The Effect of Wood Forest Products Import on Pollution Emissions: Evidence from China’s Forest Products Industry

Yuling Mao¹, Lu Wan¹,² and Yuting Zhang¹

¹School of Economics and Management, Beijing Forestry University, Beijing, China
ªcorresponding author’s e-mail: dufexiaolu@163.com

Abstract. The article uses the product-level and industry-level data to empirically test the relationship between China’s import of wood forest products and the pollution discharge of forest products industry from 2003 to 2015. The results of the benchmark model show that the import of wood forest products has a significant role in reducing the pollution emission of forest products industry. Furthermore, taking the total factor productivity as the intermediary variable, it is found that the import of wood forest products can improve the total factor productivity, thus promoting the pollution emission reduction of forest products industry. In addition, from the perspective of different factor intensive products, the empirical results show that the capital and technology intensive and the labor-intensive have different positive effects on pollution reduction through the improvement of total factor productivity.

1. Introduction

China’s import of forest products has grown steadily and rapidly since the 1990s. The import value in 2018 has increased by 5.2 times compared with that in 2000. In the meantime, the rapid development of forest products industry which is the core of China’s forestry economic growth has promoted China’s forestry industry[1]. In 2018, the State Council of China issued the Opinions on Comprehensively Strengthening Ecological Environment Protection and Resolutely Fighting Pollution Prevention and Control. Furthermore, the 2020 UN Commemoration Summit reaffirmed the important role of sustainable development in balancing security and development. In 2020, the Chinese government put forward the vision and goal for the ecological environment and construction by 2030, and made arrangements for “promoting green development and improving the harmonious coexistence of human and nature.”

Under the background of advocating green development, it is of great importance to study the impact of wood forest product import on the forest products industry that would cause pollution emissions. Further, it examines the differences in the effects of imported wood forest products with various factor intensities. Not only can it contribute to pollution reduction in the forest products industry, but it can also provide new ideas for the future green development of the industry. Therefore, firstly it establishes the benchmark regression model, on the basis of the existing theoretical framework, to study the influence level of wood forest products import on the pollution emission of the industry. Then it uses the measured total factor productivity as the intermediary variable to further build a mediation model to test its impact path. In the end, after analyzing the empirical results, this paper puts forward implications for reducing pollution emissions from the import of wood forest products.
2. Theoretical framework and hypotheses
In the field of environmental pollution emission research, sufficient studies have revealed the relationship between environmental pollution and total factor productivity. Wang et al.(2012) found that the more environmental pollution, the greater the consumption of environmental resources, and pollution reduction was manifested as a productivity improvement[2]. Peng and Gan(2020) studied the impact of manufacturing industry agglomeration on corporate pollution intensity, they concluded that the increase in corporate total factor productivity was the main reason for the pollution reduction effect[3]. Tu and Xiao(2009) investigated the influence of environmental total factor productivity on the transformation of industrial growth patterns, they found that environmental total factor productivity was the core driving force for the reduction of industrial pollution in China, and also concluded that technological progress is the main driving force for the growth environmental total factor productivity[4]. In the conclusions of the existing literature, the increase in total factor productivity promotes or triggers pollution reduction, and the main reason for the increase in total factor productivity is technological progress. In the theory of endogenous economic growth, for countries with open economy, technology spillovers from international trade would promote technological progress in the country or region. As a way of international technology spillover, import has an impact on total factor productivity[5]. In addition, international trade can also have a two-sided impact on total factor productivity through competition effects. Melitz(2003)[6] and Melitz et al.(2008)[7] used theoretical models to reveal that imports affected firm productivity through “selection effects” and “learning effects”. Loof and Andersson(2010) found that the quality level and technical content of imported products were closely related to total factor productivity through empirical research[8]. Jing and Zhang(2014) believed that imported products often contained more advanced clean production technologies. Import was conducive to importing countries to learn, imitate and innovate clean technologies from exporting countries, and it would also encourage enterprises to increase clean technology R&D because of intensified market competition[9].
In summary, import will have an impact on total factor productivity through technology spillovers and competition effects, while total factor productivity will further affect pollution emission, which to a certain extent suggests the possible pollution reduction effect by import from the mecanism of total factor productivity. Therefore, we will give an in-depth explanation of the relationship between wood forest product import and pollution emission of the forest products industry from the perspective of industrial total factor productivity.

- **Hypothesis 1**: The import of wood forest products will generally promote pollution reduction in the forest products industry.
- **Hypothesis 2**: The import of wood forest products reduces pollution emissions from forest products industry by improving total factor productivity.
- **Hypothesis 3**: Importing capital and technology intensive wood forest products can increase the industry’s total factor productivity, thereby promoting emission reduction in the forest products industry.

3. Empirical specification and data

3.1. The definition and code of wood forest products
This paper divides wood forest products into roundwood, sawnwood, other raw wood, wood-based panel, wood products, wood furniture, wood pulp, paper and paper products. According to the China national standard GB/T 4754-2002 *National Economic Industry Classification*, we define the industry scope of forest products industry[10], which mainly includes wood processing industry, furniture manufacturing industry, paper and paper products industry. Next, according to the matching principle between *the China Customs Statistical Coordination Code* and the forest product industry compiled by Sheng(2002)[11], we obtain the wood forest products’ HS codes of forest products industry as the following: a. wood processing industry: other raw wood(4404, 4405), sawnwood(4406, 4407), wood-based panel(4408, 4409, 4410, 4411, 4412). b. furniture manufacturing industry: wood products(4413,
4414, 4415, 4416, 4417, 4418, 4419, 4420, 4421). b. Furniture manufacturing industry: wood furniture(940161, 940169, 940330, 940340, 940350, 940360). c. paper and paper products industry: wood pulp(4701, 4702, 4703, 4704, 4705, 4706, 4707), paper and paper products(4801, 4802, 4803, 4804, 4805, 4806, 4807, 4808, 4809, 4810, 4811, 4812, 4813, 4814, 4815, 4816, 4817, 4818, 4819, 4821, 4822, 4823).

3.2. Model and variables

3.2.1. Benchmark model. Huang(2020)[12] built a pollution emission effect model based on the theoretical framework of Antweiler et al.(2001)[13]. In order to investigate the overall impact of wood forest products import on forest products industrial pollution emissions, this paper uses the methodology of Huang (2020) to establish benchmark as follows:

\[
\ln Y_{i,t} = \alpha_0 + \beta_1 \ln im_{i,t,x} + \beta_2 f_{di,t} + \beta_3 lnsz_{i,t} + \beta_4 ln r_{i,t} + \beta_5 ln rd_{i,t} + \mu_{i,t}
\]

(1)

Where subscript \(i=1, 2, 3\) represents the three forest products industries. \(j=1, 2, 3\), represents industrial waste water, industrial waste gas and industrial solid waste. \(x=1, 2, \ldots\), indicates the product category of wood forest products. \(t=2003, 2004, \ldots, 2015\), is the sample period. \(\beta_1, \beta_2, \beta_3, \beta_4, \beta_5\) are coefficients. \(Y_{i,t}\) represents the emissions or production of j pollutant of the i industry in the t year. \(\ln im_{i,t,x}\) is the trade value of x wood forest product imported by i industry in t year. \(f_{di,t}\) refers to foreign direct investment for i industry in t year. \(\ln sz_{i,t}\) indicates the scale of production of i industry in t year. \(\ln r_{i,t}\) indicates the level of environmental regulation of j pollutant of i industry in t year. \(\ln rd_{i,t}\) represents R&D investment of i industry in t year.

3.2.2. Mediation effect model. In the theoretical analysis, it is summarized that the import of wood forest products affects forest products industrial pollution emissions by promoting the total factor productivity. The mediation effect model can be used to determine the influence path between the two. Based on the study of Wen et al.(2004)[14], the following mediation effect model is constructed:

\[
\ln Y_{i,t} = \alpha_0 + \theta_1 \ln im_{i,t,x} + \theta_2 f_{di,t} + \theta_3 \ln sz_{i,t} + \theta_4 \ln r_{i,t} + \theta_5 \ln rd_{i,t} + \mu_{i,t}
\]

\[
\ln TFP_{i,t} = \alpha_1 + \delta_1 \ln im_{i,t,x} + \delta_2 f_{di,t} + \delta_3 \ln sz_{i,t} + \delta_4 \ln r_{i,t} + \delta_5 \ln rd_{i,t} + \mu_{i,t}
\]

\[
\ln Y_{i,t} = \alpha_0 + \varphi_1 \ln im_{i,t,x} + \varphi_2 f_{di,t} + \varphi_3 \ln sz_{i,t} + \varphi_4 \ln r_{i,t} + \varphi_5 \ln rd_{i,t} + \varphi_6 TFP_{i,t} + \mu_{i,t}
\]

(2)

Where \(\ln TFP_{i,t}\) is the total factor productivity of the i industry in the t year.

3.3. Variables

3.3.1. Explained variables. The industrial pollution discharge mainly includes industrial waste water, industrial waste gas and industrial solid waste, so select the industrial waste water discharge \(f_s\), industrial waste gas discharge \(f_g\) and industrial solid waste production \(f_g\) of three forest products industries as the explained variables.

3.3.2. Explanatory variables. In order to analyze the effect of wood forest products import on industrial pollution emissions, the explanatory variable is the import trade volume of wood forest products. The required product code is obtained by matching the HS code of wood forest products with the HS code of forest products industrial products.

3.3.3. Mediation variables. According to the above analysis, the import of wood forest products promotes the emission reduction of industrial pollution by increasing the industrial total factor.
productivity. In order to verify this effect, the industrial total factor productivity is regarded as an intermediary variable, the Stochastic Frontier Analysis (SFA) method is adopted to measure the industrial total factor productivity in the form of a logarithmic production function. The specific setting of the beyond logarithmic production function is as follows:

\[
\ln Y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln X_{nit} + \beta_t t + \sum_{n=1}^{N} \sum_{j=1}^{N} \beta_{nj} \ln X_{nit} \times \ln X_{jit} + \beta_{tt} t^2 + \sum_{n=1}^{N} \beta_{tn} t \times \ln X_{nit} + v_{it} - \mu_{it}
\]

(3)

Where \( Y_{it} \) is the output of \( i \) industry in the \( t \) year, expressed by the industry’s industrial sales value. \( X_{it} \) is the input of \( i \) industry in the \( t \) year. Learning from Han and Zhou (2020) [15], we take the net fixed capital of the industry and the average number of employees as input data. At the same time, the value expressed in monetary form in output index and input index is converted into constant price in 2003 with using the producer price index of industrial products in different industries.

3.3.4. Control variables. Based on the summary and analysis of existing research, four control variables are included. They are industry scale, R&D investment, foreign direct investment, and industry environmental regulation.

3.4. Data sources
Since the China Environmental Statistics Yearbook has not counted the industrial waste water, industrial waste gas emissions and industrial solid waste production in each subdivision industry since 2016, this paper selects 2003-2015 as the sample period. Data on the three types of industrial pollutants as explanatory variables is from China Environmental Statistics Yearbook. Import data of wood forest products comes from the WITS database (https://wits.worldbank.org/). Industry environmental regulation data is from China Environment Statistics Yearbook. Industry R&D internal expenditure is from China Science and Technology Statistics Yearbook. Industry foreign direct investment comes from China Statistical Yearbook, and the data of industry scale comes from China Industrial Economic Statistics Yearbook. After obtaining the data of each variable, the variables measured in currency are converted into GDP reduction index to eliminate the inflation factor.

4. Empirical results
4.1. Benchmark results
The panel data of the benchmark model conforms to the short panel, therefore we conduct Hausman test and F test before performing the panel regression. In addition, direct estimation of different data structures may underestimate statistical errors, so cluster standard errors are used to correct them[16]. Table 1 is the regression results of the benchmark model. The three columns(a)(b)(c) are the effect results of the wood forest products import on the three types of pollutants discharged by the forest products industry. All the influence coefficients of \( \ln \) in the table are negative, which are significant at the levels of 5%, 5% and 10% respectively. This indicates that the discharge of various pollutants in the forest products industry will decrease with the expansion of wood forest products import, which verifies Hypothesis 1. That is, import of wood forest products has emission reduction effect on all kinds of pollutants in forest products industry, but the impact levels are different.
The industry directs a significant pollution to the environment when it emits significant pollutants. The contribution of the industry to GDP is 5%, which plays a critical role in the industrial economies. The products of this industry are cleaner and more efficient. However, the forest industry is subject to emission regulation and other positive impacts. The sewage treatment of wood industry, by increasing the economic scale, reduces the level of pollution significantly. The pollution level at the forest industry is reduced by 1%, which reaches an emissions level of 10%, 5%, and 1%. The industry's pollutants are negatively correlated with the scale of the industry. The cost of products in the industry is reduced, and the efficiency of energy use is improved, thus reducing the emission of pollutants. Both influence coefficients of industry R&D investment and three kinds of pollution emissions are negative, and they are significant at the level of 1%. Among them, R&D investment on industrial wastewater emission reduction is the largest. Environmental regulation has a positive correlation with the discharge of three kinds of pollutants, and all of them are significant at the level of 1%, which indicates that the environmental pollution control in the industry has not achieved the expected effect. This may be because the treatment cost in environmental regulation is mainly aimed at sewage treatment, that is to say, it is difficult to effectively promote the industry enterprises to develop and adopt green cleaner production technology, and can not further reduce the emission of pollution [17].

4.2. Impact mechanism test

Test the ways of affecting industrial pollution emission of wood forest products. Tables 2 to 4 are the results of the mechanism test and regression of the import of wood forest products on the discharge of different types of pollutants from the forest products industry. From these tables, it can be seen that the import of wood forest products can further affect the industry pollution emissions by increasing the total factor productivity of forest products industry, verifying Hypothesis 2. 

### Table 1. The results of Benchmark model regression

| variables | industrial waste water | industrial waste gas | industrial solid waste |
|-----------|------------------------|----------------------|-----------------------|
|           | (a)                    | (b)                  | (c)                   |
| lnim      | -0.0120***             | -0.0174***           | -0.0140*              |
| fdi       | -0.7306***             | -3.0743***           | -2.6775***            |
| lnsize    | -0.1104***             | -0.0283***           | -0.0230**             |
| lnrd      | -0.3919***             | -0.1887***           | -0.1195***            |
| lner      | 1.1829***              | 0.5876***            | 0.7916***             |
| constant  | 3.8182***              | 5.2135***            | 6.4343***             |

*, **, *** respectively indicate that the variables are significant at the levels of 10%, 5% and 1%.

In addition to the core explanatory variables, each control variable has different effects on pollutant emissions in forest products industry. Foreign direct investment (fdi) in the three types of pollutant emission models are significantly negative at the level of 1%, indicating that industry pollution emissions decrease with the increase of foreign direct investment. The entry of foreign direct investment is often accompanied by advanced clean technology and production technology, which can play a considerable role in reducing pollutants. All the industry scale (size) coefficients of the three types of pollutants are negative. For the industry, when it reaches a certain scale, it brings economies of scale. Under the economies of scale, the cost of products in the industry is reduced and the efficiency of energy use is improved, thus reducing the emission of pollutants. Both influence coefficients of industry R&D investment (rd) and three kinds of pollution emissions are negative, and they are significant at the level of 1%. Among them, R&D investment on industrial wastewater emission reduction is the largest. Environmental regulation (er) has a positive correlation with the discharge of three kinds of pollutants, and all of them are significant at the level of 1%, which indicates that the environmental pollution control in the industry has not achieved the expected effect. This may be because the treatment cost in environmental regulation is mainly aimed at sewage treatment, that is to say, it is difficult to effectively promote the industry enterprises to develop and adopt green cleaner production technology, and can not further reduce the emission of pollution [17].

### 4.2. Impact mechanism test

Test the ways of affecting industrial pollution emission of wood forest products. Tables 2 to 4 are the results of the mechanism test and regression of the import of wood forest products on the discharge of different types of pollutants from the forest products industry. From these tables, it can be seen that the import of wood forest products can further affect the industry pollution emissions by increasing the total factor productivity of forest products industry, verifying Hypothesis 2. 

### Table 2. mediation effect of industrial waste water discharge

| variable | lns | tfp | lns |
|----------|-----|-----|-----|
| lnim     | -0.0423*** | 0.0183** | -0.0545*** |
| fdi      | 2.0170***  | -2.3701*** | 2.4581***  |
| lnsize   | -0.0090    | 0.0293***  | -0.0102   |
| lnrd     | -0.0920*** | -0.1192*** | -0.0439*** |
| lner     | 0.3966***  | -0.0002    | 0.3925***  |
| tfp      |           | -0.0545*  |       |
| constant | 7.2800***  | 2.5115***  | 6.5664***  |

*Same as above.

In Table 2, the influence coefficient of wood forest products import on total factor productivity is positive and significant at the level of 5%, that is, wood forest product import can promote the
The increase of industry total factor productivity. The increase of total factor productivity can further promote the reduction of industrial waste water discharge.

Table 3. mediation effect of industrial waste gas emission

| variable | lnfq   | tfp    | lnfq   |
|----------|--------|--------|--------|
| lnim     | -0.0634** | 0.0303** | -0.0539** |
| fdi      | -2.8312*** | -1.9746*** | -1.9731*** |
| lnsize   | -0.0449*** | 0.0191**  | -0.0532*** |
| lnrn     | -0.0754    | -0.1437*** | -0.0129   |
| lner     | 0.4355***  | 0.1304***  | 0.3789***  |
| tfp      |          |        | -0.4403*** |
| constant | 5.0188***  | 1.2439***  | 4.4374***  |

*Same as above.

In Table 3, it can be seen that the import of wood forest products promotes the emission reduction of industrial waste gas by increasing total factor productivity.

Table 4. mediation effect of industrial solid waste discharge

| variable | lnfg   | tfp    | lnfg   |
|----------|--------|--------|--------|
| lnim     | -0.0831*** | 0.0303* | -0.0173** |
| fdi      | -0.1354    | -0.5781*** | -2.1497*** |
| lnsize   | 0.0370***  | 0.0591**  | 0.0025   |
| lnrn     | -0.0699*** | -0.0392*** | -0.4919*** |
| lner     | 0.1281***  | 0.0002***  | 0.8748*** |
| tfp      |          |        | -0.4200*** |
| constant | 7.2783***  | 0.8415***  | 6.5104*** |

*Same as above.

Table 4 shows that the import of wood forest products promotes the discharge reduction of industrial solid waste by improving total factor productivity. To sum up, the import of wood forest products reduces the emissions of industrial waste water, industrial waste gas and industrial solid waste produced by forest products industry through promoting the improvement of total factor productivity.

4.3. Heterogeneity test

In order to investigate the influence of the import of wood forest products with different factor intensities, the wood forest products are further classified on the basis of mediation model. Combined with the content and characteristics of each element in each product, sawnwood and other raw wood are classified as resource-intensive products. Wood-based panel, wood products and wood furniture are classified as labor-intensive products. Wood pulp, paper and paper products are classified as capital and technology intensive products.

Table 5 to 7 are the regression results of different intensive wood forest products mediation effect.
Table 5. mediation effect of resource-intensive wood forest products

| Variable            | lnim  | tfp   | Control variable | Constant | Sobel test (P value) | Mediation effect |
|---------------------|-------|-------|------------------|----------|----------------------|------------------|
| industrial waste water lnfs | 0.0086** | 0.0003 | Yes              | 3.9472*** | 0.9252               | NO               |
|                     | tfp   |       |                  |          |                      |                  |
| industrial waste gas lnfs | 0.0085* | -0.4284*** | Yes            | 3.9895*** |                      | NO               |
|                     | lnfq  | 0.0250** | Yes             | -1.2139*** |                      |                  |
|                     | tfp   | -0.0001 |                  | 0.6643*** | 0.9614               |                  |
| industrial solid waste lnfg | 0.0064  |         | Yes              | 2.5470*** |                      | NO               |
|                     | lnfq  | 0.0251** | 0.8288***       | Yes      |                      |                  |
|                     | tfp   | -0.0006 |                  | 0.8459   | 0.8444               |                  |
|                     | lnfg  | 0.0055  | -1.5015***      | Yes      | 3.8172***            |                  |

Same as above.

In Table 5, there is no significant relationship between the import of resource-intensive wood forest products and total factor productivity, and there is no significant mediation effect on the emission reduction of three kinds of pollution emissions in forest products industry.

Table 6. results of mediation effect of labor-intensive wood forest products

| Variable            | lnim  | tfp   | Control variable | Constant | Sobel test (P value) | Mediation effect |
|---------------------|-------|-------|------------------|----------|----------------------|------------------|
| industrial waste water lnfs | -0.0137*** | 0.0021 | Yes              | 4.2071*** | 0.4464               | NO               |
|                     | tfp   |       |                  |          |                      |                  |
| industrial waste gas lnfs | -0.0128*** | -0.4235*** | Yes            | 4.2354*** |                      |                  |
|                     | lnfq  | 0.0214** | Yes             | -1.6497*** |                      |                  |
|                     | tfp   | 0.0122*** |                  | 0.3055**  | 0.0002               | FULL             |
| industrial solid waste lnfg | 0.0117  | 0.7948*** | Yes              | -1.8925*** |                      |                  |
|                     | lnfq  | -0.1392*** | Yes             | 5.4055***  |                      |                  |
|                     | tfp   | 0.0149*** |                  | 0.5438***  | 0.0000               | PARTIAL          |
|                     | lnfg  | -0.1253*** | -0.9326***      | Yes      | 5.9127***            |                  |

Same as above.

The import of labor-intensive wood forest products reduces the emissions of industrial waste gas and industrial solid waste from the forest products industry by improving total factor productivity, playing the role of a complete intermediary and a partial intermediary respectively.
### Table 7. mediation effect of capital and technology intensive wood forest products

| Variable         | lnim  | tfp    | Control variable | Constant | Sobel test (P value) | Mediation effect |
|------------------|-------|--------|------------------|----------|----------------------|------------------|
| industrial waste water | lnsf  | -0.0217** | Yes              | 4.6084*** | 0.0183 PARTIAL1       |                  |
|                  | tfp   | 0.0067* | Yes              | 0.0667   |                      |                  |
| industrial waste gas | lnsf  | -0.0190** | -0.4138***       | 4.2354*** |                      |                  |
|                  | tfp   | -0.0303*** | Yes              | -0.4404*** | 0.001 PARTIAL1       |                  |
| industrial solid waste | lnfg  | -0.0892*** | -0.5731***       | -4.6163*** |                      |                  |
|                  | tfp   | 0.0181*** | Yes              | -0.0336  | 0.0016 PARTIAL1      |                  |
|                  | lnfg  | -0.1536*** | -0.4353***       | 5.9127*** |                      |                  |

*Same as above.

The above conclusion verifies Hypothesis 3. The import of capital and technology-intensive wood forest products has promoted the improvement of the industry’s total factor productivity and further promoted the emission reduction of pollutants in the forest products industry. On the one hand, imports of capital and technology intensive wood forest products tend to include more advanced or cleaner technologies and production processes than domestic production of similar products and also bring market competition to domestic forest products industry enterprises to increase investment in production technology. On the other hand, the increasing domestic attention to environmental pollution forces enterprises to increase the development of their own clean technology, enterprises can also learn from imported products to meet market demand, thus achieving the effect of emission reduction.

### 5. Conclusions

According the paper, the following conclusions are drawn: First, the import of wood forest products generally promotes pollution reduction in the forest products industry. Second, the import of wood forest products can indirectly reduce the pollution discharge of industrial waste water, industrial waste gas and industrial solid waste from the forest products industry by improving total factor productivity. Third, the import of wood forest products with different factor intensities has different effects on the total factor productivity of the forest products industry, and thus on pollution emissions. Specifically, the import of capital and technology intensive wood forest products can significantly increase the industrial total factor productivity, and also have a significant reduction in emissions of the three types of pollutants. Labor-intensive wood forest products can only promote the emission reduction of industrial waste gas and industrial solid waste, while resource-intensive products cannot promote industry emission reduction by improving total factor productivity.

### Acknowledgments

It is supported by Beijing Social Science Fund Project of China (20JJC026), and State Forestry and Grassland Administration Commissioned Project of China (DLJM201901; 2019SLZY01).

### References

1. X F Luo, Z J Wang, Z L Li, L F Xue. Forestry Industrial Structure Transformation and Its Contribution to Economy. *Statistics & Decision*, 2017(14):93-97.
2. K L Wang, L Yang, Y H Cheng. Factor Use, Energy-saving and Emission Reduction, and Regional Green Total-Factor Productivity Growth. *Business Management Journal*, 2012, 34(11):30-43.
[3] Q Peng, K J Gan. Industrial Agglomeration, Productivity and Pollutant Emission: Empirical Evidence from Chinese Manufacturing Enterprises. *Journal of Shanxi University (Philosophy and Social Science Edition)*, 2020, 43(02):105-120.

[4] M J Chen, M H Cai. Research on Environmental Effects of FDI Based on Dual Regional Heterogeneity. *International Business Research*, 2019, 40(03):88-96.

[5] Z G Tu, G Xiao. Research on China's Industrial Growth Model under Environmental Constraints. *The Journal of World Economy*, 2009, 32(11):41-54.

[6] MELITZ M J. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, 2003, 71(6):1695-1725.

[7] MELITZ M J, OTTAVIANO G L P. Market Size and Productivity. *Review of Economic Studies*, 2008, 75(1):295-316.

[8] LOOF H, ANDERSSON M. Imports, Productivity and Origin Markets: The Role of Knowledge-intensive Economies. *World Economy*, 2010, 33(3):458-481.

[9] W M Jing, L Zhang. Environmental Regulation, Economic Opening and China’s Industrial Green Technology Progress. *Economic Research Journal*, 2014, 49(9):34-47.

[10] Z L Hu, Y F Nie. The Impact of Economic Globalization on the GVC Position: Empirical Research Based on Transnational Panel Data. *International Economics and Trade Research*, 2020, 36(02):56-71.

[11] B Sheng, 2002: *Political and Economic Analysis of China's Foreign Trade Policy* (Shanghai: Shanghai People's Publishing House)

[12] J Huang. Liberalization of Intermediate Goods Trade, Environmental Regulation and Industrial Pollution Emissions. *Macroeconomics*, 2020(06):144-152.

[13] ANTWELLER W, COPEL AND R B, TAYLOR S M. Is free trade good for the environment?. *American Economic Review*, 2001, 91(4):877-908.

[14] Z L Wen, L Zhang, J T Hou, H Y Liu. TESTING AND APPLICATION OF THE MEDIATING EFFECTS. *Acta Psychologica Sinica*, 2004(05):614-620.

[15] J Q Han, Q Zhou. The Impact of Expanding Intermediate Imports on the Ecological Environment and Industrial Chain Security: The Effect of Heterogeneous Intermediate Imports on Pollution Reduction in Manufacturing Industry. *Price: Theory & Practice*, 2020(07):154-157.

[16] F J Li. The Impact of Service Industry Opening on the Business Makeup Ratio: An Empirical Research Based on the Micro Data of China's Manufacturing Enterprises. *Contemporary Finance & Economics*, 2019(06):96-105.

[17] J J Gu, Q Zheng, D Xiao. A Spatial Correlation Analysis of FDI and China’s Environmental Pollution under the Background of Green Development. *Macroeconomics*, 2020(09): 119-129+175.