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Study on the Indirect Effect of Environmental Control Policy on Carbon Emission in China

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Abstract: This paper uses the systematic GMM method to investigate the heterogeneous effects of three environmental regulation policies. The results show that: (1) the direct impact of emission fee on carbon emission intensity is inverted U-shaped, but the impact is not significant. the emission fee can significantly promote the upgrading of industrial structure and indirectly achieve carbon emission reduction;(2) After the introduction of the square term, it shows a significant inverted U-shaped feature with carbon emission intensity, and is about to cross the inflection point and enter the stage of "forced emission reduction". Through the indirect mechanism analysis, it is found that the investment in industrial pollution control can not only force the upgrading of industrial structure, and then produce the "structural dividend effect", but also promote technological innovation, realize the "innovation compensation effect", and effectively inhibit the increase of carbon emissions;(3) local environmental standards can also force technological innovation of enterprises, produce the "Porter Hypothesis" effect, and indirectly inhibit carbon emissions. However, it is regrettable that none of the three environmental regulation policies has made the energy consumption structure low-carbon, at the same time, to a certain extent, it has also inhibited the environmental spillover effect and capital accumulation effect of foreign direct investment, thus making FDI show the "pollution shelter" effect. The above results show that China's current environmental regulation policies can effectively curb carbon emissions and achieve the expected carbon emission reduction goals.

Keywords Backward emission reduction; Carbon intensity; Pollution shelter

INTRODUCTION

With the rapid growth of global economy and the acceleration of industrialization, environmental pollution and global climate change are becoming more and more serious, especially the increase of carbon dioxide emissions has caused great damage and impact on human life and natural environment. As early as 1979, the Chinese government began to levy pollution charges on enterprises in order to internalize external costs. In 2003, regulations on the administration of the collection and use of pollution charges were promulgated [XU, *et. al.*, 2015]. The regulation points out that the government's pollution charge must be used to feed enterprises for pollution control in the form of environmental protection subsidies.

Is China's environmental regulation policy a positive backward effect or a negative green paradox? What are the differences in the transmission path and impact effect of different environmental regulation policies on carbon emissions [WU, *et. al.*, 2017]? Only by clarifying these issues, can China better improve and play the role of different environmental regulations in carbon emission reduction, smoothly achieve China's promised carbon emission reduction goals, and further accelerate the pace of low-carbon economic transformation.

The main contributions of this paper are as follows: First, in order to more accurately and comprehensively evaluate the effectiveness of different environmental regulation policies on carbon emission intensity, this paper brings the issued local environmental protection standards, industrial pollution control investment and emission fee income into the same analysis framework, expounds the impact mechanism and puts forward research hypotheses from direct and indirect perspectives. Secondly, this paper uses 30 provincial panel data from 2000 to 2016 in mainland China as research samples, constructs a dynamic panel model, uses the System GMM method, introduces the square terms of different environmental regulations, tests the non-linear impact of environmental regulation tools on carbon emission intensity, and empirically compares the heterogeneous effects of different environmental regulation policies on carbon emission reduction [ZHOU, *et. al.*, 2007].Third, in order to compare the effectiveness of carbon emission reduction before and after the implementation of environmental regulation policies, this paper further divided into two different periods: 2000-2006 and 2007-2016, and compared and evaluated the effectiveness of different environmental regulations on carbon emission reduction, laying the foundation for identifying the effectiveness and transmission path of different environmental regulation policies. In addition, this paper also introduces the square term of per capita income to verify the existence of carbon Kuznets Curve in China's provinces. The structure of this paper is as follows: the third part is theoretical analysis and research hypothesis, the fourth part is data from and model building, the fifth part is empirical structure analysis, the sixth part is research conclusion and policy enlightenment.

THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

Indirect Transmission Mechanism of Environmental Regulation on Carbon Emission

(1)Transmission Based on Industrial Structure

Under the constraints of strict environmental regulations, the upgrading of industrial structure can solve the dilemma of "maintaining growth and promoting emission reduction". The intervention of environmental regulation and the enhancement of regulation intensity can make the industries with high pollution and high energy consumption bear high "environmental compliance cost"[XU, *et. al.*, 2011], improve the survival threshold of enterprises, and force such enterprises to eliminate backward technology and choose to transform to green and low-carbon industries, or transfer pollution intensive industries to regions with loose environmental regulation.Therefore, appropriate environmental regulations can "fine wash" enterprises, drive the "advanced" adjustment of industrial structure, and achieve backward emission reduction, so as to reduce carbon emissions.At the same time, clean industry is less affected by the link regulation, and severe environmental regulation can further promote the development of service industry.

(2)Transmission Based on Technological Innovation

The technological innovation effect of environmental regulation has both negative "follow cost" effect and positive "Porter Hypothesis" effect.The effect of "compliance cost" is that environmental regulation will internalize the external cost of the enterprise, which will increase the production cost of the enterprise.the high cost of environmental compliance will squeeze the R&D investment of the enterprise, thus reducing the production efficiency of the enterprise [ZHENG, *et. al.*, 2013]. It is not conducive to technological innovation, let alone promoting carbon emission reduction and environmental governance.Even some enterprises take the initiative to expand product production in order to maximize the enterprise value, and then generate ancillary pollutants, which further leads to the increase of carbon emissions.

(3)Transmission Based on FDI

Due to China's special political governance system, local officials will hold a "political promotion championship" to pursue the growth of local GDP. [12]In order to promote regional economic growth and improve political achievements, local governments will implement "bottom to bottom competition" behavior, resulting in "incomplete implementation" of environmental regulation policies.This will make the region a "pollution shelter" for pollution intensive industries in developed countries, and further increase the carbon emissions of the region.But at the same time, FDI can also bring advanced production technology and production process to host country enterprises to some extent, produce technology spillover effect, promote local technology progress and innovation, and help reduce carbon emissions, which is "pollution halo effect"[13]. If the host country's environmental regulations are strict, it will prevent the pollution intensive industries of developed countries from entering the country and avoid the "pollution shelter" effect.

(4)Transmission Based on Energy Consumption Structure

On the one hand, improving the intensity of environmental regulation can increase the cost of environmental governance, promote enterprises to adopt more advanced energy-saving and emission reduction technologies, use a large amount of clean energy, and further optimize the energy consumption structure, so as to reduce the demand for high carbon energy and reduce carbon emissions [Marconi, 2012].Based on the above analysis, the following assumptions are proposed:

H1:China's local environmental protection standards can promote carbon emission reduction through industrial structure, technological innovation, foreign direct investment and energy consumption structure.

H2:China's investment in industrial pollution control can promote carbon emission reduction through industrial structure, technological innovation, foreign direct investment and energy consumption structure.

H3:China's emission revenue can promote carbon emission reduction through industrial structure, technological innovation, foreign direct investment and energy consumption structure.

RESEARCH DESIGN AND MODEL CONSTRUCTION

Data Sources

This paper uses panel data from 30 provinces of China (excluding Tibet, Hong Kong, Macao and Taiwan) for empirical analysis.The number of local environmental protection standards and investment in industrial pollution control are both from the Environmental Statistics Yearbook of China over the years.The regional GDP, population, industrial added value, proportion of tertiary industry, urban population and number of patent applications are from China Statistical Yearbook.

Variable Specification

Carbon Dioxide Emission Intensity

This paper mainly refers to the calculation method recommended in the IPCC, adopts the carbon emission coefficient recommended by the Energy Research Institute of the national development and Reform Commission of China[YUAN, *et. al.*, 2014], and uses eight major energy types of coal, coke, crude oil, gasoline, diesel, fuel oil and natural gas to calculate the carbon dioxide emissions of 30 provinces in China from 2000 to 2016 in detail.The

calculation formula of carbon emission is shown in Table 1.

$$CO_2 = \sum_{i=1}^{8} E_i \times R_i \times K_i \qquad (1)$$

Among them, CO2 — the carbon emission generated by energy consumption; Ei-the ith energy consumption; Ri — the standard coal conversion coefficient of the ith energy; Ki—the carbon dioxide emission coefficient of the ith energy.

Table1 Standard coal conversion coefficient and carbon dioxide emission coefficient of different energy

Energy	Coal	Coke	Crude Oil	Fuel Oil	Gasoline	Kerosene	Diesel Oil	Gas
R	0.7143	0.9714	1.4286	1.4286	1.4714	1.4714	1.4571	1.3300
K	2.7716	3.1305	2.1476	2.2678	2.0306	2.0951	2.0951	1.6438

(2)Environmental Regulation

As for the measurement of environmental regulation, the current indicators mainly include performance-based and investment-based.Investment type indicators mainly include investment in environmental pollution control, total operating cost of pollution control facilities or per capita operating cost, etc [XIAO, *et. al.*, 2013].Chinese scholars mainly use the removal rate and utilization rate of different pollutants as performance-based indicators.However, these single indicators can only be used as a representative of environmental regulation, and this paper will make a comparative study on the carbon emission reduction effect of different types of environmental regulation policies.This paper mainly studies the carbon emission reduction effect of three kinds of environmental regulation policies:

(1)Issued local environmental protection standards.The local environmental protection standard belongs to the environmental policy of command control type. This paper uses the practice of Li Yongyou [Jalil, *et. al.*, 2011] for reference, and uses the number of environmental standards issued by the local government as the proxy index.Because the number of local environmental protection standards can show the level of environmental governance in various regions to a certain extent.With cer, the higher the value is, the stronger the order environment regulation is.

(2)Investment in industrial pollution control.

Among them, $M_{i,t}$—Total investment in industrial pollution control in the ith Province in year t; $Y_{i,t}$— Total industrial output value of the ith Province in year t.

However, the difference of industrial structure among provinces will affect the intensity of environmental regulation. The industrial pollution control investment per unit industrial output value calculated by the above formula will underestimate the intensity of environmental regulation in clean industry intensive provinces and overestimate the intensity of environmental regulation in pollution industry intensive provinces. Therefore, it needs to be corrected by the industrial structure of each province over the years,that is, the proportion of industrial output value in GDP(S_t).The revised formula is:

$$S_{i,t} = \frac{S_{i,t}}{S_t} \qquad (2)$$

(3)Emission fee income. The emission fee income also belongs to the market incentive environmental policy. Pollution discharge fee has been implemented for a long time in China, and its development is relatively mature and perfect. It has the feasibility and rationality as an agent variable [Zhang, *et. al.*, 2010].

(3)Other Variables

(1)Advanced level of industrial structure ($lndu$).Different scholars choose different agency indicators of industrial structure. (2)Technological innovation($lntech$). There are many indicators to measure technological innovation, some scholars use the expenditure of scientific research funds, some scholars use the amount of patent granted, but this paper selects the number of patent applications received in each province over the years as an agent indicator of technological progress, which can better reflect technological innovation than other indicators.(3)FDI ($lnfdi$).This paper uses the total amount of foreign direct investment to measure this index.(4)Energy consumption structure ($ener$).In this paper, the physical quantity is converted into standard coal. (5) GDP per capita(lny).It represents the per capita GDP of each province over the years. (6)Population scale (lnp).

Model

In order to verify hypothesis 2 and test the indirect impact of environmental regulation on carbon emissions, this paper will introduce the multiplier of environmental regulation and industrial structure, technological innovation, foreign direct investment and energy consumption structure respectively, and further investigate the mechanism and effect of environmental regulation on carbon emissions through these four transmission paths. The measurement model is as follows:

$$lnc_{i,t} = \eta_0 + \eta_1 lnc_{i,t-1} + \eta_2 cer_{i,t} \times ener_{i,t} + \eta_3 cer_{i,t} \times indu_{i,t} + \eta_4 cer_{i,t} \times lntech_{i,t} + \eta_5 cer_{i,t} \times lnfdi_{i,t} + \varphi X_{i,t} + \gamma_i + \varepsilon_{i,t}$$

$$lnc_{i,t} = \eta_0 + \eta_1 lnc_{i,t-1} + \eta_2 S_{i,t} \times ener_{i,t} + \eta_3 S_{i,t} \times indu_{i,t} + \eta_4 S_{i,t} \times lntech_{i,t} + \eta_5 S_{i,t} \times lnfdi_{i,t} + \varphi X_{i,t} + \gamma_i + \varepsilon_{i,t}$$

$$lnc_{i,t} = \eta_0 + \eta_1 lnc_{i,t-1} + \eta_2 M_{i,t} \times ener_{i,t} + \eta_3 M_{i,t} \times indu_{i,t} + \eta_4 M_{i,t} \times lntech_{i,t} + \eta_5 M_{i,t} \times lnfdi_{i,t} + \varphi X_{i,t} + \gamma_i + \varepsilon_{i,t}$$

i,t represent province and year respectively, lnc is the logarithmic carbon dioxide emission intensity, η_1 Is the lag multiplier, indicating the impact of the previous strong carbon dioxide emission team on the current period, γ_i represents the regional non observation effect and reflects the continuous differences between provinces, $\varepsilon_{i,t}$ represents a specific heterogeneous effect, assuming a normal distribution, $ener_{i,t}$ represents the energy consumption structure, $indu_{i,t}$ represents the degree of industrial structure upgrading, $lntech_{i,t}$ represents technological innovation, $lnfdi_{i,t}$ represents foreign direct investment, $X_{i,t}$ represents other variables, including per capita GDP, population scale, and urbanization rate.

EMPIRICAL ANALYSIS

Analysis on the Difference of Carbon Emission Reduction Effect of Indirect Impact Mechanism

Table2 reports the indirect effects of environmental regulation on carbon emissions through four paths: industrial structure, technological innovation, foreign direct investment and energy consumption structure. This paper constructs three kinds of multiplier terms of environmental regulation policies and industrial structure, technological innovation, foreign direct investment and energy consumption structure. According to the regression results in Table2, it is found that the AR (1), AR (2) and sargan statistics are all effective in reporting tool variables, which shows that the model is reasonable and the regression results are reliable. Similar to the direct effect analysis, the first lag term of carbon emission intensity has a significant positive cumulative effect on the current carbon emission intensity. Other variables in the model, the first power coefficient of GDP per capita is significantly positive, the second power coefficient is significantly negative, indicating that economic activities significantly promote the increase of carbon emissions, and there is a carbon Kuznets curve. This is consistent with the research conclusion of Wang Xinkang [25], which means that only when the level of economic development exceeds a certain threshold, the technical effect of technological progress on carbon emission reduction and the structural effect of industrial restructuring on carbon emission reduction will be highlighted. The increase of carbon emission was significantly inhibited by the urbanization rate under the two policies of emission fee income and industrial pollution control investment.

Table2 Indirect effects of three environmental regulation tools on carbon emission reduction

Variable	$ER=M$	$ER=S$	$ER=cer$
$L.lnc$	0.946***	0.956***	0.971***
	-38.44	-23.14	-15.37
$ER\times indu$	-0.844***	-0.176***	0.0013
	(-4.48)	(-5.38)	-1.84
$ER\times lntech$	-0.0351	-0.0432***	-0.009***
	(-0.66)	(-3.71)	(-5.16)
$ER\times lnfdi$	-0.008	0.055***	0.007***
	(-0.40)	-6.64	-4.77
$ER\times ener$	0.0139**	-0.0007	0.0002***
	(-2.96)	(-1.25)	(-4.71)
lny	0.741***	0.579**	0.773*
	(-3.71)	(-2.84)	(-2.46)
$(lny)^2$	-0.039***	-0.030**	-0.041**
	(-3.81)	(-3.27)	(-2.88)
lnp	0.051	0.0199	0.0208
	(-1.55)	(-0.7)	(-0.54)
u	-0.119	-0.155**	-0.118*
	(-1.55)	(-2.80)	(-2.12)
$\_c$	-3.017**	-2.729**	-3.653*
	(-2.71)	(-2.92)	(-2.34)
N	480	480	480
$AR(1)$	-2.49	-2.59	-2.52
	(0.01)	(0.01)	(0.01)
$AR(2)$	-0.76	-0.94	-0.90
	(0.44)	(0.35)	(0.37)
Test value of $Sargan$	29.30	28.29	28.86
	(0.94)	(0.96)	(0.95)

Noted:***、**、*represents the significance level of 1%, 5% and 10%, respectively. The value in brackets below the coefficient is its standard error.AR (1) and AR (2) represent the Arellano bond autocorrelation test of the first-order and second-order difference residual sequences respectively, and sargan test is the over recognition test.

Table2 reports the indirect effects of environmental regulation on carbon emissions through four paths: industrial structure, technological innovation, foreign direct investment and energy consumption structure. This paper constructs three kinds of multiplier terms of environmental regulation policies and industrial structure, technological innovation, foreign direct investment and energy consumption structure. According to the regression results in Table2, it is found that the AR (1), AR (2) and sargan statistics are all effective in reporting tool variables, which shows that the model is reasonable and the regression results are reliable. Similar to the direct effect analysis, the first lag term of carbon emission intensity has a significant positive cumulative effect on the current carbon emission intensity. Other variables in the model, the first power coefficient of GDP per capita is significantly positive, the second power coefficient is significantly negative, indicating that economic activities significantly promote the increase of carbon emissions, and there is a carbon Kuznets curve. This is consistent with the research conclusion of Wang Xinkang [25], which means that only when the level of economic development exceeds a certain threshold, the technical effect of technological progress on carbon emission reduction and the structural effect of industrial restructuring on carbon emission reduction will be highlighted. The increase of carbon emission was significantly inhibited by the urbanization rate under the two policies of emission fee income and industrial pollution control investment.

From the path analysis of industrial structure, the cross product of emission fee, industrial pollution control investment and industrial structure is significantly negative at the level of 1%, which shows that both emission fee income and industrial pollution control investment can have a positive inhibition effect on carbon emissions through the upgrading of industrial structure.[9]The reason is that when the emission collection standard and the investment in industrial pollution treatment per unit output value reach a certain degree of severity, the enterprises with high pollution, high energy consumption and high emission will bear the high "environmental compliance cost" and raise the industry threshold, but the technology intensive and labor intensive service industries are less restricted by environmental regulations. Therefore, these two policies can inhibit the development of pollution intensive heavy industry and encourage the development of clean industry as the main tertiary industry, so as to promote the upgrading of industrial structure and reduce carbon emissions.

From the analysis of technological innovation path, the impact of the cross product of pollution charge and technological innovation is negative, but not significant. The conclusion is consistent with the table. The reason is that the income of pollution discharge fee does not stimulate the enthusiasm of enterprises in pollution control, which makes enterprises produce the effect of "cost following", and enterprises prefer to pay pollution discharge fee rather than technological innovation and upgrading.

From the analysis of technological innovation path, the impact of the cross product of pollution charge and technological innovation is negative, but not significant, the conclusion is consistent with the table.The reason is that the income of pollution charge does not stimulate the enthusiasm of enterprises in pollution control, which makes enterprises produce the effect of "cost following". Enterprises prefer to pay pollution charges rather than technological innovation and upgrading.The cross product of industrial pollution control investment, local environmental protection standards and technological innovation is significantly negative at the level of 1%.The reason lies in the fact that the government is the maker and supplier of environmental policies[10].

According to the path analysis of FDI, the multiplier coefficient of emission fee and FDI is negative, but not significant, which is consistent with the analysis in Table 2. This shows that the pollution charge income makes the FDI have a certain environmental spillover effect. However, the multiplier of industrial pollution control investment, local environmental protection standards and foreign direct investment is significantly positive. Compared with table 2, the direction of action has changed substantially, from negative to positive, from not significant to 1% level. This shows that, for the pollution intensive foreign-funded enterprises that have entered the region, with the increase of industrial pollution control investment and local environmental protection standard regulation intensity, the production cost of enterprises increases. On the one hand, it further hinders the technology and environmental spillover effects of FDI. On the other hand, it weakens the ability of absorbing technology from foreign enterprises.

From the path analysis of energy consumption structure, the multiplier coefficients of emission fee income, local environmental protection standards and energy consumption structure are significantly positive at the level of 5% and 1%, respectively, The direction of the role of the energy consumption structure has changed compared with table 2.The multiplier coefficient of industrial pollution control investment and energy consumption structure is negative, but it is not significant. Therefore, under the influence of these three kinds of environmental regulations, the energy consumption structure dominated by coal is an important factor leading to the increase of carbon emissions, which does not make the energy consumption structure low-carbon and achieve the expected purpose of restraining the increase of carbon emissions. The reasons are as follows: first, since ancient times, China has been "rich in coal, poor in oil and little in gas".

Indirect impact assessmentin Different Periods

Table3 reports the indirect effects of different environmental regulations on carbon emissions in different periods.

Table3 Indirect effects of three environmental regulation tools on carbon emission reduction in different periods

	2000-2006			2007-2016		
Variable	$ER=M$	$ER=S$	$ER=cer$	$ER=M$	$ER=S$	$ER=cer$
L.lnc	0.969***	1.035***	1.137***	0.969***	1.095***	1.112***
	(10.23)	(9.88)	(16.68)	(12.42)	(17.25)	(21.65)
ER×indu	0.168	-0.034	0.044***	-1.604**	-0.0170	-0.002
	(0.25)	(-0.20)	(8.36)	(-3.07)	(-0.45)	(-1.32)
ER×lntech	-0.202	0.031	-0.036***	0.049	-0.036*	-0.005***
	(-1.71)	(0.63)	(-3.68)	(0.35)	(-2.34)	(-3.35)
ER×lnfdi	0.160**	0.050	0.024***	-0.012	0.037***	0.004**
	(2.74)	(1.16)	(5.50)	(-0.16)	(3.99)	(3.26)
ER×ener	-0.007	-0.010**	0.0001	0.017***	-0.0001	0.0001
	(-0.77)	(-3.10)	(0.12)	(3.50)	(-0.11)	(1.70)
lny	0.618	0.570	0.202	0.0112	1.478**	0.492
	(1.92)	(1.51)	(0.59)	(0.03)	(2.63)	(1.75)
$(lny)^2$	-0.016	-0.016	0.001	0.003	-0.068*	-0.021
	(-0.94)	(-0.82)	(0.03)	(0.22)	(-2.53)	(-1.59)
lnp	0.227***	0.118	0.133***	0.154***	0.244***	0.214***
	(4.44)	(1.94)	(3.36)	(3.59)	(4.97)	(5.18)
u	-0.052	-0.108	-0.067	0.323	0.085	0.042
	(-0.56)	(-1.12)	(-0.83)	(1.41)	(0.40)	(0.21)
_c	-2.333	-1.280	-0.350	2.316	-6.103*	-1.033
	(-1.47)	(-0.68)	(-0.22)	(1.14)	(-2.09)	(-0.65)
AR(1)	-2.69	-2.72	-2.79	-3.54	-3.38	-3.88
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
AR(2)	0.52	0.45	0.87	0.41	-0.08	-0.99)
	(0.60)	(0.66)	(0.38)	(0.68)	(0.94)	(0.32)
Sargan	15.09	9.46	15.77	22.98	25.04	22.65
Test Value	(0.18)	(0.58)	(0.15)	(0.29)	(0.20)	(0.31)

Noted:***、**、*represents the significance level of 1%, 5% and 10%, respectively.The value in brackets below the coefficient is its standard error.AR (1) and AR (2) represent the Arellano bond autocorrelation test of the first-order and second-order difference residual sequences respectively, and sargan test is the over recognition test.

In the second stage, the cross multiplication coefficient between the emission fee income and the industrial structure is significantly negative, which indicates that the emission fee income significantly inhibits carbon emissions through the industrial structure. That is to say, to a certain extent, the emission fee promotes the upgrading of the industrial structure, thereby reducing carbon emissions. However, the multiplier coefficient of the emission fee income and energy structure is significantly positive. It shows that the emission fee income does not have a low-carbon energy consumption structure, does not achieve the expected purpose of promoting enterprises to optimize the energy consumption structure, and thus to achieve the goal of carbon emission control. In the two stages, the pollution fee income did not promote the technological innovation of enterprises, but the impact on foreign direct investment changed from significant positive to negative. Although not significant, it shows that the pollution fee income promotes the environmental spillover effect of foreign direct investment to a certain extent, and has a negative impact on carbon emissions.

Investment in industrial pollution control has not significantly promoted the upgrading of industrial structure, nor played a significant role in carbon emission reduction. However, the cross product with technological innovation is becoming significantly negative at the 10% level. It shows that the investment in industrial pollution control promotes the technological progress of enterprises in the second stage, and then reduces carbon emissions. The direction of both the industrial pollution control investment and foreign direct investment is positive. However, in the second stage, it becomes significant at the level of 5%, which indicates that in the second stage, industrial pollution control investment attracts foreign direct investment, but it presents a "race to the bottom line" effect. Local governments excessively pursue economic growth, fail to give full play to the technological advantages of foreign-funded enterprises, weaken their environmental spillover effect, and then increase carbon emissions. For energy consumption structure, there is no significant low-carbon energy structure.

Local environmental protection standards did not optimize the industrial structure in the first stage. It may be that the local government pursues higher economic growth and does not adopt strong environmental standards for pollution intensive industries, which makes the threshold of high pollution and high energy consumption industries lower. And there is no preferential support policy for the tertiary industry, so there is no high-level industrial level to curb carbon emissions. With the continuous development of the economy, in the second stage, the government realized the importance of environmental protection, began to strengthen the determination of environmental governance, raised the threshold of pollution intensive industries to a certain extent, and began to support the development of clean industries, thus promoting the upgrading and optimization of industrial structure, and began to change from promoting carbon emissions to inhibiting. However, in order to play a significant role in emission reduction, the government should also strengthen the governance of polluting enterprises and increase the support for the tertiary industry. In both stages, local environmental protection standards promote carbon emission reduction by promoting technological innovation of enterprises. However, for foreign direct investment, there is also a "pollution shelter" effect, which does not give full play to the technological advantages of foreign-funded enterprises to promote technological innovation and carbon emission reduction, nor to optimize the energy consumption structure.

Consistent with the previous analysis, population scale is still an important factor in significantly promoting carbon emissions, and economic activities also stimulate further increase of carbon emissions. In the second stage, the urbanization rate promotes the increase of carbon emissions. Although it is not significant, it fully reflects that with the improvement of China's urbanization level, carbon emissions have increased to a certain extent.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

In this paper, The specific conclusions are as follows:

Firstly, the emission fee income did not directly play the expected role in carbon emission reduction, but it can indirectly inhibit carbon emission reduction by forcing enterprises to upgrade their industrial structure. The reason lies in the fact that the legal collection standard of pollution charge is far lower than the cost of pollution control of enterprises. At the same time, it reflects that there are still many defects in the emission fee system in China, which can not effectively encourage enterprises to adopt cleaner technology or improve the level of pollution control.

Secondly, the investment in industrial pollution control can directly restrain the intensity of carbon emission. The third industry, which is dominated by technology and labor-intensive service industry, will benefit from this preferential environmental regulation policy, so as to promote the upgrading of industrial structure, thus bringing "structural effect dividend" of carbon emissions, and indirectly restrain the increase of carbon emissions. Investment in industrial pollution control can also force technological innovation of enterprises, make technological innovation present "compensation effect of technological innovation", make up for "follow cost" of enterprises, and also verify "Porter Hypothesis".

Thirdly, the direct impact of local environmental standards on carbon emissions has a "green paradox" effect. At the same time, the local government will increase the determination and strength of pollution control, formulate strict local environmental protection standards, force enterprises to adopt environmental protection technology and technological innovation, realize the "technological innovation compensation effect", and effectively curb carbon emissions.

Policy Enlightenment

The above conclusions are of great significance in policy. In order to give full play to the role of three different environmental regulation policies in China's low-carbon economic transformation, it is necessary to combine the different effects of different environmental regulations on carbon emission reduction and different transmission paths, and fully exert the carbon emission reduction effect of environmental regulation policies through different transmission paths, so as to promote the realization of China's carbon emission reduction goals, accelerate the transformation of China's low-carbon economy. This paper gets the following policy implications:

In the previous paper, the multiplier terms of different environmental regulations and four transmission paths are constructed to test the indirect impact on carbon emissions. It is found that the effects of different environmental regulations on carbon emissions are different, and the impact path is also very different. Therefore, in order to improve environmental governance and promote the realization of carbon emission reduction goals, we need to give full play to the transmission function of the four paths.

Firstly, actively promote the upgrading of industrial structure. The government should continue to raise the threshold of heavy industries such as high energy consumption and high pollution, and gradually transform and incline to clean service-oriented industries, so as to optimize and transfer the industrial structure and generate greater "structural effect dividend".

Second, continue to optimize the structure of energy consumption. Energy consumption structure dominated by coal hinders the realization of China's carbon emission reduction goals. The government

should actively encourage the development of a safe and clean energy supply and consumption system, and promote the use and promotion of green and clean energy such as wind energy and solar energy. At the same time, enterprises should continue to improve the efficiency of energy utilization, especially the efficiency of coal resources utilization, and truly achieve the goals of energy conservation and emission reduction, environmental pollution control and so on.

Third, give full play to the compensation effect of technological innovation. In the above analysis, both industrial pollution control investment and local environmental protection standards can significantly reduce carbon emissions by forcing technological innovation of enterprises. Therefore, the government should create favorable conditions and environment for environmental protection technology innovation of enterprises, guide enterprises to invest in environmental protection innovation, and actively focus on environmental protection technology and industry.

Fourth, optimize the strategy of attracting and utilizing foreign investment. FDI has the effect of environmental spillover. Although high-intensity environmental regulations may hinder the inflow of foreign capital, if local governments loosen environmental regulations, it may cause bottom-to-bottom competition and pollution shelter effect. Therefore, in the process of introducing foreign investment, the local government should formulate corresponding investment objectives according to the actual situation of different regions, coordinate the investment policies of different regions, prevent the competition of foreign investment among regions, strengthen the awareness of environmental protection, implement strict environmental control on foreign investment, improve the environmental spillover effect of foreign investment, and minimize the negative impact of foreign investment on the environment.

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