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STUDY ON THE INVERTED N RELATION AND THE GREENHOUSE EFFECT IMPACT MECHANISM BETWEEN FOREIGN DIRECT INVESTMENT AND CARBON EMISSIONS

by

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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 (FDI) 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.

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

Introduction

Grossman and Krueger [1] decomposed the impact of trade on the environment into three parts: scale effect, structural effect, and technological effect, which were further supported by theory. Stan [2] examined FDI in the electricity sector to improve energy efficiency. Zhao *et al*. [3] based on the FDI industry data from 1997 to 2005, using the decomposition method to confirm that FDI is concentrating on high-energy industries. Weiwu [4] summed up China's FDI policy in the field of energy, believing that FDI is an important reason for China's energy efficiency. Liu and Gong [5] 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 mechanisms of FDI to environmental pollution and energy consumption in the host country [6].

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There are three views on the impact of FDI on the environment of the host country at home and abroad:

– developed countries transfer pollution-intensive enterprises to developing countries with weak environmental control and absolutely dominant resources, resulting in direct environmental pollution,
– the FDI also brings advanced technology to improve energy consumption that it will help improve the host country's environment, and
– due to the economic development and the improvement of environmental control, the entry of foreign capital will change from the final pollution the reduction of energy consumption and environmental pollution, that is, there is an inverted U shaped or inverted N shaped curve between FDI 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 FDI 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 FDI actually utilized was increased from 381 million US $ to 1.68 billion US $ in Shandong Province. The rapid development of the economy depends largely on FDI. Therefore, it is of great significance to study the impact of FDI on carbon emissions, the ecological environment and its mechanism in Shandong Province.

The FDI and carbon emissions status

As can be seen from fig. 1, the total amount of foreign capital actually was increased from 29.71.19 million US $ in 2000 to 16.62 billion US $ 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 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 de-

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crease of FDI. The FDI 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, FDI in the primary industry accounted for only 3% of the total FDI, and investment in the secondary industry as high as 70%, especially in the manufacturing industry in the secondary industry. The proportion of

Figure 1. The FDI and carbon emissions in Shandong

investment in the third industry is relatively low, and the proportion of real estate investment was relatively high. The proportion of FDI 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.
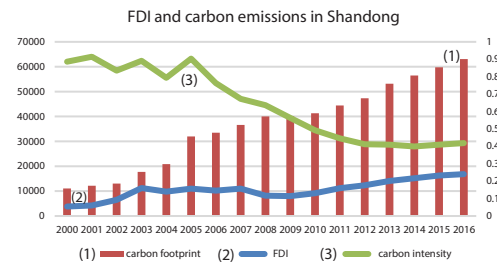
The FDI and carbon emissions correlation

Using the environmental Kuznets curve to test the relationship between carbon emissions and FDI in Shandong Province, the results are shown in tab. 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. The 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	

* 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 FDI in Shandong Province. The empirical results are eq. (1) [11]:

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

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 FDI. Based on the simultaneous equations model, the specific environmental effects of FDI on carbon emissions are analyzed in Shandong Province.

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].

$$E = e(Y, S, T) \quad (2)$$

$$Y = y\left[K, L, E, FDI(-1)\right] \quad (3)$$

$$S = s\left[FDI, S(-1)\frac{K}{L}\right] \quad (4)$$

$$(5)$$

$$T = t\left[FDI, T(-1)\right] \quad (6)$$

$$FDI = f\left[W, Y(-1), FDI(-1)\right] \quad (7)$$

Equation (2) is the contamination equation. The *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 (3) 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 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 (4) 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,

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it will bring negative environmental effects, aggravate environmental pollution and increase energy consumption with the input of FDI.

Equation (5) 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 (6) is based on the traditional location theory of FDI. The amount of FDI 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 FDI.

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 GHG emissions such as CO_2, 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 10000 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$ 10000).

The input factors that affect output include:
– Total number of employees, L
– Total number of employees in Shandong province, L
– 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 tab. 2.

Scale effect. The increase in FDI 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% points. By increasing economic size by 1 per cent, energy consumption would increase by 1.257% points. Eventually, the previous period's FDI increased by 1%, leading to an increase of 0.118% points in pollution emissions.

Structural effects. The FDI will cause structural adjustment. According to the statistical results, a 1% increase in FDI would lead to a structural change of 0.075% 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% points. At present, the FDI in Shandong

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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

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

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.

T*echnology 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% point increase in the level of technology. A 1% increase in technology would increase pollution emissions by 1.040% points. Finally, the technical effect was that FDI increased by 1% and

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pollution emissions decreased by 0.069% 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.
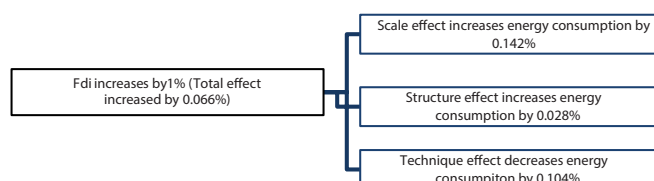

Figure 2. Impact mechanism of FDI to energy consumption

Conclusions

– *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.

● The FDI have brought the expansion of economic scale, at the same time, the entry of FDI 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 FDI 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.

– *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 FDI 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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