

Study on the Inverted N Relation and the Greenhouse Effect Impact Mechanism between FDI and Carbon Emissions

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Abstract: *The greenhouse effect was focused by more learners with the global warming. It has become a very serious issue the relationship between foreign direct investment and carbon emissions in the process of sustainable economic development in Shandong. This paper studied the relationship trend in middle of FDI, carbon emissions and greenhouse effect impact mechanism in Shandong Province based on the data from 2000 to 2016 in Shandong Province by simultaneous equation model from qualitative and quantitative analysis. There is an inverted environmental Kuznets curve correlation between FDI and carbon emissions. The mechanism of FDI's impact on Shandong's ecological environment in three aspects: scale effect, structure effect and technology effect. The results show that FDI has negative scale effect, structure effect and positive technology effect on carbon emissions in Shandong Province, and the overall effect is negative. Accordingly, taking the transformation of new and old kinetic energy in Shandong Province as the goal, this paper puts forward the optimization strategy, provides policy suggestions for the government in the implementation of the transformation of new and old kinetic energy, in order to better promote economic development, industrial restructuring and upgrading, and realize the construction of regional ecological civilization.*

Keywords: *foreign direct investment, carbon emission, energy consumption, greenhouse effect*

1. Introduction

Grossman and Krueger (1993) decomposed the impact of trade on the environment into three parts: scale effect, structural effect and technological effect, which were further supported by theory (Antweiler et al, 2001). This analytical framework was used to explain the impact of FDI on energy intensity (Hubler and Keller, 2009). Blackman and Wu (1999) examined FDI's investment in the electricity sector to improve energy efficiency. Allen and Wu (1999) summed up China's foreign direct investment policy in the field of energy, believing that foreign direct investment is an important reason for China's energy efficiency. Zhao Xiaoli et al. (2007) based on the FDI industry data from 1997 to

2005, using the decomposition method to confirm that FDI is concentrating on high-energy industries. Teng Yuhua and Chen Xiaoxia (2009) found that energy prices, FDI entry, import and export commodity structure, industry structure within industry and R&D investment intensity have a significant impact on China's industrial energy intensity, in which FDI entry will reduce the energy efficiency of the industry.

There are three views on the impact of FDI on the environment of the host country at home and abroad: (1) developed countries transfer pollution-intensive enterprises to developing countries with weak environmental control and absolutely dominant resources, resulting in direct environmental pollution; (2) FDI also brings advanced technology to improve energy consumption that it will help improve the host country's environment. (3) Due to the economic development and the improvement of environmental control, the entry of foreign capital will change from the final pollution to the reduction of energy consumption and environmental pollution, that is, there is an inverted U-shaped or inverted N-shaped curve between foreign direct investment and energy consumption [7-8].

There are three mechanisms of FDI to environmental pollution and energy consumption in the host country^[9-10]: scale effect, structure effect and technology effect. Scale effect refers to the impact of FDI on the energy consumption and ecological environment of the host country while the production scale and investment scale of the host country enterprises are increasing under the condition that the technology and industrial structure remain unchanged. Structural effect means that the inflow of FDI will change the industrial structure of Shandong province, thus affecting the ecological environment and energy consumption of Shandong province. If FDI mainly flows into pollution-intensive industries, it will lead to the deterioration of ecological environment and the increase of energy consumption in Shandong Province, which will bring negative environmental effects. If FDI belongs to the clean industry, mainly into the industries with less pollution, high-tech industries or service industries such as the tertiary industry, it will bring positive environmental effects and reduce energy consumption in Shandong Province. Technology effect means that foreign direct investment not only brings capital to Shandong province, but also solves the shortage of domestic capital, meanwhile brings advanced technology level and management idea, brings demonstration effect to Shandong province, and improves the technology level of Shandong province. Technology effect means that FDI not only brings capital to Shandong province and solves the shortage of domestic capital, but also brings advanced technology level and management idea, provides demonstration effect for Shandong province, and improves the technology level of Shandong province. The entry of foreign investment will also crowd in the domestic market, leading to increased competition among enterprises. In order to occupy the market position, domestic enterprises need to learn advanced technology and improve their technological level and production efficiency.

From 2000 to 2016, the amount of foreign direct investment actually utilized was increased from 381 million US dollars to 1.68 billion US dollars in Shandong Province. The rapid development of the economy depends largely on foreign direct investment. Therefore, it is of great significance to study the impact of FDI on carbon emissions, the ecological environment and its mechanism in Shandong Province.

2. FDI and carbon emissions status

As can be seen from Figure 1, the total amount of foreign capital actually was increased from 29.71.19 million U.S. dollars in 2000 to 16.62 billion U.S. dollars in 2016 in Shandong Province. The actual utilization of foreign capital showed a relatively stable growth trend in general. From 2001 to

2003, the growth rate reached 54% and 73%, showing a high-speed upward trend, which was closely related to China's accession to the WTO. From 2007 to 2009, the total FDI in Shandong Province showed a downward trend, which was related to the sub-prime mortgage crisis. The sub-prime mortgage crisis led to the global economic recession and the decline in demand, which made the export enterprises varying degrees difficulties and led to the decrease of FDI. Foreign direct investment in other years showed a steady growth trend. From the graph, it can be seen that the energy consumption of Shandong Province was increasing from 2000 to 2016, and the intensity of energy consumption decreasing. From the industrial structure of investment, in 2016, foreign direct investment in the primary industry accounted for only 3% of the total foreign direct investment; and investment in the secondary industry as high as 70%, especially in the manufacturing industry in the secondary industry. The proportion of investment in the third industry is relatively low, and the proportion of real estate investment was relatively high. The proportion of foreign direct investment in the secondary industry in Shandong Province had gradually declined from 88% in 2005 to 70% in 2016, and the proportion of foreign investment in the tertiary industry has been increasing from 8.9% in 2005 to 27% in 2016. Shandong's industrial structure is constantly adjusting. The industrial structure of FDI should meet the requirements of new and old kinetic energy conversion in Shandong Province, which is conducive to reducing carbon emissions and promoting the sustainable development of Shandong Province.

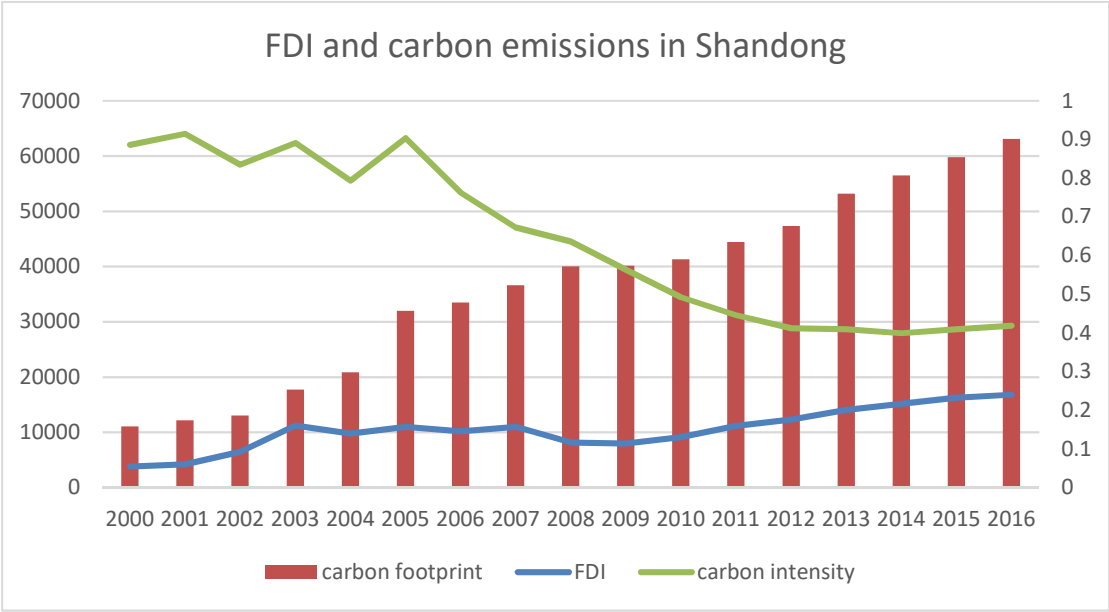


Fig.1. FDI and carbon emissions in Shandong

3. FDI and carbon emissions correlation

Using the Environmental Kuznets Curve to test the relationship between carbon emissions and foreign direct investment in Shandong Province, the results are shown in Table 1. Eliminate heteroscedasticity by taking logarithms of variables. On behalf of the actual utilization of foreign capital in Shandong Province, the carbon emissions selected in this paper are the carbon emissions of the industrial sector, so the actual utilization of foreign capital in Shandong industrial sector represents the index in the model.

Table.1. FDI and carbon emissions test result

Explain variable	N^{-1} curve test	U^{-1} curve test
C	273.8281 (0.0836)	-36.87524 (0.2782)
FDI	-128.7163 (0.0873)	6.645984 (0.2003)
$(FDI)^2$	20.7080 (0.0832)	-0.244358 (0.2120)
$(FDI)^3$	-1.1061 (0.0797)	
$LnNA$	1.3996 (0.0000)	1.382799 (0.0000)
$R - squared$	0.98	
DW value	1.87	

explanation: Figure in brackets is adjoint probability

Table 1 is a test of the trend relationship between carbon emissions and FDI in Shandong Province. The data in the table show that LnE and $LnFDI$ quadratic curve equation, The adjoint probability of the $LnFDI$ primary and quadratic square is larger and not significant, so the result of reciprocal U curve test is not significant. The Cubic Curve Equation of LnE and $LnFDI$; The adjoint probability of all explanatory variables is small, and all of them are significant at 10% confidence interval. The goodness of fit is 0.98, so the cubic function is chosen as model form. There is an inverted N -type environmental Kuznets curve between energy consumption and foreign direct investment in Shandong Province. The empirical results are as follows(1)^[11]:

$$LnE = 273.8 - 128.7LnFDI + 20.7LnFDI^2 - 1.1LnFDI^3 + 1.4LnNA \quad (1)$$

The actual use of foreign investment at the inflection point is approximately US\$ 54.46 billion. This means that when the amount of foreign investment is more than US\$54.46 billion, the energy consumption of Shandong Province will increase and the environment pollution will be serious with the entry of foreign direct investment. Based on the simultaneous equations model, the specific environmental effects of FDI on carbon emissions are analyzed in Shandong Province.

4. Model and explanations

Using the simultaneous equations model, we investigate quantitatively the impact of FDI on the carbon emissions of Shandong province from three aspects: scale, structure and technology^[12-14].

$$\left\{ \begin{array}{l} E = e(Y, S, T) \quad 1.1 \\ Y = y(K, L, E, FDI(-1)) \quad 1.2 \\ S = s(FDI, S(-1), K / L) \quad 1.3 \\ T = t(FDI, T(-1)) \quad 1.4 \\ FDI = f(W, Y(-1), FDI(-1)) \quad 1.5 \end{array} \right.$$

Equation 1.1 is the contamination equation. Y stands for economic size, S stands for economic structure and T stands for technical level. The impact of FDI on energy consumption in Shandong province is divided into three kinds of effects-scale effect, structure effect and technology effect. Among them, E is the environment. In this paper, Shandong Province from 2000 to 2016, carbon

emissions from the industrial sector are chosen as the energy consumption index. The pollution equation shows the different influence degree of *FDI* on energy consumption of Shandong province through scale effect, structure effect and technology effect.

Equation 1.2 is the economic scale equation. The traditional Cobb-Douglas production function includes material capital (k), labor force (L). In this paper, energy consumption (E) and foreign direct investment (FDI) are added to the economic growth model as a factor. It shows that *FDI* has caused indirect effect on environmental pollution and energy consumption through its direct influence on economic scale. The effect of *FDI* on energy consumption in Shandong Province is analyzed by the scale effect. In general, under the condition of constant structure, technology level and so on, the larger production scale, the more energy consumption and the more pollutant discharge.

Equation 1.3 is the economic structure equation. The inflow of *FDI* will cause the change of economic structure, and the change of economic structure will have an impact on the environment. The proportion of fixed assets investment and total number of employees indicates the change of industrial structure. The structural effect of *FDI* on ecological environment is indicated by the proportion of the secondary industry output value in Shandong Province to GDP. At the same time, S (-1) is introduced to show the effect of the time lag structure on the present structure change. If Shandong Province's environmental regulation is weak and the secondary industry is still dominant, it will attract some polluting industries to enter. When *FDI* promotes the comparative advantage of pollution-intensive industries in Shandong Province, it will bring negative environmental effects, aggravate environmental pollution and increase energy consumption with the input of *FDI*.

Equation 1.4 is the technical effect equation. Technological advances will increase the utilization rate of natural resources and reduce pollution emissions and ecological damage. If the input of *FDI* brings clean technology and strict environmental regulation standards, and improves input generation efficiency, then *FDI* will benefit the technological progress of Shandong Province and increase the intensity of energy utilization. This paper analyzes the technical effect of *FDI* on energy consumption intensity in Shandong province by using the carbon emission per unit of output.

Equation 1.5 is based on the traditional location theory of *FDI*. The amount of foreign direct investment will be affected by the labor cost, the economic scale in the early stage of Shandong Province. In this paper, the average wage of urban workers (W) is used to represent the labour force, and Y (-1) is the economic size of the previous period. Cheap labour would attract *FDI* inflows, mainly in labour-intensive and pollution-intensive industries. At the same time, the *FDI* value the market potential of Shandong Province. The small size of the market in the previous period will attract the entry of foreign direct investment.

5. Selection of variables and data sources

Based on the data from 2000 to 2016 in Shandong Province, this paper examines the relationship between *FDI* and eco-environmental effects. Energy consumption is the main source of greenhouse gas emissions such as CO₂, so we take Shandong industrial sector carbon emissions as the energy consumption index. The data are derived from the corresponding periods of Shandong Statistical Yearbook, with a unit of 10,000 tons. The selected carbon emissions include 18 major sources of carbon emissions, such as raw coal, crude oil, coke and natural gas. This paper selects GDP of Shandong Province to express scale effect, and carbon emission per unit of industrial output value to express technical effect, The share of secondary industry in GDP in Shandong Province represents the structural effect of *FDI* on energy consumption, while *FDI* represents the actual use of *FDI* in

Shandong Province (US\$ 10,000).

The input factors that affect output include: 1.Total Number of Employees (L) 2. Total Number of Employees in Shandong Province (L) 3.Foreign direct investment (FDI) For the other indicators, the annual average wage income of urban employees is used to show the wage level (W), and the change of capital labor ratio (K/L) indicates the change of industrial structure^[15-16]. The results of the econometric analysis and its economic significance are shown in table 2.

Table 2 Estimation results of simultaneous equations

	Coefficient	Std.Error	t-Statistic	Prob
C(1)	0.642323	0.861240	0.745812	0.4586
C(2)	1.059507	0.073794	14.35766	0.0000
C(3)	0.528222	0.087604	6.029655	0.0000
C(4)	0.801119	0.080302	9.976375	0.0000
C(5)	-63.76604	6.445383	-9.893288	0.0000
C(6)	0.115714	0.057640	2.007530	0.0491
C(7)	8.639229	0.878043	9.900685	0.0000
C(8)	-0.286462	0.088221	-3.247087	0.0019
C(9)	0.081774	0.029250	2.795679	0.0069
C(10)	-0.321831	0.133309	-2.414167	0.0188
C(11)	0.052852	0.019496	2.795679	0.0087
C(12)	0.984877	0.067245	14.64604	0.0000
C(13)	-0.040090	0.007544	-5.314493	0.0000
C(14)	0.801279	0.532029	1.506079	0.1372
C(15)	0.925843	0.039259	23.58301	0.0000
C(16)	-0.128966	0.076673	-1.682040	0.0977
C(17)	-0.885967	2.297218	-0.385669	0.7011
C(18)	1.871662	1.501061	1.246893	0.2172
C(19)	-1.540680	1.313013	-1.173393	0.2452
C(20)	0.612932	0.219751	2.789215	0.0070

$LOG(E) = C(1) + C(2) * LOG(Y) + C(3) * LOG(S) + C(4) * LOG(T)$			
<i>R - squared</i>	0.99	<i>Durbin - Waston stat</i>	1.72
$LOG(Y) = C(5) + C(6) * LOG(K) + C(7) * LOG(L) + C(8) * LOG(E) + C(9) * LOG(FDI(-1))$			
<i>R - squared</i>	1.00	<i>Durbin - Waston stat</i>	1.62
$LOG(S) = C(10) + C(11) * LOG(FDI) + C(12) * LOG(S(-1)) + C(13) * LOG(K / L)$			
<i>R - squared</i>	0.96	<i>Durbin - Waston stat</i>	1.57
$LOG(T) = C(14) + C(15) * LOG(T(-1)) + C(16) * LOG(FDI)$			
<i>R - squared</i>	0.99	<i>Durbin - Waston stat</i>	2.06
$LOG(FDI) = C(17) + C(18) * LOG(W) + C(19) * LOG(Y(-1)) + C(20) * LOG(FDI(-1))$			
<i>R - squared</i>	0.66	<i>Durbin - Waston stat</i>	1.84

(1)Scale effect. The increase in foreign direct investment will lead to an increase in output, and the expansion of economic scale will lead to an increase in industrial carbon emissions and an increase in energy consumption. Based on the results of the estimates, *FDI* in the previous period increased by 1 per cent, and the current economic size *Y* will increase by 0.139 percentage points. By increasing economic size by 1 per cent, energy consumption would increase by 1.257 percentage points. Eventually, the previous period's *FDI* increased by 1%, leading to an increase of 0.118 percentage points in pollution emissions.

(2)Structural effects. Foreign direct investment will cause structural adjustment. According to the statistical results, a 1 per cent increase in *FDI* would lead to a structural change of 0.075 percentage points. The 1% change in industrial structure will increase pollution by 0.427%. Eventually, *FDI* increased by 1% and energy consumption increased by 0.032 percentage points. At present, the foreign direct investment in Shandong province is still mainly invested in pollution-intensive industries, and the entry of *FDI* has not promoted the transformation of Shandong's economic structure into a clean one.

(3)Technology effects. The entry of *FDI* will bring advanced technology level and strict environmental control standard, which will promote the improvement of industrial technology level. According to the statistical results, a 1 per cent increase in *FDI* would lead to a 0.066 percentage point increase in the level of technology. A 1% increase in technology would increase pollution emissions by 1.040 percentage points. Finally, the technical effect was that *FDI* increased by 1% and pollution emissions decreased by 0.069 percentage points. It can be seen that Shandong Province has realized the importance of environmental protection. By strengthening the industrial structure, the industrial structure of introducing *FDI* is changing from labor-intensive and resource-intensive to technology-intensive.

We combined the influence of *FDI* on energy consumption in Shandong province through scale effect, structure effect and technology effect, and drew the following Fig.2.

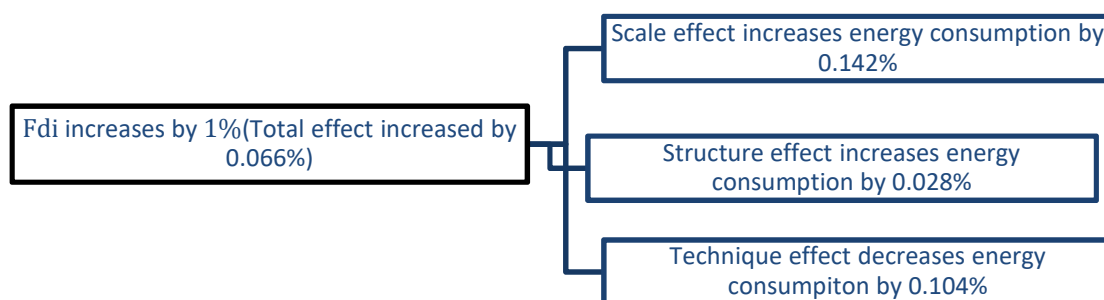


Fig.2. Impact mechanism of FDI to energy consumption

6. Conclusions and recommendations

(1) Main conclusions

This paper studied the interaction between FDI-industrial structure and economic growth-energy consumption using simultaneous equations model. Using the data from 2000 to 2016 from Shandong Province as sample data, the following conclusions are drawn:

Economic scale, structure and technological level play an important impact on carbon emissions, greenhouse effect and environmental pollution in Shandong Province. They are the vital factors of carbon emissions. The scale effect and technology effect have significant impact on carbon emissions of Shandong Industry Ministry. In order to develop the ecological environment effect of *FDI*, the government should increase the technology input and the environmental control, mainly attract the clean foreign investment.

FDI have brought the expansion of economic scale, at the same time, the entry of foreign direct investment leads to the change of industrial structure and the improvement of technological level. Performance: for every 1% increase in *FDI*, energy consumption will increase by 0.139% through the expansion of economic scale; carbon emissions increased by 0.032% through the change of industrial structure. By bringing advanced technology level to improve Shandong's industrial technology level, the energy consumption will be reduced by 0.069%. The overall effect is a 1% increase in *FDI* and a 0.081% increase in energy consumption in Shandong Province.

The effect of *FDI* on carbon emissions is negative, which promotes the increase of carbon emissions in the industrial sector. By combining qualitative analysis with quantitative analysis, it was shown that there was a positive correlation between *FDI* and carbon emissions in Shandong province at the present stage, Although foreign direct investment can promote the economic growth, solve the economic gap, bring advanced technology, it is due to the expansion of industrial scale and the structure adjustment. The carbon emissions of Shandong province is increased, that is, the high-speed development of economy is at the cost of carbon emissions, which is unfavorable to the sustainable development of economy of this province.

(2) Policy recommendations

Sound environmental standards for economic development. The government has promulgated relevant policies, improved environmental supervision mechanism, and strictly implemented relevant laws, regulations and standards on environmental protection and energy consumption. The government should change the past mode of attracting foreign investment for production, encourage the entry of

clean, capital-intensive and technology-intensive foreign investment, and restrict and prohibit the entry of pollution-intensive foreign investment from the angle of environmental protection. The government promotes transferring of foreign direct investment to the low-pollution tertiary industry, the well-developed secondary and tertiary industries by lowering taxes and granting preferential policies, and develops the progress in the field of sustainable development.

Accelerating the transformation of new and old kinetic energy and optimize industrial transformation and upgrading. We will further optimize *FDI* and upgrade the industrial structure in Shandong Province by implementing innovation drive. Through the transformation of new and old kinetic energy in Shandong Province, one is to develop high-tech industry and modern service industry, the other is to promote green manufacturing, intelligent manufacturing, advanced manufacturing. The *FDI* will be actively directed to high-tech and green industries in Shandong Province. The technology progress is promoted, the carbon emissions are reduced and the sustainable development is realized in Shandong Province through the spillover effect of *FDI*. The greenhouse effect must be finally improved.

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