Empirical analysis on the export trade patterns in the Chinese antibiotic products

Yu Hong¹, Lin Zhang¹, Na Li¹ and Ting Liu², ³

¹Jilin University of Economy and Finance, Changchun 130021, China
²Changchun Humanities and Sciences College, Changchun 130021, China
³Corresponding author’s e-mail: lqthlittle@sina.com

Abstract. This study used annual data from 1987 to 2019 to analyze the export trade patterns of antibiotic products of China. The weighted indicators of “revealed symmetric comparative advantage for export” (RXcj) is employed to capture the revealed comparative advantage of the Chinese export in the antibiotic products, and the weighted indicators of "export restriction" (HXcj) and "import restriction" (HMcj) were used to measure the Chinese export and the import policy interventions. The research data found that the export of antibiotic products is much larger than that of imports, and China has a comparative advantage in the export of antibiotic products. China restricted the export of antibiotic products from 1987 to 1993, and began to promote exports in 1994. However, in 2019, due to the impact of the epidemic, import and export trade policies were limited, relatively speaking, China exported more antibiotic products than its export advantage determined.

1. Introduction

The global epidemic of nova-corona virus infected pneumonia in 2019 is considered one of the most severe crises since World War II, with several countries starting to develop COVID-19 vaccine [1]. At the same time, due to the impact of the nova-corona virus infected epidemic, the antibiotic market also ushered in opportunities. So it is necessary to reassess the trade policy of antibiotic products.

The theory of comparative advantage holds that developing countries should protect their infant industries through trade protectionism to promote exports and restrict imports in order to improve their comparative advantage [2-5]. Although China's pharmaceutical products continue to develop and improve their competitiveness, they have never entered the ranks of the advanced countries. China has a huge population base and great market potential. In this paper, an innovative method is used to measure the difference between the net export capacity and symmetrical comparison of antibiotic products in China.

The epidemic has brought opportunities and challenges to the antibiotic market [6]. The global economic development is weak, many countries strengthen the control of import and export trade control, in this case, China's antibiotic products still have a comparative advantage? How much is the increase in import and export trade of antibiotic products related to national trade policies? This paper analyzes the pattern of import trade of antibiotic products in China from 1987 to 2019, and draws some conclusions and opinions.
2. Methods and material

2.1. Indicators of trade patterns

2.1.1. Symmetric revealed comparative advantage index. Balassa (1965) originated the indicator of "revealed comparative advantage" [7]:

\[ RCA_{ci} = \frac{X_i/X_c}{X_i/X_w} \]  \hspace{1cm} (1)

In this part, \( X \) means export, \( X_i \) is the export of \( i \) products in country \( c \), and \( X_w \) is the total export of \( i \) products in the world. If \( RCA_{ci} > 1 \), it means that country \( c \) is more capable of specialized production of \( i \) products, and has a comparative advantage over the world average standard in the export trade of \( i \) products.

The range of \( RCA_{ci} \) is 0 to infinity, but it does not determine the average value, and its distribution is asymmetrical. Dalum, Laursen and Villumsen (1998) solved the above problem by performing logarithmic transformation on \( RCA \) index [8]:

\[ RX_{ci} = RSCA_{ci} = \frac{RCA_{ci} - 1}{RCA_{ci} + 1} \]  \hspace{1cm} (2)

where \( RSCA_{ci} \) represents the "symmetrical revealed comparative advantage" of country \( c \)'s exports of product \( i \). The average of \( RSCA_{ci} \) is 0, and the range is \([-1,1]\). If \( RSCA_{ci} > 0 \), then \( RSCA > 1 \). It means that country \( c \) has a comparative advantage in the export of \( i \) products.; on the contrary, if \( RSCA_{ci} < 0 \), there will be \( RSCA < 1 \), which means that country \( c \) is of comparative disadvantage in the export of product \( i \). If \( RSCA_{ci} = 0 \), it means that the export of country \( c \)'s product \( i \) has neither comparative advantage nor comparative disadvantage.

Balassa (1965) and Dalum, Laursen and Villumsen (1998) only studied the trade patterns in the export, while this research mainly focused in the import, it is necessary to measure the comparative advantage in the import by

\[ RCA^{M}_{ci} = \frac{M_{ci}}{M_c} / \frac{M_{wi}}{M_w} \]  \hspace{1cm} (3)

where the \( M \) represents imports, and the subscripts \( c, i, \) and \( w \) represent country \( c \), product \( i \), and the world, respectively [9-11]. The "symmetrical revealed comparative advantage" of country \( c \)'s import of product \( i \) is thus

\[ RM_{ci} = RSCA^{M}_{ci} = \frac{- (RCA^{M}_{ci} - 1)}{(RCA^{M}_{ci} + 1)} \]  \hspace{1cm} (4)

A negative sign was added in equation (4) to ensure the implications of \( RM_{ci} \) to be consistent to that of \( RX_{ci} \). According to the theory of comparative advantage, when other conditions are the same, the more products \( i \) imported by country \( c \) indicates that the comparative advantage is smaller, not larger, so a minus sign is added here [12] [13].

2.1.2. Net export ratio. This research took the indicator of net export ratio (NX)

\[ NX_{ci} = \frac{(X_{ci} - M_{ci})}{(X_{ci} + M_{ci})} \]  \hspace{1cm} (5)

as a benchmark. The relative position of the import and export of product \( k \) in country \( c \)'s trade is reflected by the net export ratio (NX), so NX can reflect the net export capacity of country \( c \) [14-16]. It is obvious to find that the range of NX is the same as \( RSCA \) which also is \([-1,1]\). And its average value is also 0. When \( NX_{ci} > 0 \), it shows that country \( c \) is in a surplus position in the trade of product \( i \); \( NX_{ci} < 0 \) means that country \( c \) is in a deficit position in the trade of product \( i \). More importantly, the range and average value of NX and RSCA are the same, so that the \( RCA_{ci} \) and \( NX_{ci} \) can be analyzed at the same time [17] [18].
2.1.3. Trade pattern deviation index. According to the Heckscher-Ohlin model, in a world of perfect free trade, a country should specialize in the production and export of products with comparative advantages [19]. According to Ricardo's free trade theory: the stronger a country's comparative advantage in a certain product, the more it should export and the less it should import. Equation (6) is also a sufficient and necessary condition for free trade [20]. In equilibrium, \( NX_{ci} \), \( RX_{ci} \) and \( RM_{ci} \) should be strictly consistent, or

\[
NX_{ci} = RX_{ci} = RM_{ci}
\]  

(6)

The difference between \( NX_{ci} \) and \( RX_{ci} \) is:

\[
hm_{ci} = h^M_{ci} = NX_{ci} - RM_{ci}
\]  

(7)

\[
hx_{ci} = h^X_{ci} = NX_{ci} - RX_{ci}
\]  

(8)

The difference between \( NX_{ci} \) and \( RSCA_{ci} \) is the "trade divergence index" or "policy intervention index" of country \( c \) in the import and export trade of product \( i \). When country \( c \) shows a certain comparative advantage in the import of product \( i \), it means that the country's net export capacity is higher or lower than the actual situation of comparative advantage. When the trade pattern is in equilibrium, there should be \( hm_{ci} = hx_{ci} = 0 \). If \( hm_{ci} > 0 \), the net export ratio is greater than the revealed symmetric comparative advantage, country \( c \) adopts import restriction policy intervention in product \( i \); \( hx_{ci} < 0 \) implies that country \( c \) adopts import promotion policy intervention which makes the country imports more than the comparative advantage determines [21] [22].

2.1.4. The weighted average index of policy intervention. This study employed a weighted average approach to obtain the import trade policy intervention indicator for the product category \( z \) that includes \( n \) specific aquatic products [23]. The equation is:

\[
HM_{cj} = \sum_{j=1}^{n} \left( \lambda_j \cdot hm_{cj} \right)
\]  

(9)

\( HM_{cj} \) is the import policy intervention index for category \( j \), and the weight

\[
\lambda_j = \frac{X_{ci} + M_{ci}}{X_c + M_c}
\]  

(10)

is the proportion of each specific product \( i \) in the import and export trade of aquatic products of China. In the calculation process of \( h \) and \( H \) index, the \( NX \) part inevitably involves both the import and the export at the same time.

When weighting the \( NX \) index of the \( z \) product, the method is the same as equation (9), the analysis and utilization of the net export ratio; when weighting the indicator of revealed symmetric comparative advantage in import, the weight is the proportion of a certain product in the total import value of the product category \( j \) [24-26] or

\[
HX_{cj} = \sum_{i=1}^{n} \left( \lambda_2 \cdot hx_{ci} \right)
\]  

(11)

\[
\lambda_2 = \frac{M_{ci}}{\sum_{i=1}^{n} M_{ci}}
\]  

(12)

because only import is involved this time. It is noteworthy that the weights for the heterogeneous trade pattern indicators are case sensitively different.
2.2. Data curation
This study uses the annual trade data of 1987-2019 from UN Commodity Database under the second edition classification of Standard International Trade (SITC Rev.2).
To narrow down the range of products to be medicine, we first identified the fifth category as related products. Then according to the relevant classification of 1 in the drug, we take CHN as the reporting country, in which pharmaceutical products (code 541), including 7 quartile products, this paper mainly studies antibiotic products (code 5413).

3. Empirical results and analysis

3.1. Changes in antibiotic products trade indicators
Figure 1 depicts the weighted average indicators of \(RM_{cj}\), \(HX_{cj}\), and \(HM_{cj}\) for the Chinese antibiotic products imports during the period of 1987-2019.

![Image of Figure 1](image)

**Figure 1.** Time paths of Chinese antibiotic products export patterns.

From 1987 to 2019, the \(RM_{cj}\) index of antibiotic products has been positive, indicating that Chinese antibiotic products have been in a comparative advantage. In 2019, it was affected by the epidemic, but the export comparative advantage of antibiotic products fluctuated less.

\(NX_{cj}\) is positive in all years after 1988, indicating that China’s export of antibiotic products has been a trade surplus since 1989.

The index of \(HX_{cj}\), reflecting the export policy intervention index, was negative before 1993, indicating that China had adopted the export restriction policy in the export of antibiotic products. However, after 1993, the weighted index of \(HX\) was positive, indicating that China had adopted the export promotion policy. However, due to the COVID-19 epidemic in 2019, the intensity of export promotion policy decreased.

The Table 1 reports the descriptive statistics of \(NX_{cj}\), \(RX_{cj}\) and \(HX_{cj}\) for the period of 1987-2019.

|       | N=33 | Minimum | Maximum | Mean  | Standard Deviation |
|-------|------|---------|---------|-------|--------------------|
| \(RX_{cj}\) | 0.201 | 0.452 | 0.336 | 0.071 |
| \(NX_{cj}\) | -0.096 | 0.807 | 0.557 | 0.258 |
| \(HX_{cj}\) | -0.513 | 0.463 | 0.221 | 0.276 |

**Table 1.** Descriptive statistics for \(NX_{cj}\), \(RX_{cj}\) and \(HX_{cj}\)
At first, the indicator of $RX_{cj}$, the revealing comparative advantage of reaction symmetry, has always been positive, reaching a maximum value of 0.452 in 1987 and a minimum value of 0.336 in 2004, with an average value of 0.336 during the period, indicating that China has always had an export advantage in the export of antibiotic products.

Secondly, The indicator of $NX_{cj}$ has always been positive, with a minimum value of -0.096 in 1998, a maximum value of 0.807 in 2015, and an average value of 0.258 during the sampling period.

Thirdly, the indicator of $HX_{cj}$, which was negative before 1993 and positive in the other years, indicates that China adopted an export restriction policy before 1993 and then continued to adopt an export promotion policy until today.

3.2. One sample t-test of Chinese export statistics

Table 2 reported the one-sample t-test results of $NX_{cj}$, $RX_{cj}$ and $HX_{cj}$ for the Chinese antibiotic product exports. The test value was set to be zero in order to examine whether the mean values are statistically significantly different from zero.

| Test value=0 | T-stat | Degree of freedom | Sig. (2-tailed) | Mean difference |
|--------------|--------|------------------|----------------|-----------------|
| $RX_{cj}$    | 27.203 | 32               | 0.000          | 0.336           |
| $NX_{cj}$    | 12.358 | 32               | 0.000          | 0.556           |
| $HX_{cj}$    | 4.594  | 32               | 0.000          | 0.220           |

The mean values of the three trade pattern indicators are all larger than zero with statistical significance at 0.01 confidence level. More specifically, this research found that:

- China had a comparative advantage in the export of antibiotic products from 1987 to 2019, as the average $RX_{cj}$ over the sample period was 0.036;
- Chinese antibiotic products have a trade surplus, so the mean value of the indicator of $NX_{cj}$ is 0.550 above the test value of zero;
- The mean of the indicator of $HX_{cj}$ is 0.220, showing that the Chinese trade balance has been larger than her export comparative advantage guarantees.

4. Conclusions

By analyzing the comparative advantages and policy intervention indicators of China's antibiotic trade, the following conclusions can be drawn:

- Around 1993, there was a "trade divergence" in China's antibiotic trade. As can be seen from Figure 1, export control was greatly relaxed in 1992 and export promotion policy was implemented in 1993. With the continuous development of China's biopharmaceutical industry and good foreign trade relations with other countries, China surpassed the United States and became the world's largest exporter of antibiotic products in 2018. After the outbreak of novel coronavirus, the international trade of antibiotic products has been greatly affected. More than 100 countries have adopted export control policies, so China's export of antibiotics in 2019 has declined, but due to China's better prevention and control of the epidemic, the export advantage of antibiotics has increased to a small degree.

- As far as the above studies are concerned, we find that China has a significant comparative advantage in the export of antibiotic products ($RX_{cj}$ mean=0.336, p=0.000), and has significantly (p=0.000) promote the export of the antibiotic products , generating a mean policy intervention indicator of 0.220 for the period of 1987-2019. Under the government promotion, the export of antibiotics has been increasing and stimulated the continuous development of the level of biopharmaceutical, and correspondingly improves the comparative advantage of China's antibiotics.

Each country or region can adopt policies suitable for its own development according to its own development situation. Policy intervention should not be regarded as the opposite of free trade, but only as a means to regulate trade. We should take a rational view of policy intervention. Whether it is to restrict import or promote export, as long as the policy is properly used, it can be transformed into
its own comparative advantage and improve industrial competitiveness. At the same time, although China has achieved rapid development in the export of antibiotics, compared with developed countries, our level of biopharmaceutical has yet to be improved.

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