Empirical Study on the Environmental Effect of Global Value Chains: Based on Scale, Technique and Composition Effects

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Abstract: This paper attempts to empirical analyze the environmental impacts of Global Value Chains (GVC) based on the scale, technique and composition effects according to the mechanism of environmental caused by trade. Through using panel-data model of China's industrial data, this paper analyzes the size and the direction of different effects of GVC on environment. And the conclusion shows that GVC has negative effects both on technique and composition, but has positive scale effect. On the whole, environmental effect caused by trade has a negative effect. The effective channel of achieving the positive effect of GVC includes guiding industrial arrangement rationally, bringing technological progress and technological diffusion into play fully and enhancing environmental regulation powerfully.

1. Introduction

With the rapid development of technology globalization and trade liberalization, international trade barriers and multinational production costs have been reduced across the board, the GVC specialization characterized by process division has become a new mode of international division of labor, thus the operation mode of the global economy has changed greatly. Countries in the specialization of GVC with a comparative advantage in a certain procedure or process of production can participate in the international division of labor. In the process of participating in the GVC, China takes processing trade and foreign investment as a breakthrough point, gradually integrates into the global production network in the process of reform and opening up, and the degree of participating in the international division of labor keeps improving (CCER2006); China has gradually established the status of "world factory" through actively participating in the specialization of GVC. From the perspective of industry, the industrial sector is China's main industry participating in the GVC. Over the years, the wastewater discharge, exhaust gas discharge and solid waste production of export-oriented industrial sector have kept increasing (LiuJing 2009), and China's environment pollution has become a growing problem. Taking sulfur dioxide emission as an example, China's SO_2 emission ranks first in the world, of which industrial SO_2 emission accounted for more than 80% in 2000-2011. By 2011, China's industrial SO_2 emissions had reached 22.172 million tons, increased 38.39% over 2001. In view of the rapid development of China's global value chain and the increasingly serious pollution of the environment, it is necessary to make an in-depth analysis of the relationship between the two. This study will help us to make a more comprehensive and objective evaluation about the impact of the specialization of GVC on China, especially on the environment. The conclusions also have important guiding significance for China to participate in the international division of labor in a more appropriate way and promote the coordinate development of environment and trade.

2. Literature Review

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specialization characterized by process division has become a new mode of international division of labor, thus the operation mode of the global economy has changed greatly. Countries in the specialization of GVC with a comparative advantage in a certain procedure or process of production can participate in the international division of labor. In the process of participating in the GVC, China takes processing trade and foreign investment as a breakthrough point, gradually integrates into the global production network in the process of reform and opening up, and the degree of participating in the international division of labor keeps improving (CCER2006); China has gradually established the status of "world factory" through actively participating in the specialization of GVC. From the perspective of industry, the industrial sector is China's main industry participating in the GVC. Over the years, the wastewater discharge, exhaust gas discharge and solid waste production of export-oriented industrial sector have kept increasing (LiuJing 2009), and China’s environment pollution has become a growing problem. Taking sulfur dioxide emission as an example, China's SO_2 emission ranks first in the world, of which industrial SO_2 emission accounted for more than 80% in 2000-2011. By 2011, China's industrial SO_2 emissions had reached 22.172 million tons, increased 38.39% over 2001. In view of the rapid development of China's global value chain and the increasingly serious pollution of the environment, it is necessary to make an in-depth analysis of the relationship between the two. This study will help us to make a more comprehensive and objective evaluation about the impact of GVC specialization on China, especially on the environment. The conclusions also have important guiding significance for China to participate in the international division of labor in a more appropriate way and promote the coordinate development of environment and trade.

3. Analysis of the Affecting Mechanism of Global Value Chain on Environment

This paper uses the analysis framework of "three eco-environmental effects " to analyse the affecting mechanism of global value chain on environment. The derivation process is as follows:

$$E = T \times S \times Y \tag{1}$$

In the equation, E is the pollution emission, T is the pollution emission technology, S is the proportion of pollution-intensive processes, and Y is the economic scale. Taking derivation of two sides of the equation can decompose the scale effect, composition effect and technique effect, that is,

$$LnE = LnY + LnS + LnT \tag{2}$$

In this equation, ln Y represents the scale effect, ln S represents the composition effect, ln T represents the technique effect, and the three effects collectively represent the environmental effects of trade. The specific explanation is as follows.

3.1 Scale Effect

Under the trend of global economic integration, the trade patterns among countries has gradually changed from the specialization of GVC to a new lab our-division pattern based on global value chain. The production process is distributed into various countries which can participate in the international division of labour with a comparative advantage in a certain procedure or process of production, thus reducing the threshold of participating in the international division of labour. Production process can be broadly divided into R&D, manufacturing and operation. China actively participates in the manufacturing link of global production by processing trade with its advantages in labour resources. After more than ten years of development, China has become a giant manufacturing country in the world, with China-made commodities all over the world. The scale of global value chain is escalating, and the degree of countries participating in the division of labour is getting deeper. However, it cannot be ignored that the extensive development model of "Made in China" leads to the increase of environment pollution emissions year by year. Therefore, the expansion of global value chain may aggravate the environmental pollution in China. On the other hand, with the expansion of trade scale and the improvement of income level, consumers are more

willing to buy "clean" products which have little pollution to environment. At this time, the scale effect is positive, which is beneficial for the improvement of environment.

3.2 Composition Effect

Under the traditional labor-division pattern, the upgrading of a country's industrial structure mainly relies on its comparative advantage of factor endowment to participate in the international division of labor. Generally, after the initial accumulation of industrialization, will the industrial structure of a country climb from resource or labor-intensive industry to capital and technology intensive industry. The emergence of GVC expands the scope of a country's comparative advantage. Even if a country doesn't have a comparative advantage in the production of certain products, it can participate in the international labor-division and trade with a comparative advantage in a specific production stage of product. Thus, developing countries can bypass the initial period of industrial upgrading and develop capital and technology intensive industry directly by participating in the specialization of GVC and engage in production links in which they have comparative advantages. Therefore, global value chain has become a new way for developing countries to realize industrialization and industrial structure upgrading. For China, under the traditional labor-division pattern, Chinese main export products are labor-intensive products such as textiles and clothing in whose production process will produce a great number of pollutants. With the expansion of the scope and scale of the global value chains specialization, China's export trade structure has changed accordingly, and the export products are gradually dominated by capital and technology intensive products which have little pollution, such as electronic products and mechanical products. China's export structure has gradually transformed to "clean" by participating in the specialization of GVC. Therefore, the composition effect of global value chain on environment should be positive.

3.3 Technique Effect

The development of global value chain has promoted the development of China's trade in intermediate goods. China's intermediate goods imports increased from US $63.9 billion in 1995 to US $786.3 billion in 2010, and the imports of intermediate goods accounts for more than 60% of total imports. The import of high-quality and wide-variety of intermediate products will bring the diffusion of foreign advanced technology and new knowledge. Coupled with the dynamic effect of "learning by doing", the global value chain will bring more technology spillover effect. Compared with the traditional trade pattern, global value chain can improve the overall production efficiency of China, reduce the consumption of resources and the pollution of environment. Meanwhile, the development of global value chain has increased the liquidity of international commodities, improved the degree of specialization, and accelerated the formation of scale economy. And scale economy can increase the utilization efficiency of elements, reduce the input of elements per unit output, and then reduce the pollution per unit product.

As the two main forms of China to participate in the specialization of GVC, both FDI and processing trade have technology spillover effects. In the development process of China's global value chain, some foreign advanced technologies and production processes have been introduced, and China's production technology level has also been greatly improved. At the same time, with the raising of environmental protection consciousness and the increasing pressure of emission reduction, enterprises will tend to adopt the advanced drainage facility to reduce the burden of environment; therefore, the technique effect of global value chain on environment should be positive.

4. Model Establishment

According to the conclusion of previous analysis, the impact of global value chain on environment can be divided into scale effect, composition effect and technique effect. Based on this conclusion, a pollution emission model is established:

$$\ln \mathrm{E}_t = c_0 + c_1 \ln Y_t + c_2 \ln S_t + c_3 \ln T_t + c_4 \ln PT + c_5 \ln FDI_t + c_6 \ln R_t + c_7 \ln {K_t}/{L_t} + \varepsilon_t \tag{3}$$

Among them, the subscript “t” represents the year, ε_t represents the stochastic error; ln represents the natural logarithm; c_i represents the corresponding coefficient; there are eight variables in this model: E(pollution emission), Y (scale effect), S (composition effect),T(technique effect), FDI (foreign direct investment), R (regulation of ecological environment), PT (degree of GVC) and K / L (capital-labor ratio).

The meaning of the model is as follows: as mentioned, if other conditions remain unchanged, the development of global value chain will bring more pollution emissions, that is, the partial derivative of pollution emissions to scale effect should be positive and the partial derivative of pollution emissions to composition effect should be determined in combination with the pollution intensity of the processes involved. If it is mostly concentrated in clean procedure, the derivative of emissions to composition effect is negative. Otherwise, the result is reverse. For technique effect, the coefficient of it should be negative because the development of global value chain can bring the progress of emission reduction technology and reduce the pollution emission. Meanwhile, in order to investigate the direct effect of the GVC specialization on environment pollution, the degree of GVC specialization PT is added into the equation to investigate the impact of the labor-division in processes on the environment pollution. As mentioned above, the coefficient of the degree of GVC specialization PT should be negative, that is, the direct impact of the global value chain on the environment should be negative; the main form of the specialization of GVC in China is foreign direct investment which is also added into the equation. Since there is no theory about the direct impact of FDI on the environment pollution, the coefficient of FDI is uncertain at present. Because the intensity of regulation on environment has a direct impact on the environment pollution, the regulation of ecological environment indicator R is added into the equation. The coefficient of regulation of ecological environment should be negative, that is, strict regulation of ecological environment can reduce pollution emissions. The capital-labor ratio K/L is added into the equation to investigate the influence of factor input structure on pollution emissions.

5. Empirical Analysis Results

This paper uses panel model to analyze because it can construct and examine more complex behavior model and better measure the influence factors that cannot be found by the simple time series model or cross-sectional data model. This model includes fixed effect model and random effect model. When both fixed effect model and random effect model are significant, the Hausman test can be used to determine whether the fixed effect model or the random effect model should be used.

5.1 Data Source and Processing

Based on the three eco-environmental effects, this paper uses China's industrial regional panel data and pollution emission data to investigate the impact of global value chain on the environment from 2002 to 2011. In terms of the selection of pollutant emissions, since only the statistics of sulfur dioxide in China's ecological environment yearbook over the years are continuous and consistent, and the domestic emission of SO_2 is relatively stable, the change of total SO_2 emissions can be determined by the change of industrial sulfur dioxide emissions. Therefore, the emission of industrial SO_2 is taken as the data of environment pollution emission. The scale effect “Y” is represented by the gross industrial output value over the years; the composition effect “S” referring to the research of Jie HE (2006),is represented by the product of the proportion of provincial gross industrial output value in its GDP and its initial year (2000) emission intensity (pollution emission per unit GDP). The practice of "emission intensity is always the value of the initial year " can eliminate the impact of changes in technical factors on the economic structure, which corresponds to the definition of composition effect. Technique effect “T” is measured by the investment amount of provincial eco-environmental governance activities. “R” is the regulation of ecological environment. The regulation degree of ecological environment is measured by the pollution abatement costs per unit output value (the ratio of the provincial actual amount of investment to the local GDP). This approach not only fully considers the regional economic aggregate, but also

expresses the determination of the government to control pollution through the pollution abatement costs, which is the same as Zhao Hong's approach (2007). At present, there are three methods to determine the degree of GVC specialization PT: parts and components trade method; input-output method and ratio of processing trade. In this paper, it is measured by the proportion of processing trade in each province, the same as QianJianfeng's method (2009); FDI is represented by the amount of foreign direct investment in each province, and the determination of capital quantity K should have been determined by the capital stock , however , the net value of industrial fixed assets approximately replaces K because of the availability of data, and Li Xiaoping (2005), HuZhaoling, Zhao Yuan (2008), Wang Ling, Tu Qin (2007) have also handled it by similar method in related research; L is the labor input which is expressed by industrial employment population of each province, and the capital-labor ratio "K / L" reflects the change of industrial structure.

This paper selects 30 provinces (autonomous regions and municipalities directly under the central government) of China as research objects, including Beijing, Shanghai, Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan, Shanxi, Jilin, Heilongjiang, Henan, Hubei, Hunan, Anhui, Jiangxi, Sichuan, Chongqing, Yunnan, Guizhou, Shanxi, Gansu, Ningxia, Qinghai, Xinjiang, Inner Mongolia and Guangxi. In view of the availability of data, Taiwan, Hong Kong and Macao are not included in the sample; Tibet is also excluded from the sample due to the lack of individual data. The sample spacing is from 2002 to 2011. The above data are from China Statistical Yearbook, China Industrial statistical yearbook, China Ecological Environment Yearbook, statistical yearbook of each province and relevant information published on the website Commerce Department of each Province. The output value, the investment amount of eco-environmental governance and other data involved in the model are uniformly calculated by deflator according to the price in 2000. The initial data of FDI is US dollars which has been converted according to the exchange rate of each year.

5.2 Econometric Analysis Results and Their Economic Connotations

In this paper, the measuring software STATA12.0 is used to examine the model. The fixed effect model was used in the regression for model after the F-test and Hausman test.

From the fixed effect analysis results (Table 1), it is basically consistent with the theoretical expectation. The output results show that the total number of samples is 300, and the relative goodness-of-fit R^2 (adjusted) is 0.8144, indicating that the fixed effect model can explain the 81.44% change of pollution level. From the perspective of explanatory variables, when the significance levels of foreign direct investment, degree of GVC specialization, composition effect and technique effect is 5%, the test is significantly passed; if the level is relaxed to 10%, the scale effect can also pass the test, which shows that the above five explanatory variables have a significant impact on the emission of environment pollution. The regulation of ecological environment and capital labor input which can be regarded as control variables failed to pass the test. Among all the explanatory variables, scale effect and FDI are positively correlated with pollution emission, and negatively correlated with the composition effect, technique effect and degree of GVC specialization.

According to the analysis results, the equation form is as follows:

$$LnE = 3.06757 + 0.03046\ LnY - 0.06246\ \ln S - 0.34368\ LnT - 0.03439\ LnPT + 0.05640\ LnFDI \quad (4)$$

The specific analysis results are as follows:

5.2.1 The change of scale effect and pollution emission is in the same direction, which shows that with the increase of industrial activities and industrial scale, the ecological environment pollution will also increase. For every 1% increase in income, the pollution emission changes 0.03046% in the same direction. If we use Environmental Kuznets Curve (EKC) to explain this phenomenon, it shows that the income level is still on the left side of the Environmental Kuznets Curve, and has not passed the highest point. With the expansion of industrial scale and the income continues to increase, the degree of industrial pollution will also improve. The expansion of industrial scale leads to the increase of China's pollution level, which indicates that China's

economic growth pattern is still in the extensive growth stage, and this is related to China's relatively loose level of ecological environment regulation.

5.2.2 The technique effect is negative, and the pollution emission can be reduced by 0.34368% with every 1% change of technical progress, which shows that the technical progress has a positive effect on the control of pollution level. Technological progress can improve the utilization rate of resources and ultimately reduce the overall level of ecological environment pollution through the renewal of equipment and technology. Therefore, promoting the transformation of industrial structure and the introduction of advanced technology is the essential way to achieve the coordinate development of global value chain and environment.

Table 1. Fixed effect test results.

explanatory variables	coefficients	The value of “t”
LnY	0.0304611***	1.13
LnS	-.0624612**	-2.1
LnT	-.3436868**	-5.5
LnPT	-0.0343921*	-1.88
LnFDI	-.0564041**	-4.60
LnR	-0.0823507	-2.61
LnK/L	-0.0531603	-2.41
constant term	3.06757	--
R^2(adjusted)	0.8144	--
Sample number	300	--

Note：*, * * and* * * represent significant at the level of 10%, 5%, and 1% respectively.

5.2.3 The composition effect is negative, which shows that under the context of the GVC specialization, with the deepening of participation in the GVC specialization, China's participation in the production stage has a trend of changing from "pollution type" to "clean type", and the pollution emission will be reduced by 0.0624% with every 1% change. Therefore, it can be indicated that China's participation in GVC specialization and trade can reduce environment pollution.

5.2.4 The level of GVC specialization is significant at the level of 5%, which changes in the opposite direction with the pollution emission. The pollution emission will be reduced by 0.0343% with each 1% increase in the degree of GVC specialization, which shows that the improvement of the degree of GVC specialization can reduce the ecological environment pollution and is beneficial to the protection of environment. The main reasons are as follows: first, in the global production networks, instead of being limited to the low-end assembly link which relies on low labor prices and energy factors , China began to shift to the mid-to high-end links of the global value chain; second, the GVC specialization can separate different production stages into different countries, and the best allocation of resources can be achieved in each process of production, thus obtaining the benefits of scale economy, the level of energy consumption per unit product will also be greatly reduced; third, a large number of intermediate product trade has promoted the optimization of China's export commodity structure. According to statistics, electromechanical products, high-tech products and other products are the main export products in China's global value chain. According to the study of Li Xiaoping (2010), these products are mainly low pollution products. Therefore, the global value chain is more conducive to the development of China's economy in the direction of "clean".

5.2.5 The significance of foreign direct investment which changes in the same direction with pollution emission is very high. For every 1% increase in foreign direct investment, pollution emission increases by 0.056%. It shows that due to the relatively loose policies and standards of ecological environment in China and the low environment cost that manufacturers pay for their products, these countries will tend to transfer industries with external negative effect which have high consumption of resources and serious ecological environment pollution to China when they invest in China. While they obtain cheap resources and labor, they also obtain the advantages of low

standards of ecological environment, thus gaining its products a more obvious price advantage.

6. Conclusions and Suggestions

6.1 Conclusions

In this paper, the measuring software STATA20.0 and regional panel data is used to empirical study the eco-environmental effects of global value chain, the conclusions are as follows:

5.1.1 The scale effect of global value chain on environment is positive (0.0304611), the composition effect is negative (-0.0624612), and the technique effect is negative (-0.3436868). Therefore, the total effect of global value chain on environment is -0.3756869 (scale effect + composition effect + technique effect), which shows that in general, the development of global value chain is beneficial to environment protection.

5.1.2 The measuring results of foreign direct investment show that the inflow of foreign capital will aggravate the environment pollution, which is not conducive to the protection of environment.

5.1.3 The control of ecological environment regulation on pollution level is not obvious, which shows that China's control and supervision of ecological environment regulation on pollution is weak, the laws and regulations of environment protection are inadequate.

6.2 Suggestions

According to the analysis conclusion, we should take positive policy measures to encourage enterprises to participate in the production links or sections with high added value and less environmental pollution in the GVC specialization by constantly improving their competitiveness and optimizing their comparative advantages, thus promoting the upgrading of trade structure and industrial structure. Secondly, when introducing foreign investment, we should take environment factors into consideration, instead of just considering the pulling effect of foreign investment on the economy and ignore its impact on the environment. We should guide foreign investment to clean industries or clean product production stages through policies, thus enhancing the positive impact of foreign direct investment on environment.The trade and industrial structure are constantly optimized to be "clean”, while achieving the expansion of trade and investment scale. In addition, the government departments should further improve the system of environment regulation, and the local governments should strengthen supervising and executing the laws of relating regulation of ecological environment protection, so as to ensure that the composition effect and scale effect of the global value chain on environment can be promoted to the maximum extent from the system, thus reducing the negative effect of scale effect, and finally realize the protection of the ecological environment.

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