Linear Analysis of the Correlation Between Industrial Development and Foreign Trade Development in Guangdong Province—Based on Time Series Data from 2005 to 2018

Jiayi Zhong*

1Department of Economics and Trade, Guangzhou College of Technology and Business, Guangzhou, Guangdong, 510850, China

*Corresponding author’s e-mail: 281099022@qq.com

Abstract. As a developed province along the eastern coast of China, Guangdong Province has a close relationship between industrial development and foreign trade. Based on the 2005-2018 time series data, the relevant principles and methods such as least squares method and elasticity theory were used to conduct an empirical analysis of the correlation between Guangdong's industrial development and foreign trade. The research found that compared with the tertiary industry, the secondary industry is more closely related to foreign trade. However, the tertiary industry is more sensitive to changes in foreign trade. Based on the quantitative measurement of the correlation between industrial development and foreign trade, a number of policy recommendations were proposed.

1. Introduction
Since the reform and opening up, Guangdong Province has maintained rapid economic development due to its location advantages, policy advantages and cost advantages. The economic aggregate has maintained its number one position in the country for many years. Guangdong Province has superior geographical conditions, a long coastline and a good port group. It is the economically developed region with the closest maritime distance between China and the Maritime Silk Road. With the formal proposal of the concept of “Guangdong, Hong Kong and Macao Bay Area”, the central government requires Guangdong to be at the forefront of the country in forming a new pattern of comprehensive opening up. It can be seen that the opening up of the new era still occupies an important position for the high-quality development of the Guangdong economy. In recent years, trade protectionism and isolationism have re-emerged in the Western world. Political businessman Trump has ignored the rules of world trade and launched a trade war on a global scale, making Guangdong as an export-oriented economy, also facing many challenges. This paper analyzes the added value of the secondary industry and the added value of the tertiary industry in Guangdong Province from 2005 to 2018, empirically analyzes the synergy between industrial development and foreign trade in Guangdong Province, and transforms the industrial transformation and upgrading of Guangdong Province to realize the transformation of old and new kinetic energy of economic development. Provide a certain theoretical support for taking the road of high quality development.

2. Literature Review
Under the background of global economic integration, scholars generally believe that foreign trade can significantly affect the industrial structure and development level of the economy. This is especially
true of Guangdong Province as the frontier of national reform and opening up. Xuefeng Qian (2017) and others believe that foreign trade can have an impact on industrial structure through two ways: technology spillovers and factor endowments [1]. Mingsen Chen (2003) pointed out that the differences in trade objects and the different stages of development will have different effects on the industrial structure [2]. Hubin Guo (2018) used the theory of synergy to conduct an empirical study on the synergy between China's modern logistics industry and foreign trade, and found that there is a long-term stable synergistic relationship between them [3]. Fang Qu (2007) proposed some policy recommendations to promote the development of China's industry from the positive and negative aspects of foreign trade [4].

In order to achieve the transformation and upgrading of the economic structure and industrial structure, Guangdong Province must maintain its leading position in the international division of labor and achieve a higher level of opening up to the outside world, so that it must give full play to the benign interaction between foreign trade and industrial development.

3. An Empirical Analysis of the Coordination between Industrial Development and Foreign Trade in Guangdong Province

3.1. Indicator selection
According to the general statistical methods, the national economy can be generally divided into the primary industry, the secondary industry and the tertiary industry, followed by agriculture, industry and service industries. Referring to the existing research results, and taking into account the availability of data, this paper selects the output value of the second industry (SI) and the tertiary industry output value (TI) of Guangdong Province as representative variables of industrial development to characterize the industrial development of Guangdong Province. The relevant indicators of foreign trade are expressed by total export volume (EX), total import value (IM) and total import and export volume (IEX). The time span of data is 2005-2018, and the source is the statistical yearbook of Guangdong Province. Considering the possible heteroscedasticity of time series variables, all variables are logarithmically processed, which are recorded as Log SI, LogTI, LogEX, LogIM, and LogIEX. Eviews10.0 measurement software is used to analyze and process the data.

3.2. Analysis of correlation coefficient between variables
In order to research the synergistic development relationship between the various indicator variables of industrial development in Guangdong Province (the output value of the secondary industry and the output value of the tertiary industry) and the various indicators of foreign trade (total export volume, total import volume, total import and export volume), the correlation coefficient is determined. The specific results are shown in Table 1:

| Correlation coefficient | IM   | EX   | IEX  | SI   | TI   |
|-------------------------|------|------|------|------|------|
| IM                      | 1    |      |      |      |      |
| EX                      | 0.8745 | 1    |      |      |      |
| IEX                     | 0.9464 | 0.9836 | 1    |      |      |
| SI                      | 0.7503 | 0.9249 | 0.8870 | 1    |      |
| TI                      | 0.6406 | 0.8443 | 0.7921 | 0.9642 | 1    |

It can be seen that the correlation coefficient between Guangdong's secondary industry and total exports is the highest, at 0.9249, followed by the total volume of imports and exports, at 0.8870. Compared with the secondary industry, the correlation coefficient between the tertiary industry and foreign trade is low, with a maximum of 0.8443 and a minimum of 0.6406. It can be seen that
Guangdong Province, as a coastal open area and a traditional manufacturing province, has a higher correlation between the development of the secondary industry and foreign trade.

3.3. Building a linear correlation model

Referring to the research method of Hubin Guo (2018), the OLS method is used to carry out regression analysis on the data to examine the synergy between the secondary industry and the tertiary industry and foreign trade.

3.3.1. The Secondary Industry——Cooperative Development Model of Foreign Trade

The output of Guangdong’s secondary industry and three variables which represent the degree of foreign trade development of output value, imports value, and total imports and exports value are used to establish a linear correlation model for the coordinated development of secondary industry output and total exports, total imports, and total imports and exports. A synergy analysis can be obtained:

\[
\begin{align*}
\log(SI) &= 1.5534 \log(EX) - 6.0523 \quad (1) \\
\log(SI) &= 1.8370 \log(IM) - 8.3155 \quad (2) \\
\log(SI) &= 1.6992 \log(IEX) - 8.4593 \quad (3)
\end{align*}
\]

The statistical results of the second industry-foreign trade synergy development model fitting equation are shown in Table 2:

| Fitting equation | Sd   | T value | F value | R²   | AdjR² | P value |
|------------------|------|---------|---------|------|-------|---------|
| Formula (1)      | 0.1216 | 1.2646 | 12.7719 | -4.7859 | 163.1217 | 0.9315 | 0.9258 | 0.0000 |
| Formula (2)      | 0.2655 | 2.6608 | 6.9205  | -3.1253 | 47.8931  | 0.7996 | 0.7829 | 0.0000 |
| Formula (3)      | 0.1589 | 1.7355 | 10.6932 | -4.8743 | 114.3452 | 0.9050 | 0.8971 | 0.0000 |

It can be seen from Table 2 that the goodness of fit of formula (1) is the best, and the coefficient of determination AdjR² is 0.9258, which indicates that the correlation between the development level of the secondary industry in Guangdong and the total export volume is the highest. Followed by the total import and export, AdjR² is 0.8971. The lowest correlation is the total imports, i.e. AdjR² is 0.7829. From the overall linear regression equation of the above model, the degree of synergy between the development level of the secondary industry in Guangdong Province and the foreign trade indicators is relatively high, which is inseparable from the status of Guangdong as a traditional manufacturing province and a coastal open area.

3.3.2. The Tertiary Industry——Cooperative Development Model of Foreign Trade

Using the output value of the tertiary industry, total export value, total import volume, and total import and export volume to establish a linear correlation model for the synergistic development of tertiary industry output value and total export value, total import value and total import and export volume. A synergy analysis can be obtained:

\[
\begin{align*}
\log(TI) &= 2.0451 \log(EX) - 11.1608 \quad (4) \\
\log(TI) &= 2.3722 \log(IM) - 13.6701 \quad (5) \\
\log(TI) &= 2.2236 \log(IEX) - 14.1827 \quad (6)
\end{align*}
\]

The tertiary industry-foreign trade synergy development model fitting equations related statistical results are shown in Table 3:
Table 3. Tertiary industry - foreign trade synergy development model fitting equation related statistical results table

| Fitting equation | Sd Coefficient | T value Coefficient | F value | R² | AdjR² | P value |
|------------------|----------------|--------------------|---------|----|-------|---------|
| Formula (1)      | 0.1943         | 2.0200             | 10.5261 | -5.5249 | 110.7997 | 0.9023 | 0.8941 | 0.0000 |
| Formula (2)      | 0.4004         | 4.0138             | 5.9240 | -3.4073 | 35.0934 | 0.7452 | 0.7240 | 0.0000 |
| Formula (3)      | 0.2523         | 2.7560             | 8.8118 | -5.1462 | 77.6472 | 0.8661 | 0.8550 | 0.0000 |

It can be seen from Table 3 that the goodness of fit of formula (4) is the best, in which the coefficient of determination AdjR² is 0.8941, but lower than 0.9258 of the secondary industry; and the goodness of fit of the remaining linear regression equation models is also lower than that of the secondary industry. It can be seen that compared with the secondary industry, the synergy between the development of tertiary industry and foreign trade in Guangdong Province is relatively low, and Guangdong Province is still in the process of transition from industrial economy to service economy.

3.4. Elastic Analysis of Foreign Trade Promoting Industrial Development in Guangdong Province

In the definition of economics, elasticity refers to the ratio of the relative change of the economic variable as the dependent variable to the relative change of the economic variable as the independent variable, which can be used to analyze the sensitivity of one variable to another. It is generally believed that when the absolute value of the elastic coefficient is greater than 1, it is elastic, and vice versa. According to the collaborative development model and each linear regression equation, Table 4 shows the elastic coefficient of the second and third industry indicator variables of Guangdong Province on the changes of foreign trade indicators.

Table 4. Elasticity coefficient of the secondary and tertiary industry indicator variables of Guangdong Province on the changes of various indicators of foreign trade

| Indicator variable | Log(IM) | Log(EX) | Log(IEX) |
|--------------------|---------|---------|----------|
| Log(SI)            | 1.8370  | 1.5534  | 1.6992   |
| Log(TI)            | 2.3722  | 2.0451  | 2.2236   |

As can be seen from the above table, compared with the secondary industry, the development of tertiary industry in Guangdong Province is sensitive to changes in foreign trade (elasticity coefficient is greater than 2), probably because foreign trade can promote the cross-border of capital and technological factors. The flow of foreign capital into the tertiary industry is faster than that of the secondary industry, making the tertiary industry more sensitive to changes in foreign trade.

4. Conclusion

Based on the relevant indicators of the added value of the secondary industry in Guangdong Province, the added value of the tertiary industry and foreign trade in 2005-2018, the synergistic theory was used to empirically analyze the synergistic development relationship between China's industrial development level and foreign trade. The results show that the degree of synergy between the development level of the secondary industry in Guangdong Province and the indicators of foreign trade is relatively high, indicating that foreign trade can significantly promote the development level of the secondary industry, which is consistent with the status of Guangdong Province as a manufacturing province. At the same time, relative to the secondary industry, the development of tertiary industry in Guangdong Province is sensitive to changes in foreign trade, which may be related to the rapid transition of Guangdong Province from the industrial economy stage to the service economy stage, making the tertiary industry and foreign trade The coefficient of elasticity is higher. In summary, in order to promote the coordinated development of industrial development and foreign
trade in Guangdong Province and achieve high-quality economic development, the following policy recommendations are proposed:

4.1. Enhance the synergy between industrial development and foreign trade, initiative in the government

While deepening the opening up of the country, Guangdong Province must handle the relationship between the government and the market, adhere to the organic unity of effective markets and promising governments. First of all, we must rationalize the boundary between the government and the market, reduce intervention, strengthen coordination, and promote the coordinated development of industry and foreign trade in the process of optimizing resource allocation in the market. Besides, it is necessary to strengthen the government's macro-control function, especially in the current complex environment of Sino-US trade friction, to find the best combination of market function and government behavior, and to minimize the negative impact of trade disputes.

4.2. Enhance the synergy between industrial development and foreign trade, settle in the enterprise

Guangdong Province should create a more open and convenient business environment, reduce taxes and reduce fees, simplify administration and decentralization, effectively reduce the transaction costs of enterprises, especially institutional transaction costs, and boost market vitality. At the same time, Guangdong Province should strengthen intellectual property protection, encourage innovation, provide a more convenient trading environment, promote the establishment of overseas high-quality enterprises, stimulate the endogenous power of enterprises as the micro-main body of economic development, and realize the coordinated development of enterprise-industry-foreign trade.

4.3. Enhance the synergy between industrial development and foreign trade, adhere to a global perspective

Guangdong Province has two major policy advantages in the development of the Free Trade Zone and Guangdong, Hong Kong and Macao Dawan District. It must meet high standards of international trade and economic rules, implement high-level trade and investment liberalization and facilitation policies, greatly relax market entry barriers for industrial development, and create more open conditions for the coordinated development of industrial development and foreign trade.

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