

An Empirical Analysis of the Impact of FDI on the Environmental Quality in Shaanxi Province

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Abstract: *Since reform and opening up, especially since 1990s, the scale of foreign direct investment attracted and used by Shaanxi province has been expanding. And meanwhile, the environmental quality of Shaanxi has changed greatly. By the ADF(Augmented Dickey-Fuller) stationary test, Grainger causality and co-integration analysis, based on the data of 1992-2015, this paper made an empirical analysis about the influence of foreign direct investment on environment with the environmental effects decomposed into scale effect, structure effect and technical effect. The results indicated that the change of the emission of Shaanxi province was not the Granger cause of the change of foreign investment, but foreign investment had some impacts on the environmental quality of Shaanxi province at a certain level. And the environmental effects which brought about by the expansion of the economic scale and the technology transfer which induced by the stock of foreign direct investment were negative, only the environmental effects which brought about by the economic structure were positive, but the overall environmental effects were negative. Finally, the paper gives some helpful suggestions based on research results above.*

Keywords: foreign direct investment; environmental effects; economic scale; technology transfer; economic structure

1. Introduction

In recent years, with the improvement of living standards, environmental protection attracts more and more attention. In the academic community, the study of environmental pollution is endless. Especially the relationship between FDI (foreign direct investment) and environmental pollution, so far there is no consistent conclusion. The theory of the impact of FDI on environmental pollution based on the present research results can be summarized as “the pollution heaven hypothesis” and “pollution halo”.

“The pollution heaven hypothesis” was proposed by Dean Judy (1992), the theoretical analysis of the hypothesis is that based on the reasons for the high cost of environmental governance in developed countries, they tend to transfer their pollution-intensive industries to developing countries with lower environmental costs, which could lead to the pollution haven for pollution-intensive enterprises in those countries with lower environmental costs.

Contrary to the pollution heaven hypothesis, some domestic and foreign scholars put forward the “pollution halo” when studying the environmental effects of FDI. The meaning of this theory is that FDI does not worsen the environmental pollution of the host country. On the contrary, FDI has improved the environmental quality of host countries. And relative to domestic enterprises in host countries, foreign-funded enterprises have played a good demonstration effect in the aspect of the formulation and implementation of technical and environmental protection standards.

2. Review of Empirical Literature

Many scholars analyze not only the theory but also the data. The empirical test is focused on whether FDI has an impact on

the environment, and whether the environmental effect of FDI is positive or negative. The environmental effects of FDI can be roughly divided into two types.

First, FDI will worsen the host country's environmental pollution. Mathew A.C, Robert J.K and Fredriksson P.G. (2006) select data from 1982-1992 through the analysis of 33 countries. They conclude that the foreign investment has increased the environmental pollution and brought the negative influence to the environment. Taking the industrial panel data for 2000-2010 in China as samples, Ren, Yuan and Ma (2014) analyze the impact of carbon dioxide emissions in international trade by using the two stage GMM analysis method. They study FDI, trade development, import and export, per capita GDP and other factors on the impact of carbon dioxide. The results show that FDI aggravate the situation of environmental pollution in China.

Second, FDI will improve the host country's environmental quality. Eskeland and Harrison (2003)'s study indicate pollution intensive enterprises after entering the host country has a higher level of technology than the local. The environmental pollution caused by foreign companies is lower than the local enterprises with producing the same product. Doytch and Narayan(2016) study on the relationship between FDI and energy demand. They take 74 countries in 1985-2012 as the object of empirical analysis to study the impact of FDI on renewable energy and non-renewable energy by using dynamic panel data. The results show that FDI can effectively improve the efficiency of the two kinds of energy, which is conducive to the improvement of environmental quality.

Some scholars also believe that the impact of FDI on environment in the host country is complex and changeable, which can be either positive or negative. Yu F. and Qi J.G.(2007) study the relationship between FDI and SO₂ and

discovered FDI increases the discharge of pollutants in China through scale effect and structure effect. But the FDI has improved the environment of our country through technical effect. Zhang X.G.(2011) using the data from 1988 to 2007 in China analyze the size and direction of environmental effects through the establishment of simultaneous equations model. It is found that FDI has a negative scale effect on the environment, positive structural effect and technology effect. The control effect is not obvious. And the total effect is negative.

From the above analysis, we can see that although there are differences in the foreign scholars' views on the environmental effects of FDI, they have their own theoretical support. The research has been relatively thorough and comprehensive. The research on the environmental problems brought by FDI in China is mainly focused on the macro perspective of the whole country and the developed areas of the Southeast coast. However, the environmental problems caused by the foreign direct investment in the central and western regions are less concerned, which is consistent with the coastal areas where the most prosperous regions and the most polluted areas are. Along with the western region development strategy implementation, more and more foreign enterprises, especially the pollution intensive enterprises, have entered the western region in China. On the one hand, the entry of foreign capital has promoted the economic development of the western region. But on the other hand, it may also bring environmental pollution. In particular, as the western province of Shaanxi, the research on the problems of FDI and environmental pollution in Shaanxi has more theoretical and practical significance.

3. Materials and Methods

3.1 Stationarity Test

The classical econometrics theory is based on the stationary time series. The correlation coefficient between the assumed variables obeys normal distribution. Modern econometric studies show that most economic variables are non-stationary. Monte Carlo simulation method is used to analyze the distribution of the correlation coefficient of non-stationary time series. The results show that when the time series is not stable, the correlation coefficient pictures a reverse U-shape and a U-shape. Thus the probability of the rejection of hypothesis that the explanatory variable coefficient is zero increases. With the increase of sample size and orders of integration, the rejection probability increases. And the efficacy of the test is reduced with the increase of the likelihood of including the false. Therefore, the regression analysis is carried out by using non-stationary variables. The conclusion is that there is a correlation between variables especially in the case of large samples and higher order. The regression analysis by using 2 uncorrelated and no stationary variables is a kind of false regression (spurious regression). The stationarity test is a key problem in time series analysis.

By assuming a sequence X_t , now check whether this sequence has a unit root. There are 3 models.

$$\Delta X_t = (\rho - 1)X_{t-1} + \sum_{i=1,2,\dots} \rho_i \Delta X_{t-i} + \epsilon_t \quad (I)$$

$$\Delta X_t = \alpha + (\rho - 1)X_{t-1} + \sum_{i=1,2,\dots} \rho_i \Delta X_{t-i} + \epsilon_t \quad (II)$$

$$\Delta X_t = \alpha + \beta t + (\rho - 1)X_{t-1} + \sum_{i=1,2,\dots} \rho_i \Delta X_{t-i} + \epsilon_t \quad (III)$$

In the model, ΔX_t represents the first order difference of X_t . And t is the time. The ϵ_t is white noises.

The ADF test usually examines the most complex model III firstly, If necessary, the inspection of the model II is followed. The inspection of the simplest model I will be carried out finally if necessary. The following is the test procedure for model III. The test procedure for the other models is the same.

The first step: test $\rho=1$. We can use the corresponding t statistic according to the critical value given by Dickey & Fuller(1981) to do the hypothesis testing. If H_0 is rejected, then we will think there is no unit root. Or we'll take the second step.

The second step: given $\rho=1$. Test $\beta=0$. Wald statistics which are used to check whether the constraints are established obey the F distribution. We can do the hypothesis testing according to the critical value given by Dickey & Fuller(1981). If H_0 is rejected, we'll take the third step. Or estimate and test the model II.

The Third step: test $\rho=1$ with the normal distribution method. If H_0 is rejected, then we will think there is no unit root. Otherwise the unit root exists. In this case, we need to retest the unit root after the difference of original data sequence.

3.2 Granger causality Test

Before the Granger causality test method, the analysis of the relationship between economic phenomena is limited to qualitative analysis, which is difficult to reveal the causal relationship between various economic phenomena. To this end, Granger and Sims proposed the use of statistical methods to test the causal relationship between various economic phenomena—"Granger causality tests". The idea of the test is below. For two economic variables X and Y, the past information of X and Y is contained. In this case, the prediction effect of Y is better than that of Y predicted by the past information of Y alone. In other words, variable X is helpful to improve the prediction accuracy of variable Y. Thus it can be concluded that X is the Granger cause of Y. The specific test method is that test $\beta_i(i=1,2,\dots,m)=0$ in the equation(1). This assumption is equivalent to "X is not the cause of Y". If the result of the test rejects the original hypothesis of $\beta_i(i=1,2,\dots,m)=0$, we can reject the hypothesis that "X is not the cause of the change of Y", and thus conclude that X is the Granger cause of the change of Y. Similarly, we can test $\alpha_j(j=1,2,\dots,m)=0$ in the equation(2) to judge whether Y is the Granger cause of the change of X.

$$y_t = \alpha_0 + \sum_{i=1}^m \alpha_i y_{t-i} + \sum_{i=1}^m \beta_i x_{t-i} + \epsilon_{1t} \quad (1)$$

$$x_t = \alpha_0 + \sum_{j=1}^m \alpha_j y_{t-j} + \sum_{j=1}^m \beta_j x_{t-j} + \epsilon_{2t} \quad (2)$$

3.3 Co-integration Test

The purpose of the co-integration test is to determine whether a set of the linear combination of non-stationary sequences has a

stable equilibrium relationship. An effective test method proposed by Johansen and Juselius (1990), which is called Johansen co-integration test. The basic idea is that: if two or more time series variables are not stable and the same order difference is stationary, then these non-stationary time series variables have long-term co-integration relationship. In the economic sense, the existence of this co-integration relationship can affect the absolute value of the other variable changes through the absolute value of a variable. If there is no co-integration relationship between variables, there is no basis for a variable to affect the absolute value of the other variable.

4. Empirical Research

4.1 The Causality Test between FDI and Environmental Pollution in Shaanxi Province

4.1.1 The Data Source

FDI is foreign direct investment. In this paper, the study uses the actual utilization of foreign capital to express changes in foreign investment. There are many indicators to measure environmental pollution. As the pollution is mainly concentrated in the industrial sector, the three main pollution indicators is selected including the industrial wastewater discharge, the emission of industrial waste gas and industrial

solid wastes. See addendum 1 for information on the FDI and the main pollution indicators in Shaanxi Province. All data are from the 1993-2016 statistical yearbook of Shaanxi. Taking into account the difference in measurement units between the actual utilization of foreign capital and the emission of industrial waste and the large absolute value, in the actual test each sequence adopts the method of logarithm in order to eliminate the heteroscedasticity between the data. The study uses the Eviews7.0 software to test the causal relationship between FDI and the environment pollution.

4.1.2 Empirical Results

Table 1 showed test results of causality between FDI and the industrial wastewater discharge. When the lag phase was chosen as 1, the result showed that the industrial wastewater discharge was the Granger cause of the change of the actual utilization of foreign capital at the 95% confidence level. But the actual utilization of foreign capital was not the Granger cause of the change of the industrial wastewater discharge. When the lag phase was chosen as 3, we concluded that the actual utilization of foreign capital was the Granger cause of the change of the industrial wastewater discharge. However, the reverse was not true.

Table 1: The causality test between LNFDI and LN WATER

The causal relationship assumption	The lag phase	F value	P value	decisions
FDI is not the Granger cause of WATER	1	0.64748	0.4305	accept
WATER is not the Granger cause of FDI		5.48115	0.0297	refuse
FDI is not the Granger cause of WATER	2	1.35341	0.2848	accept
WATER is not the Granger cause of FDI		1.72532	0.2079	accept
FDI is not the Granger cause of WATER	3	3.12057	0.0600	refuse
WATER is not the Granger cause of FDI		2.21107	0.1321	accept
FDI is not the Granger cause of WATER	4	1.94780	0.1725	accept
WATER is not the Granger cause of FDI		1.97875	0.1675	accept

Table 2 showed test results of causality between FDI and the emission of industrial waste gas. We can see that no matter how to select the lag phase the emission of industrial waste gas was the Granger cause of the change of the actual utilization of

foreign capital. But the actual utilization of foreign capital was not the Granger cause of the change of the emission of industrial waste gas.

Table 2: The causality test between LNFDI and LNGAS

The causal relationship assumption	The lag phase	F value	P value	decisions
GAS is not the Granger cause of FDI	1	33.9491	1E-05	refuse
FDI is not the Granger cause of GAS		0.07765	0.7834	accept
GAS is not the Granger cause of FDI	2	4.27506	0.0313	refuse
FDI is not the Granger cause of GAS		0.09048	0.9139	accept
GAS is not the Granger cause of FDI	3	5.1804	0.0129	refuse
FDI is not the Granger cause of GAS		1.2023	0.3451	accept
GAS is not the Granger cause of FDI	4	3.78907	0.0357	refuse
FDI is not the Granger cause of GAS		1.41409	0.2928	accept

Table 3 showed test results of causality between FDI and the emission of industrial solid wastes. We found that when the lag phase was chosen as 1 the actual utilization of foreign capital was the Granger cause of the change of the emission of industrial solid wastes at the 95% confidence level. And the emission of industrial solid wastes also was the Granger cause

of the change of the actual utilization of foreign capital. When the lag phase was chosen as 2 or 3, the research showed that the actual utilization of foreign capital was the Granger cause of the change of the emission of industrial solid wastes, conversely was not.

Table 3: The causality test between LNFDI and LNSOLID

The causal relationship assumption	The lag phase	F value	P value	decisions
FDI is not the Granger cause of SOLID	1	5.25036	0.0329	refuse
SOLID is not the Granger cause of FDI		4.89085	0.0388	refuse
FDI is not the Granger cause of SOLID	2	7.63610	0.0043	refuse
SOLID is not the Granger cause of FDI		0.25227	0.7799	accept
FDI is not the Granger cause of SOLID	3	4.66864	0.0184	refuse
SOLID is not the Granger cause of FDI		0.09240	0.9630	accept
FDI is not the Granger cause of SOLID	4	1.99204	0.1654	accept
SOLID is not the Granger cause of FDI		1.18123	0.9434	accept

Based on the above analysis, there was a causal relationship between industrial wastewater discharge, industrial solid waste emissions and FDI. However, there was no causal relationship between industrial exhaust emissions and FDI. The choice of different lag periods reflected the influence of the industrial structure and the lag period of investment. The increase in FDI was not the cause of the increase in industrial exhaust emissions, but the increase of FDI led to the increase of industrial wastewater discharge and industrial solid waste emissions. The entry of foreign capital in Shaanxi province brought about the environmental pollution to a certain extent as in the East, and the environmental effect of FDI in Shaanxi province existed.

4.2 An Empirical Analysis of Environmental Effects of FDI in Shaanxi

Although the environmental effect of FDI in Shaanxi province exists, the technical effect of FDI will gradually appear with the enhancement of environmental protection consciousness and the improvement of environmental regulation. To a certain extent, FDI is conducive to the improvement of environmental quality. In order to further study the effect of FDI on environment, in this paper the effects of FDI on environment are decomposed into the scale effect, the structure effect and the technology effect.

4.2.1 The Data Source and Empirical Model

Since FDI was not the granger cause of the emission of industrial waste gas, we selected the emissions of industrial wastewater and industrial solid waste as the dependent variable in the empirical study of environmental effects. In order to eliminate heteroscedasticity and make a better economic interpretation, we took the logarithm of each variable and established the following two models:

$$\text{Lnwater}_t = \beta_0 + \beta_1 * \text{LnFDI}_t + \beta_2 * \text{LnAGDP}_t + \beta_3 * \text{LnStructure}_t + \beta_4 * \text{LnAR\&Dt}_t + \epsilon_t \quad (3)$$

$$\text{Lnsolid}_t = \beta_0 + \beta_1 * \text{LnFDI}_t + \beta_2 * \text{LnAGDP}_t + \beta_3 * \text{LnStructure}_t + \beta_4 * \text{LnAR\&Dt}_t + \epsilon_t \quad (4)$$

In the above models, “t” stands for years. “β0”, “β1”, “β2”, “β3” and “β4” represent the undetermined coefficients of each equation. “εt” is the random disturbance of each equation. “water_t” stands for the emissions of industrial wastewater from 1992 to 2015 in Shaanxi. And “solid_t” represents the emissions of industrial solid waste from 1992 to 2015 in Shaanxi. “FDI” stands for the actual utilization of foreign direct investment over the years in Shaanxi. “AGDP_t” represents per capita gross domestic product, which is used to represent the scale effect of FDI. “Structure_t” is used to describe the structural effects, which is the ratio of industrial value-added over GDP in Shaanxi. “AR&Dt” stands for technical effect of FDI, which is equal to the ratio of the R&D internal expenditure over the total work force. The data can be obtained directly or calculated from the statistical yearbook of Shaanxi province.

4.2.2 Empirical Results

(1) The ADF stationary test and results

For the unstable time series data, the traditional regression method may cause the pseudo regression problem. However, co-integration theory can avoid this error and find a balance between two or more unbalanced variables. First, we need to test the single order of variables before the co-integration analysis. The ADF method is used to test the unit root of all time series data and its difference in order to determine the stability of the time series and the order of a single integer.

Eviews7.0 software is used for the ADF stationary test. The results showed that the emissions of industrial solid waste time

series, FDI time series, per capita gross domestic product time series, the ratio of industrial value-added over GDP in Shaanxi and per capita R&D internal expenditure time series were both non-reposeful time series. And they were integrated of order 1.

(2) Co-integration test and results

Similarly, eviews7.0 software is also used for Co-integration test. The VAR model was established based on the above time series data which are integrated of order 1. The lagged rank was chosen as 1 according to Schwartz criterion. After testing the model which took the emissions of industrial solid waste as dependent variable, we found that at confidence level 99% there were at least two co-integration equations for the emissions of industrial solid waste and their respective variables. The results were shown in Table 4.

Table 4: Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.86	104.63	69.82	0.00
At most 1 *	0.68	61.97	47.86	0.00
At most 2 *	0.65	36.81	29.80	0.01
At most 3	0.37	13.65	15.49	0.09
At most 4	0.14	3.44	3.84	0.06
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

After confirming the existence of co-integration relationship, we obtained the normalized co-integration vectors by the Co-integration test. The related data can be seen in Table 5.

Table 5: Normalized co-integrating coefficients (standard error in parentheses)

Lnsolid	LnFDI	LnAGDP	InStructure	LNAR&D
1	1.15	-0.15	7.89	-1.14
	(-0.41682)	(-0.84272)	(-3.31804)	(-0.64664)

The normalized co-integration equation can be obtained from the table 5.

$$Lnsolid_t = -1.15LnFDI_t + 0.15LnAGDP_t - 7.89LnStructure_t + 1.14LnAR\&D_t \quad (5)$$

From the equation, there was a significant negative correlation between the emissions of industrial solid waste and FDI. FDI can improve the environmental quality of Shaanxi. To be more specific, a 1% increase in the foreign investment would result in a 1.15% decrease in the emissions of industrial solid waste. From the perspective of effect decomposition of FDI on environmental impact, the expansion of economic scale had a significant positive impact on the emissions of industrial solid waste. A 1% increase in per capita gross domestic product would result in a 0.15% increase in the emissions of industrial solid waste. The scale effect of foreign direct investment aggravated the environmental pollution. A 1% increase in the ratio of industrial value-added over GDP in Shaanxi would result in a 7.89% decrease in the emissions of industrial solid waste. The structural effect of FDI improved the environmental quality of Shaanxi. The impact of per capita R&D internal expenditure on the emissions of industrial solid waste was significantly positive. A 1% increase in the ratio of the R&D

internal expenditure over the total work force would result in a 1.14% increase in the emissions of industrial solid waste. The technical effect of FDI made environmental quality worse.

5. Conclusions and Recommendations

5.1 Conclusions

Based on the empirical analysis of the environmental effects of FDI in Shaanxi, the results showed that the change of the emission of Shaanxi province was not the Granger cause of the change of FDI, but FDI had some impacts on the environmental quality of Shaanxi province at a certain level. And the environmental effects which brought about by the expansion of the economic scale and the technology transfer which induced by the stock of FDI were negative, only the environmental effects which brought about by the economic structure were positive, but the overall environmental effects were negative.

5.2 Recommendations

As a big province in western China, the massive inflow of foreign direct investment promotes the economic growth of Shaanxi. FDI has brought the advanced technology and advanced management experience, which can also promote the optimization of export structure, industry upgrading and local employment. But when we see the advantages of foreign direct investment, we should also pay attention to the environmental pollution. Considering the higher pollution treatment costs, Shaanxi province can make a breakthrough out of the bottleneck only by utilizing the sustainable development. Therefore, we should start from the source and reduce pollution to find the balance between foreign direct investment and the environment.

(1) Optimizing the industrial structure of foreign investment

For a long time, the foreign investment in Shaanxi is mainly distributed in the second industry, especially the manufacturing industry. The industrial distribution of FDI is unevenly. In 2015, the actual utilization of foreign investment accounted for 87.45% in the whole Shaanxi province. However, FDI in China mainly concentrates on the traditional industry, and the proportion of high-tech industry is very small. For example, the proportion of actual utilization of foreign capital in the science and technology services is only 0.23%. When the government coordinates industrial development, on the one hand, the introduction of foreign investment in the second industry should be based on industrial upgrading and industrial structure adjustment. On the other hand, investment in primary industry and tertiary industry should be increased. In addition, foreign investment should be guided to distribute in various industries of the service industry, and the investment in real estate and social service industry should be decreased. This is due to the very big fluctuation of the third industry caused by foreign investment during the period of a strained economy and rapid economic development, which will have a negative impact on the overall economic development. Therefore, it is imperative to optimize the industrial structure of foreign capital and coordinate the development of industry

in order to realize the coordinated development between foreign investment and environment.

(2) Promoting the positive spillovers of FDI

In order to realize the positive technology effect of foreign investment, the government's policy support is indispensable. For those enterprises who are active to bring in the pollution control technology and buy the pollution control equipment the government should give policy encouragement and provide financial support to these enterprises within the scope of the policy. In addition, the government should encourage enterprises to actively participate in clean technology research and development, provide opportunities for domestic and foreign R&D professionals to promote communication between them, and vigorously promote the rapid development of clean technology. Among the many factors that determine the ability of enterprises to absorb advanced technology, the professional and technical talent storage is the key. Therefore, the cultivation of talent needs more attention to enhance the effect of technology spillover of FDI.

(3) Improving the environmental standards

We should learn from the countries with advanced experience in the world, set up a set of regulations of the environmental industry based the Chinese context and keep up with the world. So far the environmental protection legislation has been lack of penalties to punish enterprises for pollution, which is due to the strong resistance in the course of enforcing the law and concerns about the impact on economic development. Under the current system, environmental watchdogs are tasked with charging companies for pollution, but they have been ineffective in doing so. In order to improve the environmental problems, it is necessary to implement the target responsibility system for environmental protection. The environmental protection scope and responsibility of each department should be quantified and institutionalized in order to ensure the implementation of this goal. In addition, we should improve legislation of environmental protection and reinforce law of environmental protection as soon as possible to restrain the extension of the transfer of environmental protection. We should continue to implement environmental impact assessment system to curb environmental pollution and promote industrial upgrading and development.

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