Empirical Study on Environmental Pollution effect of FDI

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Abstract: This paper combs the relevant theories and literature, and analyses the three impact mechanisms of FDI on environmental pollution which includes economic scale, technology and structural effects. This paper selects foreign direct investment panel data of 29 provinces in China in 2009-2017, explores the impact of foreign direct investment on China's environmental pollution, verifies that the "pollution shelter" hypothesis does exist in China, and concludes that the inflow of foreign direct investment aggravates China's environmental pollution, and based on this, the paper puts forward targeted policy recommendations.

1. Introduction
Due to the increasingly severe environmental pollution caused by the rapid economic development, with the increasing environmental protection awareness of the people, people began to pay more attention to environmental problems. How to balance the relationship between economic development and environmental protection has become an important issue for the whole world. Only coordinated economic development and environmental protection, we can achieve sustainable economic growth. Several years ago, general secretary Xi has put forward a famous mountain theory----the green mountain is golden mountain, for the construction of Ecological Civilization; In the current trend of national ecological civilization construction, coordinating the problem of FDI and environmental pollution has become a serious and realistic problem faced by the provincial and municipal governments. Therefore, it is of practical significance to study the relationship between FDI and environmental pollution. Through the study of the impact mechanism of FDI on environmental pollution, it provides a basis for China to formulate targeted investment policies and relevant environmental supervision systems, so studying how FDI effect the environment is of great significance.

2. Domestic and foreign literature reviews
With more and more social concerns on environmental issues, many domestic scholars have paid more and more attention to the relationship between FDI and environmental pollution. Generally speaking, many domestic scholars' opinions can be divided into three categories: Li believes that some countries will take the initiative to reduce the threshold of environmental access, so as to improve the attractiveness to foreign investment, thus leading to environmental deterioration. Zen Hui also pointed out that FDI does have a negative impact on the environment, and the "pollution paradise" hypothesis exists in China. Len and others have observed the data of haze pollution, proving that foreign investment will lead to the increase of haze in China. Zhou and others supported the "pollution shelter" hypothesis, and found that the economic scale and structure effects of FDI on the carbon emission efficiency of industry exceeded the technical effect.
Li believes that the introduction of foreign investment can promote the spread of green technology in the host country, thereby reducing the environmental pollution of the host country. Li and others hold that FDI promotes the development of environmental protection technology through technology spillover effect, which supports the hypothesis of "pollution halo". Song and Yi think that the technology spillover effect of FDI is beneficial to the improvement of air quality. Zheng and others think that the "pollution halo" hypothesis is basically established in China, but with the gradual improvement of financial development level, the positive environmental effect of FDI will tend to increase. Ji Selected panel data of 30 provinces in China, from 1999 to 2012, selected industrial waste gas, industrial waste water and industrial solid waste emissions as indicators of environmental pollution, and proved that the relationship between China's FDI and environmental pollution conforms to the Environmental Kuznets curve through research.

At present, foreign scholars' research on the relationship between FDI and environmental pollution can be roughly divided into three categories: first, "pollution shelter" The hypothesis is that FDI inflow will aggravate the environmental pollution in the host country; secondly, the hypothesis of "pollution halo" is that FDI will have a positive effect on the environment of the host country through the spillover effect of advanced technology; thirdly, FDI may have both a positive and a negative impact on the environment, namely "Environmental Kuznets Curve"."pollution paradise" hypothesis was first proposed by Walter, and has been enriched and improved by scholars such as Boumol and Oates. Luisa Blanco and others analyzed several Latin American countries and found that foreign investment from high pollution industries would increase environmental pollution. Shengang Ren and others pointed out that a large number of direct foreign investment increased China's carbon dioxide emissions. Bakhsh et al, taking Pakistan as an example, pointed out that foreign direct investment was positively correlated with pollution.

With the increase of per capital income, kevub grey et al. Put forward the "pollution halo effect", and thought that foreign investment can bring advanced technology and management experience to the host country, which is conducive to the improvement of the environmental level of the host country's enterprises. Myeong Hwan Kim et al. Investigated the relationship between FDI and carbon dioxide emission pollution. The results showed that foreign investment did not necessarily increase the pollution level of the host country.

In the early stage of economic development, the degree of environmental deterioration increases with the economic growth; when the economic development reaches a certain level, the degree of environmental pollution gradually slows down, and the environmental quality gradually improves. This phenomenon is called: Environmental Kuznets curve, which is the inverted "U" curve between economic growth and environmental pollution. Grossman believed that FDI can be realized through production scale effect and industrial structure effect.

Structure effect and technology spillover effect affect the environmental pollution of host country. It is concluded that environmental pollution increases with the increase of per capital GDP at low income level, and decreases with the increase of GDP at high income level. Doytch believed that due to the influence of many factors, there are many situations similar to game, resulting in the uncertainty of the results of the game.

To sum up, the domestic and foreign scholars study the relationship between foreign direct investment and the environment, and draw conclusions: both negative and positive influences, as well as the coexistence and mutual influence of two influences, that is uncertainty.

3. Mechanism analysis of FDI on environmental pollution

3.1. scale effect

The increase of the scale of foreign investment will bring some negative effects. In the early stage of economic development, the inflow of FDI has brought a lot of capital to the eastern host country, which makes the economic scale of the host country expand. Therefore, it is necessary to expand the amount of investment and be able to source capital. The consumption of sources increases, and the use of resources will lead to the increase of pollution emissions, which makes the scale effect show as environmental negative effect. Some scholars also think that with the expansion of economic scale, it will
promote the increase of income, enhance the residents' awareness of environmental protection, and raise the requirements for environmental quality. At the same time, the government will increase the investment in environmental governance, and improve the environmental quality to a certain extent. In general, the impact of scale effect on the environment depends on the actual situation.

3.2. Technology effect

Technology effect refers to the effect of FDI on the host country's technology on the environment. In the economic development process, the R & D expenditure of enterprises is increasing continuously, which promotes the technological progress of enterprises, so as to improve the environmental quality. Technological progress can improve the production efficiency and resource use efficiency of enterprises, thus reducing the impact of enterprise production on the ecological environment; at the same time, enterprises develop clean technology and apply it to production, making resources recyclable and reducing the emission of enterprise pollutants. The technological effect brought by FDI is mainly manifested in technological spillover effect, demonstration effect and competition effect, which reduces the environmental pollution of developing countries. Due to the strict environmental regulations system in developed countries, enterprises increase investment in technology research and development, so that clean technology is vigorously developed and put into production. When multinational enterprises make foreign direct investment, advanced production technology will flow into the host country, thus producing technology spillover effect. At the same time, foreign-funded enterprises have a high level of technology and resource utilization, in order to improve the competitiveness of domestic enterprises, they are forced to increase internal research and development investment to enhance technology. The enterprises in the host country will also actively imitate the producing technology and management mode of foreign-funded enterprises. Therefore, the technology effect of FDI has a positive effect on the environment and improves the environmental pollution of the host country.

3.3. Structure effect

The inflow of FDI will change the industrial structure of the host country to a certain extent, thus affecting the environmental quality of the host country. In the early stage of FDI development, the economic structure changed from agriculture to energy intensive industry, the pollution emission increased rapidly, and then began to transfer to service industry and knowledge intensive industry, weakening the impact on the ecological environment; at present, foreign investment in China is gradually transferred to the tertiary industry, and the consumption of production resources and pollution emissions in the service industry is relatively small, which to some extent reduces the environmental pressure. However, at present, the secondary industry is still the main industry. Each province may pay more attention to the role of foreign investment in promoting the local economy when introducing foreign investment. Because the quality of foreign investment is not high, it fails to drive the optimization and upgrading of the local industrial structure, resulting in environmental negative effects.

To sum up, scale effect, technology effect and structure effect are the total effect of FDI on environment. According to the theoretical analysis, scale effect and structure effect have two-sided effects, while technology effect can improve the environmental quality of environment. In the first stage of economy, a lot of resources are consumed and a lot of hazardous wastes are produced. The negative effects of scale effect and structure effect exceed the technology effect and the environment deteriorates. When the economy develops to the next stage, the positive effect exceeds the negative effect and the environment quality is improved. However, the impact of FDI on environmental pollution still needs empirical analysis.

4. Empirical analysis of FDI on environmental pollution

4.1. Model construction

Based on the above analysis, it is found that economic scale, technological level and industrial structure will have an impact on environmental pollution. Therefore, we consider three effects as control variables to establish econometric model.
\[ p_{it} = \alpha_0 + \beta_1 \text{FDI}_{it} + \gamma_1 \text{GDP}_{it} + \gamma_2 \text{S}_{it} + \gamma_3 \text{T}_{it} + \mu_t + \epsilon_{it} \]

where \( i \) and \( t \) represent provinces and years respectively, \( P \) represents environmental pollution, \( \text{FDI} \) is foreign direct investment, \( \text{GDP} \) represents economic scale, \( S \) represents industrial structure, and \( T \) represents technical level, \( \mu_t \) is the province individual effect, \( \epsilon_{it} \) represents a random error term.

4.2. variable selection

In this model, the emission of industrial waste gas, industrial waste water and the living waste produced by residents are selected to represent the comprehensive level of environmental pollution. In this paper, the entropy method is used to calculate the comprehensive environmental pollution index of each province in 2009-2017. The following are the specific steps of the entropy method:

First, standardize the data of the above pollutants:

Positive dimensions:

\[ P_{ij} = \frac{x_{ij} - x_{\min(j)}}{x_{\max(j)} - x_{\min(j)}} \]

Negative dimensions:

\[ P_{ij} = \frac{x_{\max(j)} - x_{ij}}{x_{\max(j)} - x_{\min(j)}} \]

where \( i \) is the year, \( j \) is the pollution index, and \( x_{\min(j)} \) and \( x_{\max(j)} \) are the minimum and maximum values of the \( j \) pollution index, respectively.

Then, we calculate the entropy value of each pollutant index. The entropy value of the \( j \) pollutant index is:

\[ E_j = -k \sum_{n=1}^{m} P_{nj} \ln(p_{nj}) \quad 0 \leq E_j \leq 1 \]

Where \( k = \frac{1}{\ln m}, \) a constant, such that the maximum value of \( E \) is 1.

Then calculate the weight of the \( j \) pollutant index:

\[ W_j = \frac{1 - E_j}{\sum_{i=1}^{m} (1 - E_i)} \]

Finally, calculate the \( i \) year's , the larger the index is the higher the degree of environmental pollution.

We select the FDI data of 29 provinces in China from 2009 to 2017 as the research object, and all the data are from the China Statistical Yearbook of statistics department of China, use the actual amount of foreign investment in each province to measure the situation of foreign direct investment in each province in this paper;

Economic scale (GDP), Generally, GDP per capita is used to reflect the economic development and income level of a country in this paper;

Industrial structure(s), With the rapid development of industrialization, a large number of resources are consumed, and the emission of pollutants is increasing, which aggravates the environmental degradation. Industrial development has become the main cause of environmental pollution, and the key to solve the environmental problems brought by industrial development is the transformation and upgrading of industrial structure, and the transformation of industrial structure to extensive economic development mode. Therefore, in this paper, the proportion of the added value of the secondary industry to the total output of the region is used to reflect the industrial structure of a province. The larger the
value of this proportion is, the higher the proportion of the secondary industry in the province, the higher the possible environmental pollution;

Technology level(T), The more advanced the production technology level, the higher the utilization rate of resources, and the lower the energy consumption per unit economic output, thus reducing the pollution emissions. The technology spillover effect brought by FDI can improve a country's technology level. Both production technology and pollution treatment technology can reduce pollution emissions from the source and improve the ability of pollution control. Take the investment of enterprise scientific research as the index, through research, it is proved that the improvement of technology level can promote innovation and reduce the emission of enterprise pollutants. Therefore, we use the ratio of R & D investment of Enterprises above regional scale to GDP to express the technology level. The larger the value of this variable, the more R & D investment, the higher the technology level, and the less pollution to the environment.

4.3. data source
We take 29 provinces as samples, and adopt the annual data of each province in 2009-2017. The data mainly come from China Statistical Yearbook and China Energy Statistics Yearbook in 2009-2017. The descriptive statistic result is shown in Table 1.

|          | P      | FDI    | GDP    | S      | T      |
|----------|--------|--------|--------|--------|--------|
| Mean     | 0.359372 | 10.91359 | 10.23366 | 0.457077 | 1.014014 |
| Median   | 0.344009 | 10.81424 | 10.40973 | 0.475424 | 0.908395 |
| Maximum  | 0.749400 | 14.38209 | 11.58199 | 0.590454 | 2.186415 |
| Minimum  | 0.103797 | 7.761745 | 7.210309 | 0.190140 | 0.136718 |
| Std. Dev. | 0.142560 | 1.390902 | 0.749012 | 0.083147 | 0.547128 |
| Sum      | 93.79610 | 2848.448 | 2670.987 | 119.2972 | 264.6577 |
| Sum Sq. Dev. | 5.284048 | 502.9981 | 145.8649 | 1.797483 | 77.83089 |
| Observations | 261    | 261    | 261    | 261    | 261    |
| Cross sections | 29     | 29     | 29     | 29     | 29     |

4.4. empirical analysis results
In order to test the stationary of data, it is necessary to test whether there is unit root in panel data, to avoid causing false regression, and to ensure the validity of the estimated results.

According to the results of co-integration test, the p value is less than the corresponding significance level, rejecting the original hypothesis of unit root, so the sequence is stable. The test results show that the panel data selected in this paper are all first-order integers. Co-integration test also checked whether there is a long-term stable relationship between the variables of the model and to ensure the accuracy of the test results. The test results indicated that there is a co-integration relationship between variables. The regression equation composed of the variables selected in this paper does not have the phenomenon of pseudo regression.

The regression analysis of the model was carried out by eviews7 software. The follow table 2 is the regression results of the effect of FDI on environmental pollution in 29 provinces.
Table 2. regression results table

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | 1.460725    | 0.344775   | 4.236749    | 0.0000|
| FDI      | 0.077751    | 0.032371   | 2.401870    | 0.0171|
| GDP      | -0.308297   | 0.047547   | -6.483986   | 0.0000|
| S        | 0.028231    | 0.008379   | 3.369361    | 0.0009|
| T        | 0.010763    | 0.004481   | 2.401708    | 0.0171|

From the regression results, R-squared is equal to 0.949153, adjusted R-squared is equal to 0.942017, indicating that the goodness of fit of the model is very good.

Explanatory variable foreign direct investment, At the level of 5%, passed the significance test, and FDI had a positive correlation with the pollution index of environmental pollution. Under the condition that other variables remained unchanged, when FDI increased by 1%, the comprehensive index of environmental pollution increased by about 0.077%, indicating that the impact of FDI on environmental pollution was not significant. The impact of FDI on environmental pollution is as mentioned above, and there are three effects. The interaction between these three effects leads to a smaller coefficient, so the impact on environmental pollution is not significant. Although FDI can bring advanced clean production technology and higher environmental protection standards, which is conducive to environmental governance in China, at present, due to the imperfect environmental protection system and low quality of foreign investment in China, a large number of high polluting enterprises are attracted to China. From the perspective of the whole, although FDI shows a negative effect on the environment, the impact is relatively small and China pays more and more attention to environmental protection, In the future, the negative effect of FDI can be gradually weakened.

The control variable of economic scale, has passed the significance test at the level of 5%, and the variable has a negative correlation with environmental pollution, that is, every 1% increase in economic scale will reduce environmental pollution by 0.308%. It shows that the inflow of FDI promotes the domestic economic scale. With the expansion of economic scale, the per capita income of residents rises, which makes the residents' awareness of environmental protection enhanced, and the requirements for environmental quality also rise, so it has a positive effect on the environment.

The control variable of the industrial structure, the proportion of the added value of the secondary industry in the total output of the region, at the level of 5%, passed the significance test, and the variable has a positive correlation with environmental pollution, that is, for every 1% increase in the level of industrial structure, environmental pollution will rise by 0.028%. Although foreign capital is gradually transferred to the tertiary industry, it is still dominated by the secondary industry, and the quality of foreign capital introduced is not high, which makes the industry structure of foreign capital inflow not reach the optimal level. With the optimization and upgrading of China's industrial structure, the negative effect of structural should be further improved.

The control variable of technology level, R & D investment (R & D) of enterprises, which has passed the significant test at the level of 5%. This variable has a positive correlation with environmental pollution, that is, every 1% increase of technology level will increase environmental pollution by 0.011%. This result is not consistent with the conclusion that foreign investment can promote the spread of green technology and reduce environmental pollution. However, the author believes that technological progress can have a positive impact on the environment, but at this stage, the technological progress of Chinese enterprises is often in pursuit of economic benefits, while despises the protection of the environment, and many enterprises aggravate environmental pollution in China in order to reduce the cost of pollution control, therefore, technological progress may not have a positive impact on the environment in the short term.
To sum up, economic scale, technological level and industrial structure act on China's environment together, and the total impact effect shows a positive correlation, and for every 1% increase in FDI, China's environmental pollution level will increase. By 0.077%, indicating that the inflow of FDI has increased China's environmental pollution, and the "pollution paradise" hypothesis does exist in China. From the current situation of our country, it is still necessary to introduce foreign capital to develop economy and seize the economic development opportunity brought by FDI. Although the current FDI The total effect on environmental pollution is negative, but the author is optimistic about the impact on China's environment. With the enhancement of technology spillover effect, the strengthening of government's supervision on environment and the enhancement of residents' awareness of environmental protection, the negative effect of FDI on environmental pollution should continue to decrease.

5. Conclusions and policy recommendations

Based on the theory of Grossman and Krueger (1995), this paper makes a regression analysis of environmental pollution and foreign direct investment, selects the annual data of 29 provinces in China from 2009 to 2017, and uses the entropy method to calculate the environmental pollution index of each province. From the results of model analysis, FDI has a positive effect on environmental pollution, which supports the "pollution paradise" hypothesis. Research shows that the inflow of foreign direct investment intensifies the domestic environmental pollution in a certain degree. From the perspective of economic scale, the expansion of economic scale promotes the increase of income, which makes the residents' demand for environmental quality rise and brings positive environmental effects. From the perspective of industrial structure, although the inflow of FDI from the tertiary industry has increased, FDI is still more entering the secondary industry, especially some resource intensive enterprises, resulting in the increase of industrial pollution in China. As a whole, although the industrial structure is changing, it has a negative effect on the environment as a whole. From the technical level, in the short term, technological progress may not have a positive effect on the environment.

Based on the above empirical analysis, in order to solve the problem of environmental pollution caused by the inflow of foreign capital, this paper puts forward the following suggestions:

First of all, the government needs to strengthen the supervision of foreign investment environment. It should adhere to certain restrictions on foreign investment to enterprises in pollution intensive industries, and more actively introduce resource-saving and environment-friendly foreign investment. At the same time, we need to change the extensive and silent development mode, from the consumption type of high resources to the resource-saving mode, and strive to realize the efficient utilization of resources; we need to gradually turn the economic growth from the pollution of high environment to the sound development of environment, and realize the mutual benefit and win-win of economic growth and environmental protection.

Secondly, the environmental indicators should be added to the government performance evaluation mechanism and the environmental comprehensive supervision system should be set up for 15 degrees, and some adjustments should be made to the regional differences, so as to avoid the local government relaxing environmental supervision in order to complete the GDP assessment, so as to attract foreign investment. We should give full play to the role of market economy, improve the effect of environmental resource allocation, attract higher quality foreign investment, and make environmental management work adapt to the level of economic development.

At last, we should establish the concept of ecological civilization, strengthen the publicity and education of ecological civilization, so as to improve the awareness of environmental protection of the whole nation. Only by enhancing the awareness of environmental protection of all people.

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