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Abstract. Since China developed technology, its exports of high-tech products increased rapidly. Whether trade comparative advantage in China is reversal? Is export structure optimized? This paper measure the revealed comparative advantage (RCA) of technology of China and the U.S., and measure the export domestic added value comparative advantage (AVCA) based on non-competitive input-output model. The results show that China’s RCA has increased except special industries; the RCA exceed the U.S. in some technical industries; while the domestic value added coefficients are always less than American; compared with the U.S., RCA of different technologies after adjustments has decreased significantly in China.

1. Introduction

According to existing documents, since Ricardo (1817) came up with classical trade comparative advantage model, it formed an approach to measuring comparative advantage gradually. The most commonly used is the revealed comparative advantage (RCA) proposed by Balassa (1965) and the revised ones. Such the index has a significant feature that could measure comparative advantages of a country or a whole industry indirectly by using data of the total amount of imports and exports, and the data are readily available and easy to operate.

However, international division of labor is developing from the inter-industry and the intra-industry to intra-product division of labor, so the comparative advantage of a country cannot just measured by the cost of production or the labor productivity, it is more important that measure the comparative advantage through calculating value-added capabilities of the industrial chain. In the situation of inter-product division of labor, the same product is produced by different countries, so the total amount of imports and exports cannot reflect added value of trade of the country. Therefore, the traditional method that measuring comparative advantage has some limitations, and the result estimated by the old ways has bias in the current situation. There is an urgent need to divide exports into two parts, including domestic component and foreign added value, and using the new way, which is named added value comparative advantage (AVCA), to remeasure comparative advantage.

The amount of exports of high-tech products of the United States has been the largest in the world, while since China has implemented the “strengthening trade through science and technology” strategy in 1999, the amount of high-tech product exports in China has increased rapidly. Many scholars attribute such high growth phenomenon of “reverse comparative advantage” in high-tech industries in China to the increased labor productivity and the optimized export structure (Huang Jingye, 2006; Zhu Youwei, et al., 2007; Wang and Szirmai, 2005, 2008; Cheng Liwei, et al., 2010). However, could these data prove that export structure of China really has been improved? In the condition of international intra-product division of labor, this paper uses calculation results by AVCA to compare with the results by RCA index and the results from the United States, and these questions could be answered.
2. Empirical Model

This paper uses the traditional RCA index and AVCA method to measure comparative advantages of foreign trade in high-tech industries between China and the United States, and then compared. Here is description of the two measured indicators.

(1) **Comparative advantage indicator based on the size of import and export—RCA index**

RCA index quantitatively describes the relative performance of export in various industries (product group) of a country, it reveals comparative advantage in international trade of the country. It also makes up for the shortcomings of classical or neo-classical calculation indexes. The measuring principle showed in equation (1):

\[
RCA_i = \frac{X_{ij}}{Y_{ij}} / \frac{M_{ij}}{W_{ij}}
\]  

(1)

Where \(X\) represents exports, i represents country, \(j\) represents commodity, \(W\) represents the set of state, it can be in the world, and it can also be an area. If \(RCA_{ij} > 2.5\), it indicates that the product \(j\) in the country \(i\) has extremely strong comparison advantage; if \(1.25 \leq RCA_{ij} \leq 2.5\), it indicates that the product \(j\) in the country \(i\) has strong comparative advantage; if \(0.8 \leq RCA_{ij} \leq 1.25\), it indicates that the product \(j\) in the country \(i\) has medium comparative advantage; if \(RCA_{ij} < 0.8\), it indicates that the product \(j\) in the country \(i\) has weak comparative advantage.

The index passed test of many scholars (Yeats, 1985; Ballance, Forstner and Murray, 1987; Vollrath, 1991), and because the design of RCA is simple and clear, also it is easy to get the data, RCA index is widely used.

(2) **Comparative advantage indicator based on the added value of domestic export—AVCA index**

The first step to find AVCA index is measuring the added value of domestic export. According to Lawrence J. Lau (2007), the total export and import value equals to the sum of complete import value and complete domestic added value, the sum of the complete import value coefficients and the complete domestic added value coefficients is equal to 1. Therefore, the priority task of measuring the added value of domestic exports is to compute the complete import value coefficients of export.

Firstly, we calculate the direct import consumption coefficients (\(a^{m}_{ij}\)) and the complete import consumption coefficients (\(b^{m}_{ij}\)). \(a^{m}_{ij} = M_{ij}/Y_{ij}\) refer that sector \(j\) produce the number of products per unit which sector \(i\) need to import. Where \(M\) represents imports, \(Y\) represents output. The output of sector \(j\) needs domestic product of sector \(i\), \(a^{d}_{ij} = D_{ij}/Y_{ij}\) refer to direct consumption coefficients of domestic product. And when sector \(i\) produces domestic products, it consumes import products at the same time, which form indirect consumption sector \(j\) of import products, complete import consumption in the productive process of sector \(j\) is equal to the sum of direct import and indirect import of consumption. And \(b^{n}_{ij}\) can be denoted by the formula (2):

\[
b^{n}_{ij} = \sum_{k=1}^{n} b^{m}_{ik} a^{d}_{kj} \quad (1,2, \ldots, n)
\]  

(2)

Written in matrix form as shown in equation (2), after the form of the converted to the matrix \(B^{m}\) formula (Equation (3)):

\[
B^{m} = A^{m} + B^{m}A^{d}
\]  

(3)

\[
B^{m} = A^{m}(1 - a^{d})^{-1}
\]  

(4)

Secondly, obtain the direct import coefficients (\(a_{mj}\)) and the complete import coefficients (\(b_{mj}\)). Lawrence J. Lau (2007) define that direct import coefficients (\(a_{mj}\)) is the sum of total import intermediate product of direct input when industry \(j\) produce one unit product, which equal to the sum of direct consumption coefficients of industry \(j\), namely:

\[
a_{mj} = \sum_{i=1}^{n} a^{m}_{ij}
\]  

(5)
Formed by matrix: \( Am = \mu A^m \), where \( \mu \) is a unit row vector, i.e., \( \mu = (1, 1, \ldots, 1) \), thus \( Am \) is a row-vector and can be expressed as \( Am = (a_{m1}, a_{m2}, \ldots, a_{mn}) \).

Therefore, complete import coefficients \((b_{mj})\) can be defined as the sum of direct import and total indirect import when industry \( j \) produces one unit product, which is:

\[
b_{mj} = a_{mj} + \sum_{i=1}^{m} a_{mi} a_{ij} + \sum_{i=1}^{m} \sum_{k=1}^{m} a_{mi} a_{mk} a_{kj} + \sum_{i=1}^{m} \sum_{k=1}^{m} \sum_{l=1}^{m} a_{mi} a_{ml} a_{kj} + \ldots (l = 1, 2, \ldots, r)
\]

(6)

The right equation (6) is direct import coefficients of industry \( j \), the sum of first indirect import of industry \( j \) and the sum of second indirect import of industry \( j \), respectively. Written to matrix form as shown in equation (7), wherein, \( B_m \) is also a row vector, it can be expressed as \( B_m = (b_{m1}, b_{m2}, \ldots, b_{mn}) \).

\[
B_m = A_m + A_m A^2 + A_m A^2 A^2 + A_m A^2 A^2 A^2 + \ldots = A_m (I - A^2)^{-1}
\]

(7)

Finally, we need to calculate the complete added value of domestic export (AV), then modify RCA index. Because the total export of industrial \( j \) \((x_j)\) is equal to the sum of complete import and complete domestic added value, thus complete domestic added value of industry \( j \) can be expressed as the equation (8). This paper called the \( 1-b_{mj} \) as the domestic added value coefficients of export. After calculating the domestic added value of export, it could get AVCA by replacing the export of RCA.

\[
CV_j = x_j - x_j \cdot b_{mj} = x_j (1 - b_{mj})
\]

(8)

3. Empirical Analysis

(1) Data sources

In this paper, import and export data in this paper comes mainly from the UN Comtrade database, and other data are from the World Input-Output Database.

(2) Measuring high-tech industry RCA of China and the US

According to the proposed method to calculate RCA (Equation 1) and the relevant trade data, it can calculate the RCA index of China and the US from 1996 to 2012. From the results of RCA, it concludes the following conclusions: first of all, compared with the US, code 01 and 07 of the technical industries in China has a strong comparative advantage, especially after 2005, this advantage is more obvious. Second, compared with the US, the technical industries code 03, 04, 05 and 08 in China has a weak comparative advantage. For technical industry code 03 and 04, the United States used to have a strong comparative advantage in 2005, while after 2005, China is likely to surpass the United States. Finally, for the products of new technology of materials in industry 06 and modern agricultural technology in industry 09, foreign trade comparative advantages of China and the US are quite similar.

(3) Measuring AVCA of high-tech industry in China and the US

However, these conclusions from RCA are on the basis of calculated RCA index which based on total value of export, and in the current state of intra-product specialization, if increasing added value of domestic export in various technical industries, could these conclusions still exist? So, this paper calculated domestic complete added value coefficients of export in various technical industries in China and the United States. From the results of calculation, domestic complete added value coefficients of export in various technical industries in China is smaller than in the United States, and domestic complete added value coefficients of export in various technical industries are tend to decrease. Compared with data in 1996, domestic complete added value coefficients of export in 8 technical industries decrease 12.03% on average in 2012, and coefficients in biomedical and medical equipment of industry 05 decrease the most (13.09%). From yearly data of the United States, it found that domestic complete added value coefficients of export in various technical
industries in the United States is larger than in China, in spite of domestic complete added value coefficients of export in the United States also tend to decrease, but the decrease trend is not obvious. Compared with data in 1996, it decline by 2.45% in 2012, and even the coefficients in electronic information of industry 01 and new energy and energy-saving products of industry 07 are tend to slightly increase.

It can predict that if replace total export value by domestic added value, re-calculation of RCA index data in will has some deviation, but because the added value coefficients of the two countries are more than 60%, the difference is not significant. Adjusted RCA index is calculated. Compared to the data of RCA, comparative advantages in each year and each technical industry in China and the US are decrease in adjusted RCA. After 2005, compare to the United States, in spite electronics information in industry 01 and new energy and energy-saving products in industry 07 in China have strong comparative advantages, but the gap decline obviously. In 2012, RCA that based on total export value in China is 2.7729, which is three times than in the United States (0.8970). The gap seems not obvious after adjustment, and RCA in China is 1.9305, which is only twice than in the United States (0.7884), thus the advantage is declined. For aerospace technology in industry 03 and light electromechanical integration in industry 04, RCA that based on total export value in China has a little comparative advantage over the United States after 2005, but not has a comparative advantage after adjustment. For technical industry 06 and 09, RCA that based on total export value in China is similar to the United States, while the United States has comparative advantage to China after adjustment. For biopharmaceutical and medical equipment in industry 05 and environmental protection in industry 08, the United States has a strong comparative advantage to China before the adjustment, RCA in the United States is 3.72 and 2.02 times than in China, respectively. While after adjustment, in spite comparative advantages of the United States decrease, but the gap is increased, RCA in the United States is 4.17 and 2.34 times than in China, respectively.

4. Conclusion and Insights

The analysis above can be concluded as follows:

First, from data of the RCA, the two countries have comparative advantage in the different industries of technology varies, and China has stronger comparative advantages than the United States in some industries. For example, China has stronger comparative advantages than the United States in the industry 01 and 07, while for industry 05 and 08, the United States have a strong comparative advantage than China. For industry 03 and 04, the United States has more comparative advantage than China before 2005, and then after 2005, China has stronger comparative advantages than the United States. For industry 06-09, the two countries both have obvious comparative advantages.

Second, the difference of domestic added value coefficients between China and the US is obvious. Each year domestic added value coefficients of the United States in each technical industry is higher than China, and has increased every year, while coefficients of China significantly decrease in each year.

Third, after the adjustment by domestic added value of export, comparative advantages in each industry in China and the United States are weaker than before, but the decreases in China are larger than in the United States. Compare to the United States, China have strong comparative advantages in some industries before adjustment, but after adjustment, the gap decline obviously in the same industries; in the industries that the United States have comparative advantage to China, the gap increase obviously after adjustment; in the industries that the United States have same comparative advantage with China, while after adjustment, the United States have strong comparative advantage to China.

The following are insights based on conclusions of this article:

Firstly, the phenomenon of “reverse comparative advantage” growing in China export cannot indicate the constantly optimize of the export structure. Under the condition of intra-product division of labor, the high-tech industry in China is still in the low-end segment of the high-tech industry chain, although the exports increase rapidly, the domestic added value coefficients of
export has continued to decrease, indicating that the conclusions of “reverse comparative advantage” growing in China export and constantly optimize of the export structure is still controversial.

Secondly, the technical industries that domestic added value coefficients of export are larger than the United States should be encouraged to develop. For new technology of materials in industry 06 and modern agricultural technology in industry 09, RCA and AVCA in China and the United States are basically the same, two countries do not have obvious competitive advantage. But for China, the domestic added value coefficients of export in these two industries are larger than in other industries. It indicates that the development of new materials and modern agricultural trade will help to improve trade revenue of China, so the government could formulate policies to encourage the development of new materials and modern agriculture, in order to increase the added value of complete domestic exports of China.

Moreover, the technical industries, which China has comparative advantage and coefficients of domestic added value are larger, should be encouraged to develop. RCA and AVCA of light electromechanical integration in industry 04 have a significant growth after 2005, and compared with other high-tech industries, its domestic added value coefficients is relatively higher. Therefore, China should continue to take advantage of light electromechanical integration, makes more efforts on development, in order to increase exports of light electromechanical integration products, and earn more trade revenue.

Finally, it is better to appropriately adjust the current export structure of China in high-tech industries. Electronic information and new energy-saving products have a strong comparative advantage, but compared with other industries, domestic added value coefficients is the lowest, indicating that current export structure and mode of China in high-tech industries need to be adjusted.

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