapore through World Bank, and complete the entrepot trade data of 2000, 2001, and 2006 through the interpolation method. Finally, the domestic trade data is obtained through the same calculation method. According to the model 4, the bilateral trade cost between China and 86 trade partners from 2000 to 2013 is calculated.

In order to calculate the aggregate trade cost of China, the weighted average method is calculated, which needs the weight of each trading partner and seeks out the aggregate cost in China. The formula of calculating the weight of China in the year t is as follows which draws lessons from Milner and McGowan (2013):

$$\omega_{jt} = T_{jt}^F / \sum\nolimits_{j=1}^{N} T_{jt}^F \tag{5}$$

Among them, T_{jt}^F represents the export of China to trade partner j in the situation without the frictionless (the bilateral trade cost is zero), and $T_{jt}^F = \sigma \tau_{jt} T_{jt}$. τ_{it} represents the bilateral trade cost between China and trade partner j in the year t. T_{it} represents the actual total export of China to trade partner j. According to the formula (5), the weight of bilateral trade cost between China and 86 trade partners could be calculated. The results of Chinese aggregate trade cost from 2000 to 2013 are shown in Table 1, and the corresponding figure is shown as follows.[2]

Overall, Chinese trade cost shows a downward trend with 108.4% in 2000 declining to 0.9089 in 2013, which falls by 16.2%. This is mainly due to China's joining WTO in 2001, and China's economic rapidly integrated into the global with the reduction of

Table 1 Chinese aggregate trade cost from 2000 to 2013

Year	2000	2001	2002	2003	2004	2005	2006
Trade cost	1.084	1.070	1.036	0.981	0.943	0.916	0.912
Year	2007	2008	2009	2010	2011	2012	2013
Trade cost	0.914	0.935	0.973	0.925	0.911	0.920	0.909

non tariff and tariff, as well as the declining access barriers. During this period, the trade cost reached 0.973, which ranks fourth. This is due to the declining economic since the global financial crisis, which contributes to the deterioration of external situation. For example, the year of 2009 has the highest number of Chinese trade friction cases and highest amount. During 2009 and 2013, Chinese foreign trade gradually gets rid of the impact of financial crisis, and shows a declining trend of aggregate trade cost. In 2004, the average aggregate trade cost is only 0.66 in these 37 industrialized countries and the countries that are in transition (Milner and McGowan 2013). It can be seen that although the Chinese aggregate trade cost shows a downward, Chinese aggregate trade cost is still 30% high than that of industrial and transition countries 10 years ago. China's reducing the aggregate trade cost has a long way to go.

Figure 1 reflects the situation of Chinese aggregate trade cost while not reflect the structural changes of bilateral trade cost between China and trade partners. This analysis of structure is conductive to the reduction of bilateral cost with specific trade partner, and then reduces the aggregate trade cost. The calculation results show that from 2000 to 2013, the declining degree of bilateral trade cost between China and Zambia, Botswana is largest with 243.0 and 243.7%, respectively. Botswana and Zambia are landlocked African countries. China and Africa give full play to the complementary between resources and economic structure, and constantly strengthen economic and trade cooperation and strive to achieve mutual benefit and win-win. Especially after the establishment of FOCAC in 2000, the economic and trade cooperation was further actively strengthened. Trade, investment, and infrastructure construction are comprehensively promoted, and finance, tourism, and other areas' cooperation are gradually expanded, which forms a pattern with multi-level and wide area, and is conductive to the declining of bilateral trade cost between China and Africa. The other extreme is that the trade cost between China and Austria shows a rising trend with 386.2% in 2000 increasing to 414.2% in 2013, which has 28 percentage points in total. This is due to difficult relationship of Sino Austrian during the period,[3] which shows various forms of tariff of non-tariff barriers.

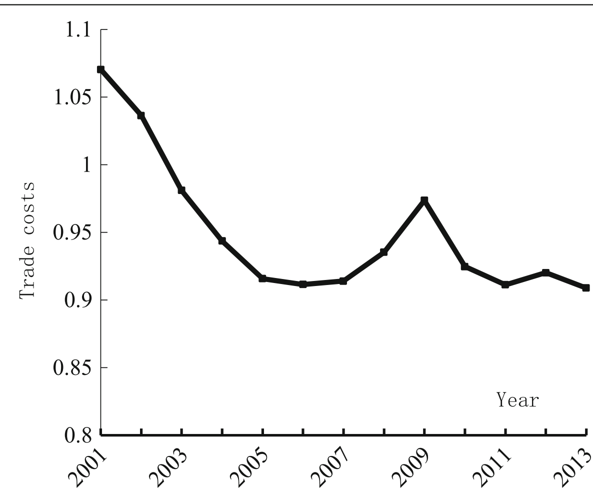

Fig. 1 The changing trend of aggregate trade costs of China

Figure 2 lists the changing trend of aggregate trade costs. It can be seen that the aggregate trade cost between China and developed countries is obviously lower than that between China and developing countries, and also has a different gap with 29 countries[4] along the "Belt and Road". [5]This reflects the relative prefect of legal environment, system and infrastructure construction in the developed counties or regions, and the less tariff and non-tariff barriers. The counties along the "Belt and Road" show the worst performance in these areas, which show that it is imminent to achieve the interoperability in the strategy of the "Belt and Road". Table 2 lists the average bilateral trade cost between China and 86 trade partners during the 14 years. In the trade partners with low bilateral trade cost, they are either China's neighboring countries or these major developed economies. It can be seen that Hong Kong and Singapore rank reciprocal one or two, respectively. Those trade partners with higher trade cost are those developing countries that are far away from China while the trade partner with the highest trade cost is the developed country Austria. The reason is as before. It needs to be pointed out that Costa Rica (1.65), Peru (1.24), and New Zealand (1.24) signed a free trade agreement with China in 2008 and 2009, respectively, and the free trade agreement was singed in 2008. Trade cost is still high and the free trade agreement is unworthy of the name, which should raise the attention of relevant departments.[6]

Econometric empirical analyses

In order to study the effect of aggregate trade cost on manufacturing export commodity structure, the regression model is set as follows refer to Levchenko (2007), Milner and McGowan (2013):

$$x_{it} = \alpha + \alpha_1 c_i T_t + \gamma_i + \gamma_t + \varepsilon_{it} \tag{6}$$

The dependent variable x_{it} represents the export share of manufacturing industry i that is in the ISIC two digit classification (i = 1, … 17). The formula is as follows: the export share of the industry i = China's export of manufacturing industry i to partners/ partners' total export of manufacturing industry. c_i represents the trade cost's intensity

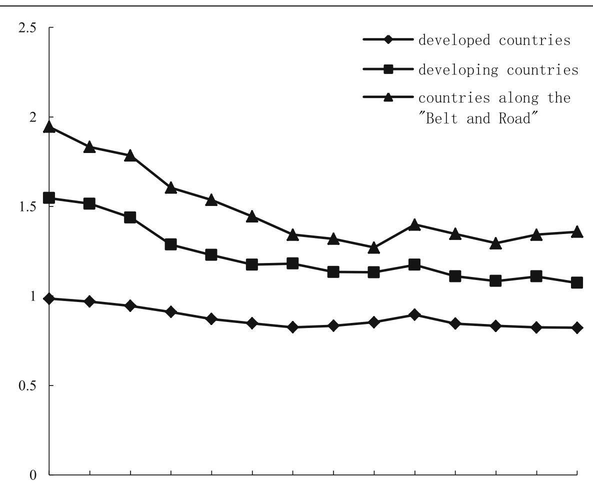

Fig. 2 The aggregate trade costs of China, developed countries, developing countries, and countries along the "Belt and Road"

Table 2 The average bilateral trade cost between China and 86 counties or regions from 2000 to 2013

Low (0, 1]	Chile 0.97, Philippines 0.95, Holland 0.91, Indonesia 0.90, Russia 0.89, Saudi Arabia 0.88, Australia 0.87, Germany 0.81, Belgium 0.80, United States 0.79, Vietnam 0.73, Thailand 0.72, Japan 0.67, Korea 0.57, Malaysia 0.47, Singapore 0.44, China Hong Kong 0.24
Middle and low (1, 2]	Zambia 1.89, Mozambique 1.87, Paraguay 1.85, Ethiopia 1.84, Madagascar 1.84, Tanzania 1.82, Greece 1.82, Slovenia 1.81, Ecuador 1.80, Ivory Coast 1.79, Sri Lanka 1.78, Portugal 1.77, Venezuela 1.74, Bulgaria 1.71, Morocco 1.68, Costa Rica 1.65, Malta 1.65, Luxemburg 1.59, Jordan 1.58, Slovakia 1.56, Egypt 1.56, Estonia 1.55, Romania 1.55, Uruguay 1.53, Algeria 1.50, Benin 1.46, Norway 1.43, Turkey 1.42, Poland 1.40, Mexico 1.32, Czech 1.31, Israel 1.31, Denmark 1.31, Oman 1.31, Spain 1.31, Switzerland 1.29, Ireland 1.27, Argentina 1.27, New Zealand 1.24, Peru 1.24, Sweden 1.22, Ukraine 1.20, Hungary 1.16, Finland 1.15, South Africa 1.13, Italy 1.12, France 1.12, United Kingdom 1.10, Brazil 1.10, India 1.09, Kazakhstan 1.09, Canada 1.05
Middle and high (2,3]	Botswana 2.78, Salvatore 2.62, Uganda 2.52, Nicaragua 2.49, Guatemala 2.22, Cyprus 2.22, Kyrgyzstan 2.18, Croatia 2.17, Mauritius 2.16, Senegal 2.15, Guyana 2.10, Latvia 2.10, Tunisia 2.05, Jamaica 2.03, Lithuania 2.02, Lebanon 2.00
High (3, + ∞)	Austria 3.90

or sensitivity in the industry i, that is the share of import input in the export production in industry i (Milner and McGowan 2013). T_t represents the aggregate trade cost of China in the year of t, and the results are as shown in Table 1 γ_i is the time-fixed effects, which measures the effect of variable that varies with individual but not with time. γ_t is the individual fixed effect, which measures the effect of variable that varies with time but not with individual. These two variables have no relationship with trade costs. ε_{it} is the random error term, which includes the factors of political, economic, culture, and industry characteristic that have potential impact on export share.

In the econometric estimation of the impact of trade costs on the export share of each industry, the possible impact of "endogeneity bias" on estimated value needs to be paid attention. The trade cost may be related to the error term, which makes the ordinary least square method product biased and inconsistent estimates. "Simultaneity bias" and the missing variables are the two sources of the endogenous nature, and the most likely one is the omission of other relevant variables (Milner and McGowan 2013).[7] These missing variables are related to the trade costs, and potentially determine the export share that is not explained by the existing explanatory variables. In order to overcome the endogeneity bias, time-fixed effects γ_i and the individual fixed effects γ_t are introduced, and the possible missing variables in the national level and industrial level are added in the robustness test. The national level variables include the deregulation of international trade in the tariff and non-tariff barriers, changing of human and physical capital endowment, system reform, establishment of bilateral or multilateral regional trade agreements or joining the WTO and other factors. The industry specific variables include the enterprise productivity affected by the enterprise export behavior and the outsourced degree of the intermediate input.

In addition of the endogeneity bias, the model 6 has the following characteristics: (1) it is the study of the impact of aggregate trade cost on comparative advantage or export structure, which is different from some literature that only study the effect of one specific trade cost on trade flows, such as information barriers (Felbermayr et al 2009; Rauch and Trindabe 2002), geographical area (Limao and Venable 1999), Monetary Union (Rose and Wincoop 2001), monopoly power of cartel in transportation enterprises (Hummels et al 2009). Although the analysis is instructive, there is no explanation for the proportion of trade cost in the full significance, which is due to the high requirement for data. It is difficult to estimate the total trade costs through the aggregation of these specific trade costs, especially for the countries with large sample. (2) Some trade costs have difficult effects on the exports of different products due to the difficulties in transportation and policy barriers, which is reflected by the sensitivity of trade cost in this model. The sensitivity of industry trade costs reflects the effect of trade cost on intermediate inputs in the export production, and further affects the export share of such products. The model (6) indicates the effect of aggregate trade cost on export structure or the comparative advantage of manufacturing is achieved by the sensitivity of trade costs in different industries. This means the level of aggregate trade cost would lead to different export reaction in different industries. (3) This model reflects a typical fact that the export production contains the import input, which highlights a characteristic that the processing trade based on the vertical division has a large proportion in Chinese export trade.

The data of x_{it} in the model (6) is from the industry export data in the OECD Structural Analysis database. The export data of China to each trade partner in each sub industry in each year and the total export data of manufacturing industry in each year are from OECD STAN Bilateral Trade in Goods by Industry and End-use (BTDIxE), ISIC 3 database and World Integrated Trade Solution. The data sample in this paper is the 17 sub industries in the manufacturing classified in ISIC 2, and the time span is from 2000 to 2013. The data of trade cost sensitivity c_i is based on the two digit of ISIC classification, which is from the OECD STAN I-O Import Content of Exports dataset. The sub industry C23 is removed due to the missing data. The value of trade cost sensitivity is shown in Table 3. The aggregate trade cost T_{t} is shown in Table 1. The regression results in the model (6) are shown in Table 4. The first column is the test of

Table 3 The trade cost sensitivity of 17 sub industries in manufacturing

Industry		Trade cost sensitivity
C15T16	Food, beverage and manufacturing	0.118279
C17T19	Textile, garment and leather manufacturing	0.201804
C20	Wood products	0.178894
C21T22	Paper products and printing products	0.216988
C24	Chemical products manufacturing	0.241970
C25	Rubber and plastic products manufacturing	0.210127
C26	Other non-metallic mineral products manufacturing	0.166794
C27	Basic metal manufacturing	0.311347
C28	Metal products manufacturing, except for machinery and equipment	0.262296
C29	Manufacturing of machinery and equipment not yet be classified	0.276759
C30	Office, accounting and computing machinery manufacturing	0.523639
C31	Manufacture of electrical machinery and equipment not yet be classified	0.352378
C32	Manufacture of radio, television and communication equipment and apparatus	0.464463
C33	Manufacture of medical equipment, precision instruments and optical instruments, watches and clocks manufacturing	0.353313
C34	Manufacture of vehicles, trailers and semi trailers	0.270345
C35	Other transportation equipment manufacturing	0.264931
C36T37	Miscellaneous products and waste resource recovery	0.212123

Table 4 The regression results of "global comparative advantage" and "local comparative advantage"

Dependent variable: χ_{it}	1	2	3	4
$c_i \times T_t$	−2.860***	−5.120***	−0.681***	−0.327***
	(−8.11)	(−8.41)	(-3.03)	(−3.13)
Industrial fixed effect	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Observation	153	238	238	238
R^2	0.689	0.6001	0.7048	0.7304

Note: *** represents a significant level at 1%. Values in the brackets are that of *t*

"global comparative advantage" with all sample, and the second, third and fourth column is sample with developed countries, developing countries and countries along the "Belt and Road" respectively to test the "local comparative advantage".[8]

Table 4 shows, whether it is from the perspective of "global comparative advantage" or of "local comparative advantage" (Deardorff 2004), the aggregate trade cost has the effect on export structure of manufacturing,[9] which indicates the trade cost is similar with the material capital and human capital, and is also a factor that influences the trade pattern or structure. The increase in Chinese aggregate trade cost significantly reduces the export share of manufacturing. This effect in the industry with higher trade cost sensitivity is more obvious, and thereby affects the structure of trade commodities. Specifically, the trade cost sensitivity of "manufacturing of office, accounting and computing machinery (C30)" is highest with the value of 0.523639; the trade cost sensitivity of "manufacture of radio, television and communication equipment and apparatus (C32)" ranks second with the value of 0.464463; the trade cost sensitivity of "manufacture of medical equipment, precision instruments and optical instruments, watches and clocks manufacturing (C33)" ranks third with the value of 0.464463. The decline of aggregate trade cost contributes to the effect of these industries export ranking the top three. The trade cost sensitivity of "food, beverage and tobacco manufacturing (C15T16)" is lowest with the value of 0.118279. The trade cost sensitivity of "other non metallic mineral products manufacturing (C26)" is in the reciprocal second with the value of 0.166794. The trade cost sensitivity of "wood products (C20)" is in the reciprocal third with the value of 0.178894. The decline of aggregate trade cost contributes to the effect of these industries export in the reciprocal three. This paper calculates the average degree of the effect of aggregate trade cost on different industries: for the first column that reflects the "global comparative advantage", one unit decreasing of standard deviation in the Chinese aggregate trade cost contributes to 0.081 percentages increasing of export average value of the 17 industries; for the second column that reflects the "local comparative advantage" with the developed countries as the sample, one unit decreasing of standard deviation in the Chinese aggregate trade cost contributes to 0.095 percentages increasing of export average value of the 17 industries; for the third or fourth column that reflects the "local comparative advantage" with developing countries and countries along the "Belt and Road" as the sample, respectively, one unit decreasing of standard deviation in the Chinese aggregate trade cost contributes to 0.062 and 0.033 percentages increasing of export average value of the 17 industries, respectively.[10]

Robustness test

The above results are obtained with the industry and national factors that effect export are controlling. The following parts retest with these factors adding to overcome the internal deviation.

Adding the cross terms of industry characteristics and trade cost sensitivity

It includes the labor productivity index and R&D intensity. Adding the labor productivity index is based on the David Ricardo's theory of comparative advantage and its extended model (1), (2), and (3). These expressions indicate the unit labor requirement of the industry has impact on comparative advantage and export. The recent developing model of heterogeneous enterprise trade theory stressed the role of enterprise and industry labor productivity in the export. It is due to the sunk costs of export, only the enterprises with high level of productivity export (Melitz 2003). The labor productivity index reflects the average productivity of enterprises in a certain industry. The reason why the variable of industry R&D intensity is added in the regression model is that the investment in the enterprise plant, machinery and innovation promotes the export (Alvarez and Lopez 2005; Iavavone and Javorcik 2008). Due to the availability of data, labor productivity index and R&D intensity could be indirectly obtained through the following formula: Labor productivity = industrial added value/all staff and workers; the intensity of R&D = the added value calculated with the RMB price/the total output calculated with RMB price. The data of two industries is from EU Klems database, but the date is only updated to 2008. In order to ensure the accuracy of results, the time span of the panel data is adjusted to 2000-2008. The test results of the two sets of variables are shown in the first and second columns in Table 5.[11]

Table 5 shows the coefficient of the cross term of labor productivity index and trade cost intensity is -0.001, which indicates the increasing level of industry labor productivity not promote export. This means the enterprises with the high level of productivity prefer to the domestic market rather than the foreign market. This effect is more obvious in the industry with higher trade cost intensity, and the export share of the enterprises with low productivity is larger, which is the famous "productivity paradox" that is

Table 5 The robustness test of the cross terms of industrial characteristic variable and trade cost density (general)

Explanatory variable: χ_{it}	1	2
$c_i \times T_t$	−3.305***	−3.777***
	(−8.20)	(−7.06)
$c_i \times$ Labor productivity index $_{it}$	−0.001 ***	
	(−2.18)	
$c_i \times R\&D$ intensity $_{it}$		2.678***
		(2.25)
Industrial fixed effect	Yes	Yes
Time-fixed effect	Yes	Yes
R^2	0.7007	0.7014
Observation	153	153

Note: *** represents a significant level at 1%. The value in the brackets is value of *t* contrary to the trade theory of heterogeneous firms. The industry of manufacturing has a large number of processing trade enterprises, and these enterprises have high labor intensity and ignore technological progress, which contributes to the low productivity and increased export share. Table 5 indicates industries with high R&D intensity has larger export share, as well as with more input that imported from other markets. The reason is that R&D is not only conductive to improving the production process, but also to the optimization of intermediate inputs channels in the procurement, which contributes to the production with cheap price and high quality. Even if the processing trade enterprises with low productivity, different R&D intensity also has different effect. Therefore, the aggregate trade cost is still the decisive factor of the export share of manufacturing and global comparative advantage. The conclusion does not change.

Adding the cross term of national level variables and trade costs intensity

A series of national indicators with the range from 1 to 10 is obtained from the database of Economic Freedom of the World, and this kind of data has a main advantage of strong direct comparability. Since the establishment of the socialist market economic system, especially since the accession to the WTO, government took a series of policies and measures, including signing bilateral and multilateral free trade agreements, reducing the regulation of foreign trade, lowering tariffs and non-tariff barriers, strengthening the laws and regulations in intellectual property rights protection, constructing market vitality. The results of robustness test that adding the national level variables are shown in Table 6.[12]

The first and second columns in the Table 6 show that the higher value of the fair court indicates the more transparent and fair legal procedures. This paper also found the improvement in country court justice and in the law quality, such as law structure, property rights protection, would improve the formation of comparative advantage and increase the export share of the industry that has higher trade cost intensity, which is the same with the results of Nunn (2007) that suggest that the justice of court and intellectual property protection in China play a role in the import of input. However, the two cross term coefficients are lower than the coefficient of trade cost cross term, which shows that although the legal quality affect the comparative advantages of system, there are still other factors playing greater role on the comparative advantage. The regression equation 6 shows that the increase in the overall economic freedom would promote the production export. The higher value of tariff means the lower tariffs of import imposed by China,[13] and the lower price and cost of the import input, which is conductive to the export of manufacturing products. The regression equation 4 also illustrates the results. The similar effects of non-tariff barrier, control index and total degree of freedom are reflected in the regression equation 5 and 6. The regression equation 6 shows Chinese economic development level significantly affects the manufacturing export, which means the higher economic development level, the more manufacturing export. The regression equation 3 shows the higher compliance costs of trade leads to lower export share of manufacture. Moreover, the effect is more obvious in the industry with high sensitivity of trade cost. It can be seen that the core conclusions of the study in Table 5 and Table 6 are unchanged.

Table 6 The robustness test of the cross terms of national level variable and trade cost density (general)

Dependent variable: χ_{it}	1	2	3	4	5	6	7	8
$c_i \times T_t$	−3.959***	−2.142***	−2.506***	−0.377	−3.372 ***	−3.622***	−2.229***	−0.951
	(−8.09)	(−3.33)	(−2.94)	(−0.37)	(−6.77)	(−7.12)	(−3.31)	(−1.36)
$c_i \times$ Justice Court $_t$	0.245***							
	(−3.89)							
$c_i \times$ Legal structure and Property rights $_t$		0.287***						
		(−3.99)						
$c_i \times$ Trade compliance costs$_t$			−0.203*					
			(−1.90)					
$c_i \times$ Tariff $_t$				0.574***				
				(−3.87)				
$c_i \times$ Control index $_t$					0.211***			
					(−4.1)			
$c_i \times$ Non-tariff barrier $_t$						0.114**		
						(−2.08)		
$c_i \times$ Total degree of freedom index $_t$							0.584***	
							(−3.45)	
$c_i \times$ ln(capital GDP) $_t$								0.346***
								(−5.57)
Industrial fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.6715	0.6727	0.6535	0.6713	0.6741	0.6547	0.6667	0.6935
Observation	238	238	238	238	238	238	238	238

Note: *** represents a significant level at 1%; ** represents a significant level at 5%; * represents a significant level at 10%. The value in the brackets is value of *t*

Adding the cross term of industrial characteristic and national characteristic

The international trade theory and many existing literature shows that the country-industry correlate is an important source of comparative advantage, such as the material capital, human capital, and legal system. Adding the cross terms in the model 6, the Table 7 shows the effect of the national factor endowments in different industries on export structure.[14] It can be seen that the cross coefficient is not only in line with expectation with significant positive value, but also the cross term of aggregate trade cost is negative, which means the aggregate trade cost is the determinant in comparative advantage of manufacturing export and export structure.

Conclusions

Using the frontier model of trade cost measurement, this paper measures the bilateral trade costs between China and other 86 trade partners as well as the aggregate trade costs from 2000 to 2013. Based on the extended Ricardo Model and the facts that processing trade accounts for relatively large, this paper empirically analyzes the effect of aggregate trade cost on the advantage and trade structure in the 17 sub industries classified based on ISIC two digits, and the following are several conclusions.

First, although Chinese aggregate trade cost shows a downward trend, it is still 1/3 higher than the average aggregate trade costs of the industrialized countries 10 years

Table 7 The robustness test of the cross terms of industrial characteristic and national characteristic (general)

Dependent variable: χ_{it}	1	2	3	4
$c_i \times T_t$	−3.614***	−3.993***	−3.501***	−3.263***
	(−6.50)	(−8.94)	(−6.88)	(−6.69)
Human capital intensive$_i$ × human capital stock$_t$	0.002			0.0065***
	(0.87)			(2.92)
Material capital intensive$_i$ × material capital stock$_t$		0.00063***		0.00067***
		(7.67)		(7.88)
Contract density$_i$ × legal rules$_t$			0.066***	0.027
			(2.79)	(1.27)
Industrial fixed effect	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
R^2	0.6487	0.7257	0.6602	0.7402
Observation	238	238	238	238

Note: *** represents a significant level at 1%. The value in the brackets is value of *t*
Source: (1) The human capital intensity and material capital intensity are from the table of Sheng Wenwen (2014). (2) The contract intensity is from the table of Huang (2013). Data in the above three industrial level are re docking by industry. (3) The data of human capital stock is from World Bank secondary education enrolment rate. (4) The data of material capital stock is from the gross fixed capital formation in EU Klems database. (5) The data of law rule is the average value of these five indicators: Judicial independence, Impartial courts, Integrity of system, Protection of property rights and Legal Structure and Property Rights

ago. The bilateral trade cost in different countries and regions vary greatly, especially in some countries, the trade cost increases in a certain extent. Even signing FTA with China, the trade cost is still high, and the bilateral trade cost between China and countries that along with the "Belt and Road" is not only higher than that between China and developed countries, but also higher than that between China and developing countries. The policy implication is that reducing the aggregate trade cost is still arduous, and the regional structure of bilateral trade cost should be improved, free-trade zone should play an effective role. Since the trade cost, from a full sense, includes transportation cost, information cost, policy barriers cost, contract implementation cost, legal and regulation cost and distribution costs, reducing trade cost should take these components into consideration in order to further promote the implementation of the strategy of the "Belt and Road". The following aspects should be paid attention: (1) Speeding up the construction of railways, highways, ports and other hardware infrastructure, which is the most basic link to reduce the transport trade costs. (2) Make efforts to promote the interoperability of information and communication technology in the internet era, to strengthen cultural exchanges, to reduce information costs and distribution costs. (3) Actively carry out the financial cooperation and gradually implement the bilateral currency settlement, reduce the cost of currency exchange. (4) To coordinate the interconnection of rules, regulations, standards, policies, laws and so on, for example, there are differences between China and the United States in the railway width standard, which are the objective obstacles that cannot be overcome. However, the interoperability in legal, institutional and policy can reduce the cost of contract execution and policy barriers. (5) We should give full play to the existing silk-road fund and the Asian infrastructure investment bank to reduce trade cost, or to learn from the EU to strengthen the interoperability of infrastructure and to alleviate the financial constraints of the difficult situation.

Second, the aggregate trade cost is not only the "global comparative advantage" in manufacturing industry, but also the determinants of "local comparative advantage". Reducing the aggregate trade cost would significantly promote the export of manufacturing industry products, and the effect is more obvious in the industry with higher trade cost intensity. The same degree of declining in the aggregate trade cost has the most promotional effect on "Office, accounting and computing machinery manufacturing (C30)" while that has the minimal effect on "food, beverage and tobacco manufacturing (C15T16)". Three kinds of the robustness tests demonstrate the results. The domestic additional value rates of the "food" and "drink" rank the second and first in 19 industries, respectively (Zhang et al 2013). Only the increasing in the export share and total amount in the products with high domestic export value added can transform the export of high "DVA" into the increasing of the total inventory of "DVA", and realize the true transformation of foreign trade. Therefore, for the products that have highest domestic value-added rate but lowest trade cost intensity, they can play a promotional role in export, and is also the core in transforming the trade development mode. Government should make effort to reduce the trade cost, including transportation, customs, system implementation, etc. The "DVA" of the "office, mechanical manufacturing" is lowest in 19 industries (Zhang et al 2013). However, the trade cost intensity has the highest degree. Therefore, this kind of product is not the main object of reduce the trade cost since the declining of the trade cost would contribute to the increase of export share, which not only not make the total added value of export efficiently increase, but also consume too much resources to undermine the domestic natural ecological environment.

Third, for the three kinds of local comparative advantage, the aggregate trade cost has the maximum obstacle on the local comparative advantage and on export share of manufacturing with the developed countries as sample, while has minimum obstacle on that with countries that along with the "Belt and Road". The policy implementation is that in order to achieve the same degree of promoting manufacturing exports, the trade cost in the counties along with the "Belt and Road" needs the most effort, which needs government support capital, technology, personnel and other aspects. The efficiency of reducing trade cost is highest in developed countries. Based on the national strategy, government and the enterprises should reduce the trade cost in combined with the actual situation of enterprises.

Fourth, the robust test show that, in addition to the aggregate trade cost that has effect on the "global" or "local" comparative advantage of Chinese manufacturing industry, it also includes the fairness of Chinese law, intellectual property protection, tariff and non-tariff barriers, economic freedom, economic development level, human capital, R&D intensity in the enterprise, labor productivity, etc. Among the factors, only the increase of labor productivity has a negative relationship on the export with the small influence. The policy implication is that in order to promote the export of manufacturing production, China should take measures from the above aspects. Currently, it is particular to improve various laws and regulations, increase the degree of economic freedom, to reduce the excessive administrative intervention, to promote market vitality. There is a negative relationship between labor productivity and export due to the large number of processing enterprises, and the non-processing export enterprise is more than the domestic enterprises (Li 2010). Therefore, it cannot indicate that technology has no role on export. Instead, government and enterprise should pay attention to the improvement of technological innovation and labor productivity in order to promote the export of manufacturing products in the form of non-processing trade.

Endnotes

[1]Despite the fast development of trade theory, such as new trade theory, new trade theory, the David Ricardo's theory of comparative advantage is still the cornerstone of international trade theory.

[2]In order to analyze the sensitivity, the range of Sigma is from 5 to 10 according to Anderson & Wincoop (2004). We calculate the value of the aggregate trade cost when the value of σ is 5, 10 respectively. From the figure, we found the basic trend has not changed. Due to the limited space, it is omitted. Results can be obtained from the author if interested.

[3]Wang Jianing, "I believe that the president of Austria's visit to China will promote the friendly relations and cooperation between China and Austria to a new level- visit to Chinese ambassador to Austria, Zhao Bin", Xinhua news, March 20, 2015, http://news.xinhuanet.com/world/2015-03/20/c_1114714246.htm.

[4]These 29 countries include: Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, India, Sri Lanka, Kazakhstan, Kyrgyzstan, Turkey, Jordan, Israel, Saudi Arabia, Oman, Lebanon, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Poland, Slovakia, Slovenia, Ukraine, and Egypt.

[5]We calculate the value of the aggregate trade cost when the value of σ is 5 and 10, respectively. From the figure, we found the basic trend has not changed. Due to the limited space, it is omitted. Results can be obtained from the author if interested.

[6]The free trade zone was established in Switzerland and China, the trade cost is still high with the value of 1.29. But the signing time is 2013, and the effective is July 2014, which is not in the sample period.

[7]At the same time, the biased property indicates the change of trade cost is explained by the change of export share of the current industry. For the data of export share's change in the sub industries, the role of bias is fall.

[8]Several sub samples are extracted from the general sample according to regions and level of economic development in the paper of Greenaway et al (2009), for example, developing country, transition country and Africa are analyzed in the paper as the sub samples.

[9]This result is not consistent with Greenaway et al (2009), and the local comparative advantage in the paper of Greenaway is not significant.

[10]Since the explanatory variable is different from the explained variable, it is explained by the standard deviation. The efficient of α is 0.081, 0.095, 0.062 and 0.033 in the different four situations, respectively. The significance of x, T is explained in the paper.

[11]The robustness test of developed countries, developing countries, countries along with the "Belt and Road" is effective. Results can be obtained from the author if interested.

[12]The robustness test of developed countries, developing countries, countries along with the "Belt and Road" is effective. Results can be obtained from the author if interested.

[13]No tax on international trade record the highest score 10. http://www.freetheworld.com/efw_previous.html.

[14]Greenaway et al. (2009), Milner and McGowan (2013), Sheng Wenwen (2014) use the explanatory variable of "national- industry relativity" to analyze the comparative advantage.

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Authors' contributions
XT made the theoretical analysis. LX made the data analysis. Both authors read and approved the final manuscript.

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