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Research Article

Nonlinear Effects of Environmental Regulation on Environmental Pollution

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This paper classifies environmental regulation into two types and constructs a theoretical framework to explore the influences of fee-based environmental regulation and invest-based environmental regulation on environmental pollution. It then establishes some dynamic spatial autoregressive nonlinear econometric models to test the theoretical hypothesis based on 30-area panel data from 2004 to 2016. The results illustrate that inverted "U" shape curve relationship exists between fee-based environmental regulation and environmental pollution, while a "U" shape curve relationship between invest-based environmental regulation and environmental pollution exists. In addition, the findings suggest that improving the proportion of secondary industry can directly promote the environmental quality while effectively control of foreign direct investment and fiscal decentralization is also indispensable. Thus, the government should make targeted research about the optimal intensity of fee-based environmental regulation and invest-based environmental regulation and make targeted enterprise policy for the environmental pollution reduce, which contains promoting the energy revolution and strengthening the depth and strength of opening-up step by step.

1. Introduction

The economic growth in the process of industrialization is accompanied by the rapid consumption of production factors and the massive emission of pollutants, which means the environmental quality is inevitably eroded by pollutants even if considering the natural purification and recycling effect of the ecological environment. Since the reform and opening up, this phenomenon has become more prominent. The main reason is industrial development without giving priority to environmental governance. In order to get rid of poverty, Chinese government has gradually lowered the entry threshold of foreign-funded industries and used large amount of foreign capital while the backward production technology and the lack of infrastructure construction lead to the establishment of a simple and rough manufacturing system, which are mainly concentrated in the southeast coast, inland provincial capital cities, and subprovincial cities. Finally, the extensive factor-oriented economic development model is obtained, which is difficult to be adjusted in the medium and long term and can result in the coexistence of economic development and environmental deterioration.

In order to achieve a win-win posture of economic development and environmental protection, the government has implemented environmental regulations on polluting enterprises. However, the core is whether the improvement of environmental quality is really promoted by environmental regulation. Then, a lot of researches is conducted on the specific impact of environmental regulation on environmental pollution or productivity that are conducted by scholars and related institutions (Christainsen and Haveman, 1981; Porter, 1991; Porter and van der Linde, 1995; Jaffe and Palmer, 1997; Alpay et al., 2002; Gray and Shadbegian, 2003; Telle and Larsson, 2007; Frondel et al., 2007; Lanoie et al., 2011; Iraldo et al., 2011; Zhang et al., 2011; Greenstone et al., 2012; Amber et al., 2013; Rassier and Earnhart, 2015; Wang and Shen, 2016; Li and Wu, 2017; Galinato and Chouinard, 2018) [1–17]. While there are significant differences in the above research results, it was found that numerous researches are fasten on the following two aspects. One is the classification and definition of environmental regulation and the other is research method that contains econometric model, game model, and regression measurement.

In this article, we endeavor to provide an unambiguous understanding of nonlinear linkages between environmental regulation and environmental pollution by dividing the environmental regulation into fee-based environmental regulation and invest-based environmental regulation for solving the following questions. Is there an inverted "U" relationship between fee-based environmental regulation and environmental pollution? Is there a "U" shape curve characteristic between invest-based environmental regulation and environmental pollution? Will environmental pollution have spatial autoregressive effect? The remainder of this article is organized as follows. Section 2 stands for the literature review. Section 3 presents the theoretical analysis and research hypothesis. Section 4 represents method and data. Section 5 denotes empirical analysis. And Section 6 shows the conclusions and policy recommendations.

2. Literature Review

The Porter Hypothesis is that appropriate environmental regulation can encourage enterprises to carry out more innovation activities, and these innovations will increase the productivity of enterprises, so as to offset by the cost of environmental protection. Then, we can use the above theoretical basis for analyzing the impact of environmental regulation on environmental pollution. While, applying Porter Hypothesis to analyze the effect of environmental regulation on environmental pollution, the existence of compensation effect and the scale effect caused by technological progress should be further studied. Three distinct research statements about the effect of environmental regulation on environmental pollution are shown as follows.

Some scholars believe that the environmental regulation will aggravate the operating cost and reduce the capital capacity of enterprises to a greater extent, which is not conducive to the improvement of environmental quality (Kneller and Manderson, 2012; Rubashkina et al., 2015; Li et al., 2018) [18–20]. Lanoie (2011) explored the relationship between environmental policy stringency on the business performance and found that the innovation cannot offset the cost from governmental regulation [9]. Rubashkina et al. (2015) investigated the "weak" and "strong" versions of Porter Hypothesis focusing on the manufacturing sectors of 17 European countries between 1997 and 2009 and found no evidence in favor of the "strong" Porter Hypothesis, as productivity appears to be unaffected by the degree of pollution control and abatement efforts [19]. Li et al. (2018) explored the impact of environmental regulation on the efficiency of technological innovation and its temporal and spatial evolution with a combined data envelopment analysis model and found that there is no influence [20].

Some scholars believe that compensation effect can be achieved which can support porter hypothesis. Then the environmental quality can be greatly improved through effective environmental regulation (Berman and Bui, 2001; Yang et al., 2012; Franco and Marin, 2013; Peuckert, 2014; Yang et al., 2018) [21–25]. Zhang et al. (2011) proposed the relationship between productivity measured by Malmquist Luenberger index and environmental regulation and found more stringent enforcement of environmental regulation can help to promote the productivity [11]. Franco and Marin (2013) support the above conclusions by using energy taxes strength to proxy environmental regulation stringency in manufacturing [23]. Yang et al. (2018) suggested that local government may use environmental regulations to achieve economic objectives [25].

Other scholars believe that there is nonlinear transformation between environmental regulation and environmental pollution (Sanchez-Vargas et al., 2013; Yin et al., 2015; Chakraborty and Chatterjee, 2017; Xie et al., 2017) [26–29]. Sanchez-Vargas et al. (2013) found that the nonlinear effects of manufacturing productivity and environmental regulation are reflected in the size of the enterprise [26]. Wang and Shen (2016) showed an inverted "U" relationship with three thresholds between China's environmental regulation and environmental productivity based on data envelopment analysis model [15]. Xie et al. (2017) found both command-and-control and market-based environmental regulation have nonlinear shape curve with green productivity [29]. Li and Wu (2017) took the spatial spillover effect into spatial Durbin econometric model to explore the relationship between environmental and productivity and found environmental regulation can improve the environmental quality by "race to the top" in parts cities, while deteriorating the environmental pollution by "race to the bottom" in the other cities [16].

The existing research has important reference and guiding significance for clarifying the correlation between environmental regulation and environmental pollution, but few scholars analyze environmental regulation from the perspective of environmental regulation funds, such as fee-based environmental regulation and invest-based environmental regulation. As a consequence, this paper will establish dynamic spatial autoregressive model of 30-area panel data from 2004 to 2016 to explore the relationship between fee-based environmental regulation or invest-based environmental regulation and environmental pollution.

3. Theoretical Analysis and Research Hypothesis

3.1. The Classification of Environmental Regulation. According to the instructions of the *Chinese Ministry of Ecology and Environment*, environmental regulation is to supply rules and regulations, restraint system, mechanism, and measures to meet high quality environment of residents and society. A number of researches have been established by different method (Chintrakarn, 2008; Hafstead and Williams, 2018) or setting different types of environmental regulation, which mainly contains command-and-control environmental regulation, market-based environmental regulation, informal environmental regulation (Li and Ramanathan, 2018; Peng et al., 2018; Zhao et al., 2018), or local and civil environmental regulation (Li and Wu, 2017) [16, 30–34]. While few scholars have divided environmental regulation based on perspective of funds use, which is obtained or spent from environmental regulation, then environmental regulation can be divided into fee-based environmental regulation and investment-based environmental regulation referring to Yuan and Liu (2013) [35]. Fee-based environmental regulation mainly represents the regulatory expenses, which include forfeiture income, administrative expenses, and tax revenue. And invest-based environmental regulation focus primarily on environmental improvement investment expenses, including technology investment, infrastructure construction, cultivation of talents expenditure, and so on.

3.2. The Nonlinear Effect of Environmental Regulation on Environmental Pollution. The government formulates punishment standard of pollution by referring to the regional environmental capacity, pollutant discharge, residents' and society health needs, and international industry standard. The penalty proceeds shall be used as environmental governance funds to compensate for environmental losses. The expenditure of fee-based environmental regulation would be undertaken by the polluters, which will increase enterprise cost directly. In response to the government's environmental penalty, polluting enterprises do not actively purchase efficient production equipment, introduce advanced clean technologies, or recruit experienced managerial and technical personnel. The main reason is that they need to assess the difference between the intensity of fee-based environmental regulation and the enterprise costs for measures needed to reduce environmental pollution. If the intensity of fee-based environmental regulation is higher than the enterprise costs which will be used to reduce environmental pollution, polluters would be happily to invest more enterprise internal investment to reduce their pollution. At the same time, based on enterprise heterogeneity and information asymmetry, the intensity of fee-based environmental regulation may be more likely lower than the enterprise costs, companies tend to pay pollution fines rather than halt production. At this situation, the quality of local environment will not be improved or even worsen. Based on the above analysis, the following hypothesis is proposed.

Hypothesis 1. There are inverted "U" shape relationships between fee-based environmental regulation and environmental pollution. After a certain threshold is exceeded, increasing intensity of fee-based environmental regulation can improve environmental quality.

The above fee-based environmental regulation is from a regulatory perspective without any government or society support measures, which determine that it does not make sense when the sunrise industry enterprise or some particularly important state-owned enterprises have strong desire to increase enterprise green productivity without effective capital or market information. Then the invest-based environmental regulation is coming, which will effectively solve the lack of funds or information to help the enterprise to improve their technical level and cultivate professional and technical personnel for reducing pollutant emissions per unit of output. The specific methods of invest-based environmental regulation mainly contain special financial subsidies, provide discount interest loans, reduce corporate tax burden, establish carbon trading market, cultivate environmental management talents, define the enterprise pollutant discharge property rights, and so on. Because the invest-based environmental regulation cannot add the enterprise cost, companies will be glad to receive the government support measures. What needs to be emphasized is an optimum intensity of invest-based environmental regulation. If the intensity of invest-based environmental regulation is higher than the enterprise costs that will be used to enhance environmental quality, the extra fund will be used to expand production scale. At this situation, invest-based environmental regulation not only improves green productivity, but also expands production scale, which will not be helpful to reduce pollution for "pollutant aggregate effect" because increased productivity and scale of production, which greatly increases the number of products, will likely increase the total amount of pollutant emissions. Therefore, the following hypothesis is proposed.

Hypothesis 2. There are "U" shaped curves between the invest-based environmental regulation and environmental pollution. Before a certain threshold is exceeded, increasing intensity of invest-based environmental regulation can decrease environmental pollution.

4. Method and Data

4.1. Econometric Model. Taking the different volatility of economic development into consideration, static econometric model has been established as equations (1) and (2). Moreover, it has been optimized as dynamic econometric model as equations (3) and (4) that contain the hysteric characteristic of environmental pollution:

$$LnPOL_{it} = \alpha_0 + \alpha_1 LnENF_{it} + \alpha_2 LnENF_{it}^2 + \varepsilon_{it} \quad (1)$$

$$LnPOL_{it} = \beta_0 + \beta_1 LnENI_{it} + \beta_2 LnENI_{it}^2 + \varepsilon_{it} \quad (2)$$

$$\begin{aligned} LnPOL_{it} = {} & \alpha_0 + \alpha LnPOL_{it-1} + \alpha_1 LnENF_{it} \\ & + \alpha_2 LnENF_{it}^2 + \varepsilon_{it} \end{aligned} \quad (3)$$

$$\begin{aligned} LnPOL_{it} = {} & \beta_0 + \beta LnPOL_{it-1} + \beta_1 LnENI_{it} \\ & + \beta_2 LnENI_{it}^2 + \varepsilon_{it} \end{aligned} \quad (4)$$

where i is the province; t is the year; POL_{it} is environmental pollution of year t in province i; POL_{it-1} is the hysteric characteristic of environmental pollution of year t in province i; ENF_{it} is fee-based environmental regulation of year t in province i; ENF_{it}^2 is the quadratic of ENF_{it}; ENI_{it} is invest-based environmental regulation of year t in province i; ENI_{it}^2 is the quadratic of ENI_{it}; α_i and β_i are the parameter to be estimated.

As we all know, environmental pollution has strong spatial correlation. On one hand, pollutant can move from one place to adjacent area or other nonadjacent places through air flow, river flow, and industrial transportation, which can aggravate environmental pollution of the above areas where pollutants are transferred. On the other hand, environmental governance has a certain demonstration effect on neighboring areas or areas of equal political nature. The important is that the demonstration effect will be further enhanced by the competition of political promotion championship in China. The above analysis means that the spatial effect of environmental pollution should be considered into equations (3) and (4). Then, spatial measurement models are constructed as follows:

$$LnPOL_{it} = \alpha_0 + \rho WLnPOL_{it} + \alpha_1 LnENF_{it} + \alpha_2 LnENF_{it}^2 + \alpha_3 LnPOL_{it-1} + \varepsilon_{it} \quad (5)$$

$$LnPOL_{it} = \beta_0 + \rho WLnPOL_{it} + \beta_1 LnENI_{it} + \beta_2 LnENI_{it}^2 + \beta_3 LnPOL_{it-1} + \varepsilon_{it} \quad (6)$$

In order to control the impact of other factors on environmental pollution, referring to research of some scholars (Wang et al., 2018; Que et al., 2018; Sapkota and Bastola, 2017; Sghari and Hammami, 2016), industrial structure, fiscal decentralization, foreign direct investment, and local economic development are included in the measurement model as control variables [36–39]. Adjusted econometric models based on equations (5) and (6) have been established as follows:

$$\begin{aligned} LnPOL_{it} = {} & \alpha_0 + \rho WLnPOL_{it} + \alpha_1 LnENF_{it} \\ & + \alpha_2 LnENF_{it}^2 + \alpha_3 LnPOL_{it-1} \\ & + \alpha_4 LnSTR_{it} + \alpha_5 LnFIN_{it} \\ & + \alpha_6 LnFDI_{it} + \alpha_7 LnRGDP_{it} + \varepsilon_{it} \end{aligned} \quad (7)$$

$$\begin{aligned} LnPOL_{it} = {} & \beta_0 + \rho WLnPOL_{it} + \beta_1 LnENI_{it} \\ & + \beta_2 LnENI_{it}^2 + \beta_3 LnPOL_{it-1} \\ & + \beta_4 LnSTR_{it} + \alpha_5 LnFIN_{it} \\ & + \beta_6 LnFDI_{it} + \beta_7 LnRGDP_{it} + \varepsilon_{it} \end{aligned} \quad (8)$$

where W stands for spatial weight matrix, which can reflect the spatial correlation characteristic of environmental pollution. Second-order adjacency weight matrix and geographical distance weight matrix are been used in this paper for both of them can effectively denote the logistic relationship of environmental pollution between different areas. In terms of regression method, econometric model (7) and (8) may be underlying the endogenous problems, while the generalized method of moments (GMM) (Bond, 2002; Windmeijer, 2005) can be valid in solving the above question [40, 41].

4.2. Variables Settings and Data Sources

4.2.1. Environmental Pollution. In order to fully reflect the true level of environmental pollution in various regions, water pollution, air pollution, and noise pollution are all included. The weighted sum of annual per capita emissions of various pollutants is used to represent the level of regional environmental pollution (Liu and Wen, 2007; Zhou and Chen, 2016) [42, 43]. Firstly, the unit monetary quantity level of eliminating all kinds of environmental pollution has been adopted as the intensity of environmental pollution due to the dimensional differences in contaminants. Secondly, combining with pollutant discharge, the regional environmental pollution level can be obtained by multiplying and weighting. In addition, unit monetary quantity level of eliminating noise pollution is measured by the one percent of GDP, carbon dioxide, sulfur dioxide, and tobacco dust represent air pollutants, and water pollutants are expressed in terms of per capita chemical oxygen demand for considering the consistency of statistical caliber and availability of data.

4.2.2. Independent Variables. (1) *Core independent variable: environmental regulation.* Based on the above definition, referring to Yuan and Liu (2013), fee-based environmental regulation is measured by pollution charges levied by the government; invest-based environmental regulation is measured by the total amount of pollution control investment and its decomposition [35]. The decomposition items include urban environmental infrastructure construction investment, industrial pollution source management, and construction of the "three-simultaneity" environmental protection investment. (2) *Control variables.* The industrial structure adopts proportion of secondary industrial output on regional GDP to express. Foreign direct investment uses proportion of the actual amount of foreign capital on regional GDP. Fiscal decentralization is measured from the self-sufficiency rate of local government fiscal revenue and self-determination rate of local government fiscal expenditure. Economic development level adopts the per capita GDP after the adjustment of the GDP provincial price index. (3) According to data availability, panel data period is set from 2004 to 2016. All the data are from *China statistical yearbook*, *China financial yearbook*, *and China environmental yearbook*. The descriptive statistical results of all variables are given in Table 1.

5. Empirical Analysis

5.1. Spatial Autocorrelation Test of Environmental Pollution. As mentioned above, environmental pollution has significant spatial agglomeration effect, which needs to be verified through hypothesis test. Then, Moran's I index can be used to test the spatial heterogeneity or agglomeration of environmental pollution. And the mathematical definition of Moran's

Table 1: Descriptive statistics for 390 observations.

Variable, Abbreviation, Unit	Mean	Standard deviation	Minimum	Maximum
Environmental pollution (Environmental pollution is structural variable with no dimension.), POL	5.248	0.423	4.308	6.329
Fee-based environmental regulation, ENF, Ten thousand yuan	55902.000	48075.000	1562.000	287343.000
Investment environmental regulation, ENI, Ten thousand yuan	165.166	167.403	5.300	1416.200
Urban environmental infrastructure construction investment, ENIA, Ten thousand yuan	99.874	119.004	1.200	1262.700
Industrial pollution source management, ENIB, Ten thousand yuan	18.105	17.113	0.200	141.600
Construction of "three simultaneity" environmental protection investment, ENIC, Ten thousand yuan	47.184	53.219	1.400	399.500
Industrial structure, STR, %	48.025	7.676	21.300	61.500
Foreign direct investment, FDI, %	2.496	1.923	0.068	8.191
Fiscal decentralization (Fiscal decentralization is also structural variable with no dimension.), FIN	0.453	0.066	0.358	0.642
Economic development level, RGDP, Ten thousand yuan	2.327	1.469	0.407	7.442

I is as follows:

$$Moran's\ I = \frac{\sum_i \sum_j w_{ij} \left(Y_i - \overline{Y}\right)\left(Y_j - \overline{Y}\right)}{S^2 \sum_i \sum_j w_{ij}} \tag{9}$$

$$S^2 = \frac{\sum_i \left(Y_i - \overline{Y}\right)}{N}, \quad \overline{Y} = \frac{\sum_i Y_i}{N} \tag{10}$$

where subscripts i and j stand for the provinces i and j and Y_i and Y_j denote the intensity of environmental pollution. $\overline{Y}$ represents the average of environmental pollution and S^2 is the variance of environmental pollution. N is the number of provinces. The static value of environmental pollution ranges from -1 to 1. If it is greater than zero, there is positive spatial correlation. If it is smaller than zero, there is negative spatial correlation. The larger the absolute value of Moran's I of environmental pollution, the higher the spatial correlation. Figure 1 shows the Moran's I index of environmental pollution every year from 2004 to 2016 based on the second-order adjacency weight matrix and geographical distance weight matrix. Results show that all the Moran's I indexes are positive and significant at 10% significance level, which indicates that environmental pollution has significant spatial dependence.

5.2. Exploring the Relationship between Fee-Based Environmental Regulation and Environmental Pollution. Table 2 shows the estimation results of dynamic spatial autoregressive model which explore the relationship between fee-based environmental regulation and environmental pollution. As presented in the table, M1 and M2 represent regression results of the differential GMM and system GMM method based on the traditional dynamic econometric model, and M3 and M4 stand for the regression results of second-order adjacency and geographical distance method based on spatial econometric model. Moreover, the regression results in traditional dynamic measurement model (M1, M2) and spatial econometric model (M3, M4) are coincident in the sign of coefficient. The test in Table 2 denotes that the spatial correlation coefficient is positive and significant at 5% significance level (t=2.26, 1.99) in M3 and M4, which indicates that environmental pollution has significantly positive externalities consistent with the above measured Moran's I indices. All L-likehood values are greater (744.0021, 752.0418), indicating the spatial models are reasonable and better than M1 and M4. The Sargan test results show that there is no over-identification of tool variable.

As for coefficients, the regression results of LnPOL_{t-1} are both positive and significant at 1% significance level. On one hand, the above results show that there is a significant transmission effect of environmental pollution, which means the situation level of environmental pollution in the early stage will enhance the severity of next stage of the same area. On the other hand, if the environmental pollution of the early stage is dramatically reduced, it means the intensity of environmental pollution in next stage will give better expectations of improving environment for market, enterprise, and consumer.

In terms of core explanatory variable, LnENF is highly positive in all models, while LnENF2 is significantly negative, indicating an inverted "U" relationship between fee-based environmental regulation and environmental pollution, illustrating a threshold regulation strength exists. From the regulatory process, the fee-based environmental regulation can directly increase the enterprise environmental governance

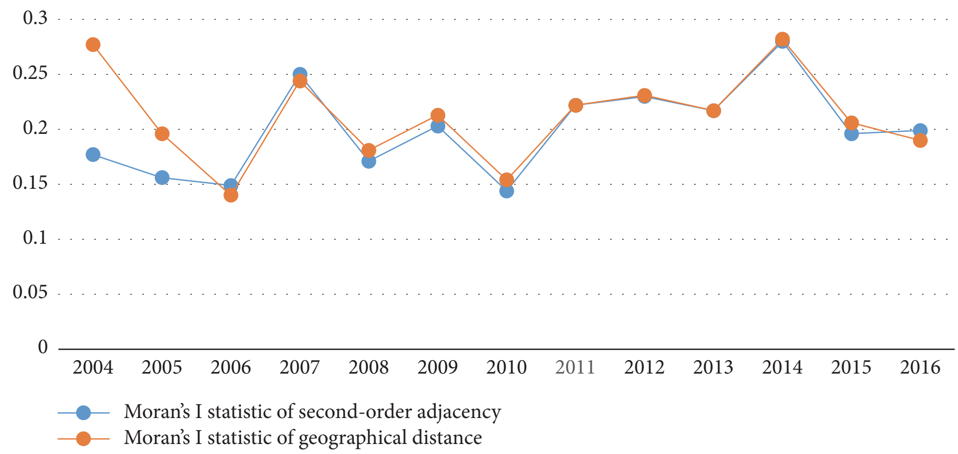

Figure 1: Moran's I index of environmental pollution.

Table 2: Fee-based environmental regulation and regression results of environmental pollution measurement.

Method	Traditional dynamic measurement model		Spatial econometric model	
Variable	D-GMM(M1)	S-GMM(M2)	Second-order adjacency (M3)	Geographical distance (M4)
LnPOLt-1	0.0301***	0.0154***	0.1058***	0.1158***
	(7.8812)	(6.6509)	(11.8802)	(13.6522)
LnENF	0.0311**	0.0401**	0.0504**	0.0471***
	(2.0422)	(2.2698)	(2.0433)	(4.2823)
LnENF2	-0.0075**	-0.0090**	-0.0175**	-0.0170**
	(-2.2209)	(-2.1809)	(-2.2240)	(-2.1881)
LnSTR	-0.0282**	-0.0154*	-0.0202*	-0.0104**
	(-2.2112)	(-1.7846)	(-1.8778)	(-1.9880)
LnFDI	-0.0003	-0.0045**	0.0013	0.0045*
	(-0.1064)	(-2.1022)	(1.1056)	(1.9009)
LnFIN	0.0626***	0.0428**	0.0526**	0.0405**
	(3.3311)	(2.1832)	(2.3360)	(2.1860)
LnRGDP	0.0186***	0.0132	0.0116***	0.0262**
	(2.6901)	(0.6554)	(2.8907)	(2.0243)
CONS	1.4462***	2.0371***	4.4001***	6.0801***
	(3.6304)	(8.3354)	(3.7709)	(5.2034)
ρ			0.0882**	0.0963**
			(2.2620)	(1.9922)
L-likehood			744.0021	752.0418
Adj-R2	0.6520	0.6678	0.7478	0.7953
Sargan	0.0878	0.0982	0.1107	0.0985

Note. $* * *$, $**$, and $*$ respectively represent passing hypothesis tests with significance levels of 1%, 5%, and 10%.

cost. While enterprise will make an assessment of the amount of environmental compensation according to the pollution polluted by themselves, this paper shows the value assessment is equal to the enterprise costs for measures needed to reduce environmental pollution. In other way, the enterprise costs for measures needed to reduce environmental pollution are the threshold. Due to information asymmetry and deviation of measurement methods, the intensity of fee-based environmental regulation will fluctuate around the threshold. If the former is less than the latter, the enterprise tends to pay fines to continue production for obtaining more excess profit while, if not, the results will be quite different. At this situation, the enterprise will purchase advanced equipment and introduce technology and managerial talent instead of paying for fine.

As for control variables, the coefficient of LnSTR is negative, both significant at 10% significance level, which means moderately enlarging the proportion of second industry share of GDP will not increase environmental pollution. The results have largely benefited from a series of national strategies which mainly contain "*Sustainable Development,*" "*Energy Conservation and Emissions Reduction*," and "*Beauty China* *and Ecological Civilization*." The coefficient of variable LnFDI is negative in model M1 and M2 and positive in model M3 and M4. The main reason is that the effect of foreign direct investment on environmental pollution concurrently is technology effect, scale effect, and structure effect, indicating that the overall effect is uncertain. All coefficients of variable LnFIN are highly significantly positive, indicating that if the degree of fiscal decentralization increases 1%, the level of environmental pollution will deteriorate 0.0626%, 0.0428%, 0.0526%, and 0.0405% correspondingly. The main reason is that fiscal decentralization provides the government a great degree of fiscal autonomy, which promotes abnormal project approval without strict third-party evaluation and process system supervision. Finally, the above behavior will result in low efficiency of resource allocation and is not conducive to formation of green economy development model.

5.3. Exploring the Relationship between Invest-Based Environmental Regulation and Environmental Pollution. Table 3 denotes the regression results of dynamic spatial autoregressive model for the relationship between invest-based environmental regulation and environmental pollution based on second-order adjacency weight matrix and geographical distance weight matrix. The core explanatory variables contain invest-based environmental regulation and their decomposition which are ENIA, ENIB, and ENIC. As shown in the table, M5 and M6 are empirical of ENI, M7 and M8 are empirical of ENIA, M9 and M10 are empirical of ENIB, and M11 and M12 are empirical of ENIC. On the whole, both of the spatial coefficients are positive and significant at 5% significance level. The L-likehood shows the spatial econometric models are valid. The Sargan test indicates the instrumental variables are appropriate. In addition, Adj-R^2 means explanatory variables can effectively analyze 75% fluctuations of environmental pollution.

The coefficient of variables LnENI, LnENIA, LnENIB, and LnENIC are highly significantly negative, while LnENI2, LnENIA2, LnENIB2, LnENIC2 are both positive, and both of them except in M9 and M10 are significant at 10% significance level. The above results indicate a "U" shape curve between ENI, ENIA, ENIB, ENIC and environmental pollution, which means an optimal invest-based regulation intensity exists. Because the invest-based environmental regulation can reduce corporate environmental governance spent by different fiscal and monetary policies, companies will use government subsidies to boost green productivity and reduce pollutant emissions per unit of output. It does not make sense when the intensity of invest-based environmental regulation is bigger than the enterprise costs for measures needed to reduce the environmental pollution. The main reason is the surplus government subsidies are used to expand production instead of continue promoting green technology, which will probably result in the expansion of total pollutant emission. Then the quality of environment will be worse than before. The important result of the above analysis tells us the study of invest-based environmental regulation and its decomposition threshold should be strengthened. As for other control variables, the coefficients of LnSTR, LnFDI, and LnFIN are harmonious and consistent with Table 3, which indicates that the model is reasonable and the regression results are effective.

6. Conclusions and Policy Recommendations

6.1. Conclusions. By controlling industry structure, foreign direct investment, and fiscal decentralization, the paper establishes a spatial autoregressive model to analyze the relationship between environmental regulation and environmental pollution in China's 30 provinces, municipalities, and autonomous region during 2004 to 2016. Following the classification of government and scholar, the environmental regulation is divided into fee-based environmental regulation and invest-based environmental regulation. After empirical analysis, an inverted "U" shape relationship between fee-based environmental regulation and environmental pollution is found, while a "U" shape curve characteristic between invest-based environmental regulation and environmental pollution is found. Furthermore, development of industry structure and foreign direct investment can improve the environment quality, while fiscal decentralization will worsen the environmental pollution. Based on the above main conclusions, the following relevant policy implications are suggested to reduce environmental pollution.

6.2. Policy Recommendations. (1) The inverted "U" relationship between fee-based environmental regulation and environmental pollution indicates that the above regulatory should be enhanced only if intensity of fee-based environmental regulation crosses the threshold value which is equal to the enterprise costs for measures needed to reduce environmental pollution. The above conclusion tells us that governmental regulation is useful, but the precondition is to set reasonable regulation intensity. This is consistent with the study of Porter's hypothesis about the compensation effect (Porter and van der Linde, 1995) and the top-to-top competition effect (Li and Wu, 2017) [3, 16]. Firstly, government agencies should regularly adopt pollution data of polluting enterprises to measure the degree of environmental pollution and the capacity of environmental carrying capacity in the region. According to professional theories and industry standards, the dynamic amount of compensation money for environmental governance is measured. Secondly, formulating reasonable fee-based environmental regulation strengthened by analyzing enterprise business benefit and bearing capacity. However, it does not mean the end of regulation; the government agencies should be timely attentive to enterprise dynamics. The government tries to achieve a win-win situation, which can promote enterprises to increase investment in environmental governance without affecting enterprises' production in the game.

(2) The "U" shape curve between invest-based environmental regulation and environmental pollution suggests that the government should not blindly intervene to help enterprises by different preferential policies. On one hand, the function of optimal resource allocation is left to the market. On the other hand, appropriate intervention can avoid

Table 3: Invest-based environmental regulation and regression results of environmental pollution measurement.

Method	ENI Second-order adjacency	ENI Geographical distance	ENIA Second-order adjacency	ENIA Geographical distance	ENIB Second-order adjacency	ENIB Geographical distance	ENIC Second-order adjacency	ENIC Geographical distance
Variable	M5	M6	M7	M8	M9	M10	M11	M12
LnPOLt-1	0.0902***	0.0929***	0.0913***	0.1032***	0.0857***	0.8416***	0.0907***	0.0967***
LnENI	-0.0264***	-0.0165***						
LnENI2	0.0076**	0.0066**						
LnENIA			-0.0195***	-0.0208***				
LnENIA2			0.0022**	0.0034**				
LnENIB					-0.0158***	-0.0098***		
LnENIB2					0.0016	0.0016		
LnENIC							-0.0438**	-0.0419**
LnENIC2							0.0126*	0.0114**
LnSTR	-0.1364***	-0.1136***	-0.2008*	-0.1103*	-0.0772*	-0.0572*	-0.0535***	-0.0637***
LnFDI	-0.0046	-0.0055	-0.0053*	-0.0054*	-0.0053*	-0.0052*	-0.0057	-0.0057
LnFIN	0.0455***	0.0419***	0.0359**	0.0339**	0.0371***	0.0408***	0.0398**	0.0158**
LnRGDP	-0.0213**	-0.0376**	-0.0062	-0.0062	-0.0725	-0.1025	-0.1042	-0.0954
CONS	4.2832	3.2832	-0.2648***	-0.4102***	11.3054***	14.1004***	-0.2573**	-0.2859**
ρ	0.2878**	0.3596**	0.4028**	0.3096**	0.2122***	0.2596***	0.3088**	0.3096**
L-likehood	714.4170	702.0528	734.8050	752.2871	700.0021	699.2487	748.5521	759.2318
Adj-R2	0.8474	0.7653	0.8418	0.8953	0.7928	0.7953	0.7778	0.7953
Sargan	0.0907	0.1385	0.1107	0.0984	0.1007	0.1185	0.1114	0.0996

Note. ∗ ∗ ∗, ∗∗, and ∗ respectively represent passing hypothesis tests with significance levels of 1%, 5%, and 10%.

deteriorating environmental quality results from enterprise excessive competition. The above results coincide with the nonlinear effect from the perspective of investment, which is significantly different from previous scholars' research (Sanchez-Vargas et al., 2013; Yin et al., 2015) [26, 27]. The latter tells us the government should enhance research of the optimal intensity of invest-based environmental regulation in different areas. In addition, the invest-based environmental regulation and fee-based environmental regulation should be coordinated cross-application. Moreover, on the priority of two regulatory measures, fee-based environmental regulation is recommended. And, it should be the normal as the recently environmental tax imposed in China.

(3) Relationships between other control and environmental pollution illustrates that continuous optimization of industrial structure, reasonable control of the scope of foreign direct investment, and adjustment of fiscal decentralization in various regions are of great help to improve environmental quality. Firstly, industrial production should focus on the use of clean energy and reduce the proportion of fossil energy use at the same time. Secondly, the government should lower the threshold of foreign direct investment in an orderly way, but only if it provides efficient green production technology. Thirdly, local governments should strengthen the study of optimal fiscal decentralization. Then the government tries its best to increase the transfer of environmental governance to capital spent for improving environmental quality by optimization and adjustment of economic structure and strengthening targeted supervision of fiscal revenues and expenditures.

Data Availability

(1) The environmental pollution data used to support the finding of this study have been deposited in the CNKI (China National Knowledge Infrastructure) repository, and the DOI of reference paper are 10.3969/j.issn.1674-8131.2016.04.011 and 10.13516/j.cnki.wes.2007.11.010. In addition, the data of carbon dioxide, sulfur dioxide, tobacco dust, chemical oxygen demand, and noise pollution used to measure environmental pollution for supporting the findings of this study may be released upon application to the China's National Bureau of Statistics. (2) The environmental regulation data used to support the finding of this study have been deposited in the CNKI (China National Knowledge Infrastructure) repository, and the DOI of reference paper is 10.19361/j.er.2013.01.004. In addition, the data of pollution charges levied by the government, urban environmental infrastructure construction investment, and industrial pollution source management, construction of the "three-simultaneity" environmental protection investment used to measure environmental pollution for supporting the findings of this study may be released upon application to the China's National Bureau of Statistics. (3) The data of secondary industrial output, GDP, actual amount of foreign capital, local government fiscal revenue, and local government fiscal expenditure used to measure control variables for supporting the finding of this study may be released upon application to the China's National Bureau of Statistics.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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