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Original Research

Environmental Legislation and Pollution Emissions: An Empirical Analysis Based on China

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Abstract

Passively waiting for the natural appearance of a turning point in the Environmental Kuznets Curve is no longer the appropriate attitude for coping with the increasing environmental pressures. The present study selected the provincial legislation regarding environmental protection as the current measurements of environmental policies. Then, tests were conducted in order to determine whether or not the current environmental policies were empirically conducive for reducing industrial pollution emission intensities using the provincial panel data for the period ranging from 2005 to 2014. The results indicated that the introduction and implementation of environmental policies could significantly reduce industrial pollution emission levels. However, such obvious inhibitions caused by the environmental policies regarding pollution emission reductions were found to be highly dependent on the marketization processes and environmental behaviors of the government. Furthermore, it was revealed in this research investigation that the effectiveness of the environmental policies for pollution reduction was related to regional environmental quality. The findings of this study bear important policy implications in China.

Keywords: environmental policies, pollution emission reductions, marketization processes, environmental behaviors of the government

Introduction

Since the "Reform and Opening Up" was introduced 40 years ago, the economy in China has experienced continuous rapid growth. At the same time, consequences of the increases in pollution emissions inevitably appeared with the decreases in environmental quality. These consequences have severely restricted the sustainability of economic development and prevented improvements in the living standards of China's citizens. The "Bulletin of China's Environmental Situation (2016)" showed that the environmental quality situation was still not optimistic in China. Especially in the process of rapid industrialization, industrial pollution was the main embodiment of environmental pollution in China. In 2015, for example, industrial SO_2 accounted for 83.73% of the total SO_2 emission, and industrial smoke (powder) dust accounted for 80.14% of the total. Therefore, investigations were carried out to determine how environmental pollution levels could

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be substantially improved. In particular, the unknown inflections of the Environmental Kuznets Curve (EKC) appeared, and it was obvious that serious environmental policies needed to be introduced and implemented without delay [1]. Due to the urgent and realistic problem of environmental pollution, it was important to quickly establish and perfect a system of environmental regulations and policies. This was considered to be the only way to drive the unknown points in the EKC in a timely way in China. Since 1979, as the Basic Law on Environmental Protection promulgated for the first time, China's central government has introduced a series of policies, laws, and regulations. These include the Law on the Prevention and Control of Water Pollution; the Law on the Prevention and Control of Air Pollution; and the Law on the Prevention and Control of Environmental Pollution by Solid Waste, and so on. The goals have been to restrain pollution emissions and improve environmental quality. In addition, local government agencies have also formulated a number of laws and regulations in accordance with regional conditions, which resulted in initially forming a relatively complete system of environmental laws and regulations [2].

However, it has yet to be determined if the current environmental policies implemented by the Chinese government have had the expected effects in reducing pollution emissions. Also, which factors the environmental policies mainly affect in order to reduce pollution emission levels is a matter which requires further investigation. Therefore, studying the aforementioned problems will not only be helpful in deepening the understanding of the effectiveness of environmental policies in reducing pollution emissions, but will also provide important practical significance for the formulation of future environmental policies in China.

In order to answer the above-mentioned questions, the present study attempted to make inroads into the following areas: 1. This study elaborated on the mechanisms of the current environmental policies for pollution emission reduction; 2. All of the legislation related to environmental protection was collected and sorted. Then this study constructed a data set in order to obtain the proxy indicators of the environmental policies for all of the provincial governments; 3. Tests were conducted in order to perform an analysis on the influences of the current environmental policies on the reduction of industrial pollution emissions using the provincial panel data for the period ranging from 2005 to 2014; 4. This study also discussed two different ways in which environmental policies could potentially play key roles using a mediation effect model.

The main contributions of this study were from four aspects. First of all, the environmental policies were measured based on the provincial legislation in order to expand the measurement perspectives reported in previous studies, along with the rationality and feasibility which had been demonstrated. However, differing from the existing studies, which had mainly focused on the impacts of environmental regulation on the total factor productivity [3], introduction of foreign investment [4], and the health of labor force [5], this study took a more direct judgment of whether provincial legislation regarding environmental protection could in fact effectively reduce the pollution emissions. Furthermore, in order to exclude the influencing effects of economic scale, the pollution emission intensity levels were represented by the pollution levels, which could better reflect the local regulatory effects brought on by the introduction of environmental controls. This study also examined the mechanisms of the current environmental legislation affecting pollution emissions using a mediation effect model.

The remainder of this research is organized as follows: Section 2 presents a review of the relevant literature and theoretical hypotheses; Section 3 introduces this study's design and methodology; Section 4 presents the results of this study's empirical analysis; and Section 5 details the extensional analysis discussion; Finally, this study's conclusions and pertinent policy implications can be found in Section 6.

Literature Review and Theoretical Hypotheses

Due to the "negative externality" nature of environmental pollution, many researchers have reached similar conclusions, such as the government could control the pollution caused by the resource development and utilization of economic individuals by implementing reasonable environmental policies and other social regulations for the purpose of intervening in the production and environmental protection behaviors of the polluters.

Basic Theoretical Hypothesis

Most existing research reports have presented the beliefs that environmental policies have positive effects on pollution emission reduction. Magat and Viscusi [6] pointed out that under the EPA's regulatory enforcement, approximately 20 percent of the Biological Oxygen Demand discharges could be reduced in the United States. Acemoglu et al. [7] successfully introduced endogenous and directed technical changes into a growth model with environmental constraints. It was found that government environmental regulations could potentially promote technological innovation, thereby enabling producers to reduce pollution emissions without sacrificing economic growth. That viewpoint has been verified in many previous studies. Shimizu [8] investigated how pollution abatement efforts affected industrial emission reductions, and found that the pollution abatement efforts measured by the pollution abatement expenditures in industrial waste gas could potentially assist in the improvement of environmental

quality. Quy-Toan et al. [9] found that the rulings targeting the industrial pollution in the Ganga River precipitated reductions in the river's pollution levels.

In addition, some of the previous empirical studies carried out regarding the relationships between various factors were found to be uncertain or nonlinear. It was observed that the effects of different types of environmental policy tools targeted at reducing pollution emissions were quite different if the firm behaviors were under the conditions of imperfectly enforceable pollution standards [10]. Some of the previous studies found that command and control regulations were conducive to emission reduction. However, the effects of market-based regulations on the reduction of emissions were generally relatively weak [11]. Some studies also pointed out that the environmental laws helped to decrease the local pollution emissions only in those provinces which had introduced stricter enforcement of the laws. Meanwhile, there were no significant effects observed if only minimal environmental laws were passed [2].

This study found that by perusing the above-mentioned research reports that the variations in the effectiveness of the environmental policies in reducing pollution emissions were the main factors. On one hand, the classification and measurement processes for the effectiveness of the environmental policies were not completely consistent, and the measurement index was endogenous. Therefore, it has been difficult to accurately determine the actual effects of the environmental policies. On the other hand, as inherent requirements of the DID model, some studies had not considered the possibility that different policies needed each other functions.

In recent years, the government of China has improved systems of environmental policies for the control of environmental pollution and the improvement of environmental quality [12]. Under the environmental decentralization, the local governments which are not only the makers of the environmental policies, but also the executors of the environmental policies, become the main body of the environmental governance. Therefore, any environmental constraints would be considered when making decisions regarding economic development, industrial structure, and urbanization development [13]. In addition, the provincial governments in China have formulated a number of environmental policies according their own environmental conditions and have formed a relatively complete system of environmental policies [2]. However, the local environmental policies are not only in place to improve the national environmental policy system, but also to reflect local governments' attention to environmental governance processes. This method realizes that signals from the government would strengthen the environmental governance and the external costs of pollution emission behaviors would increase. Under that background, the pollution behaviors of economic activities would be restrained [14]. For example, enterprises may choose the behaviors which limit inputs causing high pollution and adopt technological innovations in order to achieve cleaner production, as well as implementing effective treatments of any pollutants they produce [15 - 17]. Subsequently, the amount of pollutant production and pollutants discharged into the environment would be minimized, with the purpose of improving the regional environmental quality.

Hypothesis 1 was as follows: In China, the environmental policies issued by local governments could effectively restrain pollution emissions.

Extended Theoretical Hypothesis

The introduction of environmental policies has shown positive effects in constraining pollution emissions. However, it has not been fully determined how those effects occur. This study found by summarizing the related research results that under parallel systems of fiscal decentralization and administrative centralization in China, the progress made in regional marketization and the environmental behaviors of the government were the two factors which most greatly affected the environmental policies effects on pollution emission reductions.

Marketization of the Environmental Policies Affecting Emissions Levels

The results of previous empirical studies have shown that many government policies can play positive roles, either on the basis of a certain market efficiency, or in response to an increase in market efficiency [18]. The "market-enhancing view" showed that the government should partake in the development of the market, but government policies should not be substitutes for the market mechanisms [19]. The main way for the government to effectively participate in market-development should be to support the development of the main economic activities through institutional construction and policies matching processes.

Generally speaking, the influencing effects of the marketization processes on pollution emissions may be manifested as follows.

1. The marketization processes are accompanied by the expansion of economic scale and increases in market potential. However, although this agglomeration process could potentially bring about increases in enterprises and total pollution levels, such agglomeration externality as classical labor storage pools by Marshall, knowledge spillover, and industrial correlation characteristics, may also promote the reduction of the unit pollution emission levels [20];

2. The structural effects of the market-oriented processes are inseparable from the economic development. During the primary stage, the transformation from agricultural production to energy-intensive and capital-intensive industries has aggravated environmental pollution. Also, with the further

development of the economy, the industrial structure has gradually changed from first and second type industries to third type industries with low pollution, high knowledge-intensity, and high human capital, which has reduced the pollution emissions per unit of output [21];

3. The high degrees of marketization are often accompanied by high regional economic development. Therefore, the demand for environmental quality is higher, which helps to force enterprises to choose clean production methods, thereby, reducing the levels of pollution emissions. Furthermore, high marketization means that the completeness of the enterprises are more effectively, forcing enterprises to increase research and development expenditures and green production technology in order to reduce pollution emissions [22].

Hypothesis 2 was as follows: The influencing effects of environmental policies on pollution emission reduction are affected by the progress of marketization. The higher of the marketization degree, the more influence environmental policies will have on pollution emission reduction.

Government Behaviors Regarding Environmental Policies and Pollution Emissions

Hypothesis 1 demonstrated the necessity for and possibility of positive effects of environmental policies. Also, the motivation of environmental policies from the government perspective in China were discussed. In the cases of governments having incentives for introducing policies to meet the market rules, as well as developing requirements to promote environmental protection, effective implementation was considered to be the decisive factor for achieving positive effects.

The existing research studies realized that the effectiveness of emission reduction by environmental policies was dependent not only on the adoption of written legislation, but also on the governments' environmental protection behaviors. This was found to be particularly relevant in situations where environmental legislation was not fully implemented in practice. It was considered that the deeper reasons for such behavior were as follows:

1. Against the background of political centralization and fiscal decentralization in China, the "promotion tournament" in local governments may reduce the environmental standards when wishing to attract investment. Also, the pollution discharge behaviors of the enterprises may be indulged in order to pursue more fiscal revenue, causing the environmental pollution levels to increase;

2. Some environmental authorities are often at a disadvantage in the game against many polluting factories in China, which results in incomplete implementation of the written environmental legislation;

3. The third situation is the extreme form of the two mentioned above, where local governments conspire with polluting enterprises, resulting in such unwanted phenomena as a lack of compliance with the laws, lax enforcement of the laws, and impunity. This is generally done for short-term economic gain, allowing enterprises to violate environmental protection regulations. Under those types of circumstances, environmental policies can clearly not achieve efficient results. In summary, the promulgation of environmental policies may reduce pollution emissions, but this is entirely dependent on the environmental behaviors of the local governments.

Hypothesis 3 was as follows: The emission reductions of local environmental policies will be affected by environmental protection behaviors.

Methodology and Data

Model Design

On the basis of a STIRPAT Model [23] and the EKC Hypothesis [1], this study constructed the following empirical model to test the impacts of environmental policies on pollution emissions:

$$P_{it} = \beta_0 + \beta_1 policy_{it} + \phi X_{it} + a_i + z_t + \varepsilon_{it} \quad (1)$$

...where i and t indicate region and year, respectively. P_{it} represents the intensity of pollution emissions in order to reflect the degree of the regional pollution emissions; $policy_{it}$ is the main explanatory variable, which represents the levels of the local environmental policies; and X_{it} represents the control variables, which will be detailed below. Also, a_i denotes the individual effect; z_i indicates the time effect; ε_{it} is a random interference term and obeys a normal distribution, among which a_i and ε_{it} are not related.

Formula (1) is a static panel model. The regional pollution will remain in a stable state during a short term. That is to say, the environmental pollution in the past will directly affect the subsequent regional pollution situation. Therefore, the first phase lag term of the dependent variable was considered in this study's regression model. The model was transformed into a dynamic panel model as follows:

$$P_{it} = \beta_0 + \eta P_{it\text{-}1} + \beta_1 policy_{it} + \phi X_{it} + a_i + z_t + \varepsilon_{it} \quad (2)$$

...where P_{it-1} represents the first-order lag term of the pollution emission intensity (P_{it}).

In Formula (1) and Formula (2), the coefficient β_1 is the measurement of the impacts of the local government environmental policies on pollution emissions. However, if β_1 is significantly less than zero, it indicates that the local environmental policies can potentially significantly suppress regional pollution emissions.

Descriptions of the Variables

Explained Variables

The explained variables were the degrees of regional pollution emissions. This study found that the measurements of pollution emissions had two main types in the existing research reports. The first were the measurements using the total emissions of the pollutants, which directly reflected the changes in the local environmental quality. However, there may have been some defects in that measurement strategy due to its vulnerability to other factors, such as economic scales and output levels. The second type of measurement system involved determining the intensity levels characterized by the pollution emissions per unit of GDP. The advantage of that type of measurement strategy was that the effects of environmental policies could be better reflected for the standardized treatments of pollution emissions on an economic scale.

In this research investigation, the intensities of industrial pollution levels were chosen as the indicators of the explanatory variables. In other words, the emission levels of industrial waste-water, gas waste, and solid waste per unit of industrial output were measured and analyzed, which were characterized by following considerations: 1. Environmental pollution is a common problem which occurs during the process of industrialization. Therefore, it was considered that industrial pollution was the main embodiment of the environmental pollution in China; 2. Water pollution, air pollution, and solid waste pollution were considered to be the three main types of pollution which urgently required control measures in China; 3. Since the provincial scales varied greatly, with different levels of technology, industrial structure, and developmental stages, the pollution intensities had not only accurately reflected the regional industrial pollution levels, but also improved the regional comparability.

Main Explanatory Variables

The levels of the provincial environmental policies were considered to be the core explanatory variables in this study. Howerer, since the number of local environmental legislations varied from year to year, the quantitative assessments of environmental policies, both scientifically and effectively, have become cutting-edge issues between the academic community and the policy making community. In most of the related research in those fields, this study found that the levels of the environmental policies could be measured by such indicators as the investment in pollution treatments, sewage discharge fees of the enterprises, and the employment of the environmental sector [24, 25]. Some researchers have also adopted various weighting methods in order to integrate composite indicators for characterizing the levels of environmental policies [26]. These indicators were mainly related to such factors as the stages of economic development, behaviors of the polluting enterprises, and the cleanliness of the production technology. Therefore, it has been difficult to accurately reflect the adjustment results caused by environmental policies. In order to avoid endogenous problems, Pei et al. [27] selected the frequency ratios of environmental-related words in government work reports as the measurements of environmental policies while exploring the mechanisms of environmental policies related to carbon emissions.

In China, the local people's congresses have the power to enact local legislation based on their own realities and needs. These local environmental legislation actions are important parts of the Chinese environmental legal system. Therefore, measuring environmental policies based on the environmental legislations adopted by the provincial people's congresses may provide a new perspective for testing the effectiveness of the current environmental policies. In the present study, the number of effective provincial legislations related to environmental protection was defined as *policy*, in order to reflect the levels of the environmental policies currently in place. The specific collection method was as follows:

This study found that according to Peking University Center for Legal Information (http://www.pkulaw.cn/), more than 1,000,000 local legislations were promulgated in China by Dec 31th of 2014. These occurred at various levels, including laws, regulations, judicial analyses, and so on. Following the manual collating and screening the aforementioned database, it is determined that there were 1,138 local legislations related to environmental protection. Then, through further screening and processing, the numbers of effective environmental legislations during each year at the provincial level were obtained. The in-practice steps were as follows:

1. Due to the fact that the research dimension was the provincial domain, this study eliminated the samples of the cities divided into districts, special economic zones, and those with autonomous and separate regulations;

2. Considering the timeliness of this research investigation, the documents regarding the environmental policies were divided into five states: validity, revision, amendment, invalidation, and partial invalidation, and this study excluded any invalid samples. In regard to the revision, amendment, and partial invalidation states, if one document was amended after the first one to five years (or more), then they were regarded as two different regulations. Otherwise, they were considered to be the same one;

3. In terms of the lag effects of the policies, this study calculated the validity (expiry) of the regulatory documents which were in force (invalidation) on or before June 30th of the current year. Otherwise, they were considered to be in effect for the following year.

Control Variables

In this study's empirical model, X represented the control variables and ϕ was the coefficient of each one. The selection of the control variables was summarized around the two main approaches for containing pollution emissions, from the front-end prevention and end-end control. Front-end prevention refers to a way of improving environmental quality by using resources to create new knowledge and applying technological innovations in the areas of production and pollution removal. Therefore, the technological innovation levels of enterprises are important indexes which reflect front-end prevention in pollution control strategies. This study selected the regional research and development funds of large and medium-sized industrial enterprises, which was defined as *RDE*, in order to measure the levels of technological innovation for the enterprises. End-end control refers to the process of controlling pollution discharge through the construction of pollution control facilities. Therefore, the investment levels of pollution controls of the industrial enterprises were considered to be important measurements and the investment in industrial pollution controls in different areas was defined as *investment* in this study.

Furthermore, controlling the differences in regional scales was found to be conducive to the key variables. Since the regional industrial layouts and industrial development scales were closely related to the environmental quality, this study selected the proportions of industry output to gross domestic products (GDP) as the control variable which could accurately reflect the differences in regional scale. This was defined as *scale* in the current research.

Data Sources and Sample Selection

As in most empirical studies, based on the data availability and statistical consistency, the present study utilized the provincial panel data (not including Tibet, Taiwan, Hong Kong, and Macau) from 2005 to 2014 as the research data. Also, with the except of certain special descriptions, the original data used in this study were all collected from the China Statistical Yearbook; China Statistical Yearbook of Environment; China Population and Employment Statistics Yearbook; China Energy Statistics Yearbook; China Statistics Yearbook of Science and Technology; China's Environmental Yearbook; and the Statistical Yearbooks of the relevant provinces. A descriptive statistical list of the related variables is shown in Table 1.

Empirical Results and Discussion

Characteristic Analysis of the Industrial Pollution Intensity Levels in China

In the present study, it can be seen that the provincial spatial pattern of the industrial pollution intensity was quite different throughout China. As illustrated in Fig. 1, there were more obvious concentration tendencies in certain areas, which displayed the following three characteristics:

1. In regard to the intensity of industrial gas waste pollution, there was a little change observed in the spatial distribution patterns. However, it can be seen in Figs 1a) and 1b) that the intensity levels in the northern provinces were obviously higher. In 2005, the regions with high levels were mainly concentrated in the north, with Ningxia reaching the highest level. Meanwhile, the coastal and southern areas were lower. Then, in 2014, it was found that the distribution pattern had generally become stable. However, at the provincial levels in the northern and northwestern section, such as Shanxi, Gansu, and Xinjiang, the intensity levels were found to be markedly raised, and the tendencies of the distribution concentrations were obvious.

2. The spatial patterns of the industrial wastewater discharge intensities were observed to change greatly. For example, in 2005, the high-intensity areas were mainly located in the southern provinces. The intensity levels of industrial wastewater emissions in Guangxi were the highest. Meanwhile, the entirety of northern regions were observed to be lower, with the exception of Liaoning, Jilin, and Ningxia. However, by 2014, the provinces with high levels of emission intensity in southern China began to become significantly smaller,

Table 1. Statistical descriptions of the variables.

Variables	Obs.	Mean	Std.Dev	Min.	Max.
Pa	300	3.8170	2.5998	0.95	25.39
Pw	300	17.0932	15.1161	2.45	115.12
Pf	300	116.6423	319.2766	0.00	2855.44
police	300	6.8767	2.8275	2.00	17.00
RDE	300	154.1007	234.6735	0.14	1376.54
investment	300	0.4314	0.3466	0.04	2.80
scale	300	0.4095	0.0787	0.15	0.54

and the intensity levels in the northern provinces, such as Henan, Shanxi, Ningxia, Gansu, and Xinjiang, had significantly increased, as illustrated in Figs 1c) and 1d).

3. The emission intensity levels of the industrial solid waste pollution in the northern provinces were the highest in the country in 2005. This mainly included Hebei, Inner Mongolia, Shanxi, Ningxia, Gansu, and others. At the same time, the intensity levels were not as high in the southern regions, with the exception of Jiangxi, Guizhou, and Yunnan. However, by 2014, the pollution situation had improved significantly across the south provinces and the levels were generally lower to the south of the Yellow River and east of the Qinghai-Tibet Plateau. Moreover, the pollution intensity levels were found to be obviously decreased in Jiangxi, Yunnan, Guizhou, Guangxi, and Sichuan, but had risen quickly in the Qinghai area, as shown in Figs 1e) and 1f).

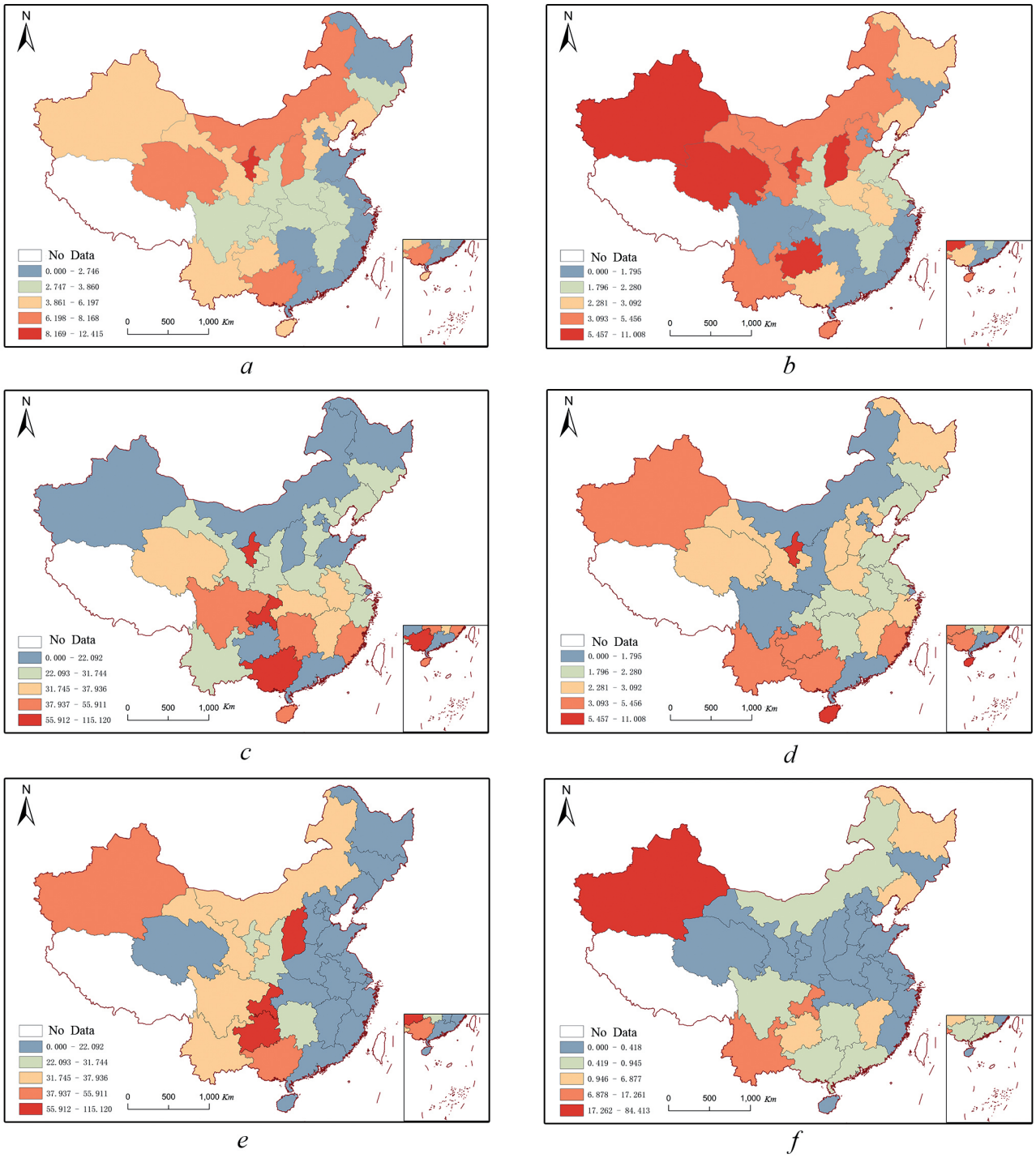

Fig. 1. Provincial spatial patterns of the industrial pollution intensity levels in China for the period ranging from 2005 to 2014.

Analysis of the Relationships between Environmental Policies and the Industrial Pollution Levels

Using the panel data of 30 provinces in China for the period ranging from 2005 to 2014, the present study used Formula (1) to perform estimations via a statistical panel model. The empirical results of the fixed effect models are shown in Table 2.

This study also considered that there may have been a certain path dependence of the pollution emissions. Therefore, the first-order lag term of the explained variables was added into Formula (2) in order to establish a dynamic panel model. Then, for the purpose of addressing any endogeneity issues, this study selected a Generalized Method of Moments (GMM) to estimate the coefficients in Formula (2). During the process, the GMM method constructed an equation which contained parameters from the moment condition. It was not found to be necessary to assume the distributions of the variables, or to know the distribution information of the random interference terms, which effectively solves the endogeneity issues [28].

In the current study, the static panel model did not take into account the possible missing variables and endogeneity, while the estimated efficiency of the SYS-GMM was higher than that of the DIFF-GMM, and the standard error obtained by the two-step estimations of the SYS-GMM had significantly reduced the estimated deviations in small sample cases, as well as the problem of weak instrumental variables in the horizontal lag term of the short panel data model. Therefore, there were some differences observed between the estimation results of the SYS-GMM and DIFF-GMM models, and the estimation results of the fixed effects in the static panel model.

In the present study, in order to consider the robustness of the results, a DIFF-GMM model and SYS-GMM model were applied to investigate the relationships between the number of effective provincial legislations related to environmental protection and the intensity levels of the pollution emissions. Table 2 lists the estimated results.

In accordance with the results obtained using the numbers of effective provincial legislations as the variables, and whether or not the explained variables were industrial gas emission intensity, industrial wastewater emission intensity, or industrial solid waste emission intensity, the coefficients of the environmental policies regarding pollution emissions were found to be significantly negative, as detailed in Table 2. For the two-step estimated results in the SYS-GMM model, it could be seen that the coefficients were -0.1706, -0.5549, and -7.7677, respectively, and all were significant at the 1% statistical level. The economic significance results indicated that for each increase in the effective number of provincial legislations related to environmental protection, the emission intensity levels of the industrial gas waste, wastewater, and solid waste could be significantly reduced by 0.1706, 0.5549, and 7.7677 units, respectively. The above-mentioned results also showed that the promulgation of the environmental legislation could reduce the intensity levels of the environmental pollution emissions, which verified this study's theoretical Hypothesis 1. That is to say, the environmental policies issued by the local governments in China could restrain the emission of environmental pollutants to a certain extent.

However, some previous studies have pointed out that the enforcements of written laws were infelicity in China [29]. For short-term economic benefits, most government agencies have tried to "hide the sky from the sea" when regional environmental problems arose. In addition, relaxation of the intensity of legal constraints were found to still be common practices for some governments. The present study tended to consider the significance of local government promulgating environmental legislations, where misrepresentations were evident in not only the perfection of systems for China's environmental laws and regulations, but also in demonstrating the governments' attached importance to environmental control practices. The implementation of the aforementioned would at least send signals that the local governments were committed to strengthening environmental governance, which could ultimately inhibit regional pollution emissions in a macro sense.

This study found that when comparing the coefficients, some differences existed in the marginal inhibitory effects of environmental policies on the intensity levels of industrial waste-water, gas waste, and solid waste. That is to say, the control processes of the environmental policies on water pollution were easier to implement than that of the air pollution. Also, the influencing effects of environmental policies on the prevention and control of solid waste were obviously greater than those of industrial gas waste and water-waste. The possible reason may have been that the treatment of industrial solid waste was relatively difficult, and the treatment and management processes for industrial solid waste had been strengthened in recent years.

In regard to the control variables, the coefficients of the enterprise technological innovations for industrial gas waste and solid waste were found to be significantly negative. These results indicated that the investments in the transformation of backward production processes had effectively restrained the industrial gas waste and solid waste pollution levels. Meanwhile, the influencing coefficients of the industrial wastewater emission intensity levels were positive, but not significantly so. Therefore, it remained uncertain whether or not the enterprises' technological innovations played effective roles in wastewater discharge levels. However, the investment intensities of the industrial pollution controls were found to have obvious positive effects on the industrial pollution emissions. These findings indicated that investments in environmental pollution control measures would not necessarily improve

Table 2. Impact testing of environmental policies on the emission intensity levels of industry pollutants.

Variables	Static Panel			Dynamic Panel					
	FE			*DIFF-GMM*			*SYS-GMM*		
	Pa	*Pw*	*Pf*	*Pa*	*Pw*	*Pf*	*Pa*	*Pw*	*Pf*
$L_1.P$				0.1084*** (0.0015)	0.6983*** (0.0032)	0.5990*** (0.0015)	0.3519*** (0.0019)	0.7391*** (0.0023)	0.6015*** (0.0001)
policy	-0.1121* (0.0659)	-3.2274*** (0.5148)	-39.3261*** (14.1239)	-0.2334*** (0.0219)	-0.5920*** (0.0724)	-20.5326*** (0.9414)	-0.1706*** (0.0156)	-0.5549*** (0.0811)	-7.7677*** (0.0612)
RED	-0.0011* (0.0006)	-0.0186*** (0.0047)	0.0705 (0.1296)	-0.0002 (0.0003)	-0.0027*** (0.0007)	0.0647*** (0.0038)	-0.0007*** (0.0002)	0.0004 (0.0004)	-0.0136*** (0.0025)
investment	-0.2894 (0.3012)	3.7866 (2.3524)	194.5061*** (64.5445)	0.4242*** (0.0116)	0.7715*** (0.1976)	98.5983*** (2.2972)	0.0976*** (0.0143)	1.3614*** (0.2366)	122.2556*** (0.1623)
scale	-12.0218*** (2.4391)	-191.3868*** (19.0486)	-961.2601* (522.6529)	-11.7556*** (0.6857)	-42.8046*** (2.2536)	-425.3271*** (17.3717)	-5.6249*** (0.3855)	-28.5370*** (2.4853)	-3.3661** (1.5010)
Cons	9.8115*** (1.2018)	118.8871*** (9.3857)	685.9259*** (257.5228)	10.0292*** (0.2861)	24.1606*** (1.3336)	276.5142*** (10.9719)	5.8844*** (0.1614)	16.8692*** (1.3720)	16.2328*** (0.3195)
AR(1)				0.2052	0.0253	0.0371	0.1941	0.0232	0.0384
AR(2)				0.5734	0.8912	0.7551	0.2907	0.7454	0.7665
Sargan Test				0.1243	0.2617	0.2056	0.5507	0.6443	0.5447
Obs	300	300	300	300	300	300	300	300	300

Notes: *, **, *** denote a significance of 10%, 5% and 1%, respectively.

the environmental quality in China. This was mainly due to the fact that the increased portions of the investments were eliminated by the continued pollution effects. The regional scales had significant inhibitory effects on the industrial pollution related to gas waste, wastewater, and solid waste. These findings were consistent with the expectations.

As shown in Table 2, the first-order lag coefficients of the pollution emission intensity levels were all tested at a 1% significance level. The results showed that environmental pollution may have a certain path dependence. In other words, the past polluting status would affect the current environmental situation.

Robustness Tests

Test for Missing Variables

It usually takes long periods of time for policy making, adjustments, and implementation to show their effects. When governments intend to improve environmental quality through stricter legislation, enterprises generally require a period of time to make adjustments in order to improve their output planning, production technology, and so on. There is also the possibility that enterprises may temporarily wait to see whether the policies will actually being enforced. Therefore, in order to reflect the lag effects of environmental legislations, this study used a lag term of the environmental policies as an explanatory variable during the testing process. The results shown in Table 3 reinforce the robustness of the benchmark regression results.

Tests for the Replacements of Explained Variables

The effects of environmental legislation on environmental quality improvements were mainly reflected in the emission intensity per unit output. However, the total pollution control is considered to be an important management system stipulated by the current environmental regulations in China. Therefore, other pollution measurements were used to perform the regressive tests in this study. The first involved using the logarithmic values of the pollution emissions levels. The second utilized the levels of the per capita pollution emissions in order to eliminate the impacts of the regional population size factors. It was determined that the estimation results still confirmed Hypothesis 1.

Extensional Analyses

Regional Differences in the Effectiveness of the Implemented Environmental Policies

The data regarding economic development and industrial structures revealed that there were significant regional differences in China. Therefore, the environmental capacity levels and environmental management capacity levels were also different. These findings suggested that this study should consider whether or not the influences of environmental policies on pollution reduction could be affected by the regional environmental quality and pollution emission status. In order to address these issues, the present study calculated the median emission intensity levels of different pollutants during different years, and then classified the provinces with higher values than the median as examples of high pollution areas, and vice versa. Subsequently, the influencing effects of the differences between the regional environmental quality and the pollution emission status on the effectiveness of the environmental policies were analyzed. As can be seen in Table 4, the test results supported the fact that the effects of the environmental policies on pollution emissions were closely related to the regional environment quality. For example, in the lightly

Table 3. Estimations of the effects of the lag periods of environmental polices on the emission intensity levels of industry pollutants.

Variables	*FE*			*SYS-GMM*		
	Pa	*Pw*	*Pf*	*Pa*	*Pw*	*Pf*
L_1. *P*				0.3610*** (0.0030)	0.7247*** (0.0033)	0.5950*** (0.0009)
policy	-0.1340 (0.1192)	-1.7459** (0.7018)	-4.7218 (16.5778)	-0.1081*** (0.2363)	-0.5916*** (0.0834)	-10.6119*** (1.2101)
L. *policy*	0.0395 (0.1262)	-0.9649 (0.7430)	-22.8940 (17.5501)	0.1112*** (0.0337)	0.0870*** (0.0305)	3.5612*** (1.0621)
Control Variables	Y	Y	Y	Y	Y	Y
AR(1)				0.1812	0.0271	0.0395
AR(2)				0.3967	0.8929	0.7730
Sargan Test				0.4602	0.7286	0.5296

Notes: *, **, *** denote a significance of 10%, 5% and 1%, respectively

contaminated situations, the environmental policies could significantly reduce the emission intensity levels of gas waste and solid waste pollutants. However, there were significantly positive correlations observed with the discharge intensity levels of the wastewater. Meanwhile, in the regions with high pollution levels, it was found that effective environmental policies could significantly inhibit wastewater and solid waste emissions, but significantly positive correlations existed with the gas waste emission intensity levels.

It was concluded in this study that the governance effectiveness of the environmental policies on gas waste in the lightly polluted areas was better than that in the heavily polluted areas. This indicated that environmental policies were sensitive to the gas waste pollution intensity levels, and the effects of the environmental policies regarding gas waste may be weakened under the condition of intensified pollution levels. The effects of environmental policies on wastewater in heavily polluted areas were found to be better than that in lightly polluted areas. These findings suggested that the waste-water had strong "concealment" characteristics, and the inhibition effects of the environmental policies on wastewater gradually appeared with the deepening of the pollution levels. In addition, regardless of the conditions of heavy pollution or light pollution, this study found that the environmental policies had significant inhibitory effects on the emission intensity levels of the solid waste pollution, which indicates that the treatment of industrial solid waste was relatively less difficult when compared with gas waste and wastewater treatments.

Impact Mechanisms of the Environmental Policies Regarding Pollution Emission Reduction

It can be ascertained from the above-mentioned results that the environmental policies issued by local governments could effectively impact pollution emissions in two ways. The first was to strengthen the environmental behaviors of the government agencies, and the second was to lead to the changes in the regional marketization processes. This research investigation adopted a mediation effect model in order to identify the two conduction pathways. In the cases of the government environmental behaviors, the study selected the frequency of environmental related words in provincial government work reports in order to measure from the idea presented by Chen et al. (2016) [30]. In addition, the market-oriented index put forward by Wang Xiaolu et al. [31] was selected to reflect the marketization processes. Then, according the principle of mediation effects [32], this study's testing processes were realized by the following three steps:

1. The first step was to determine whether or not the premise of doing mediation effect tests had been established. In other words, to examine whether the core explanatory variables had significant effects on the explained variables. It was found that if the coefficients of the core explanatory variables were significant, then the second step would take place. Otherwise, the mediation effect analysis process was required to be terminated. In accordance with the results listed in Section 5, the coefficients β_1 of the variables characterizing the environmental policy ($policy_{it}$) had been significant in every model, which indicated that the mediation effect analysis process could be continued;

2. In the second step, two types of the possible intermediary variables, including the government behaviors (*gove*) and the market-oriented indexes (*market*), were taken as the explained variables in Model (4), respectively. The coefficients σ_2 could be obtained using the estimated model consistent with the first step. Then, if σ_2 was found to be significant, then the mediation variable was up held. Conversely, the mediation variable was not.

Table 4. Results of the dynamic model regression of the sub-region samples.

Variables	The lightly polluted areas			The heavily polluted areas		
	Pa	*Pw*	*Pf*	*Pa*	*Pw*	*Pf*
$L_1.P$	0.2980*** (0.0397)	0.6787*** (0.0100)	0.4071*** (0.0063)	0.2767*** (0.0305)	0.7566*** (0.0041)	0.5652*** (0.0008)
policy	-0.1019*** (0.0178)	0.1028* (0.0622)	-0.2845** (0.1152)	0.1011** (0.0463)	-0.5342*** (0.0579)	-16.2011*** (0.6207)
Control Variables	Y	Y	Y	Y	Y	Y
AR(1)	0.0549	0.0127	0.0917	0.2235	0.0383	0.0399
AR(2)	0.3195	0.5250	0.2199	0.3483	0.7647	0.7331
Sargan Test	0.9781	0.8787	0.8423	0.9771	0.8640	0.9022
Obs	135	135	135	135	135	135

Notes: *, **, *** denote a significance of 10%, 5% and 1%, respectively.

Table 5. Institutional inspections of environmental policies regarding pollution emission reduction.

Variables	*Emission intensity levels of industrial gas waste*					
	D = market			*D=gove*		
	(2)	(3)	(4)	(2)	(3)	(4)
policy	-0.1706*** (0.0156)	0.1744*** (0.0152)	-0.1635*** (0.0130)	-0.1706*** (0.0156)	0.0002*** (0.0001)	-0.1305*** (0.0172)
D			-0.1530*** (0.0204)			-77.1756*** (6.6921)
Variables	*Emission intensity levels of industrial wastewater*					
	D = market			*D=gove*		
	(2)	(3)	(4)	(2)	(3)	(4)
policy	-0.5549*** (0.0811)	0.1744*** (0.0152)	-0.6484*** (0.0985)	-0.5549*** (0.0811)	0.0002*** (0.0001)	-0.6051 (0.0754)
D			0.2469*** (0.0519)			-274.6015*** (38.2179)
Variables	*Emission intensity levels of industrial solid waste*					
	D = market			*D=gove*		
	(2)	(3)	(4)	(2)	(3)	(4)
policy	-7.7677*** (0.0612)	0.1744*** (0.0152)	-8.4771*** (0.2418)	-7.7677*** (0.0612)	0.0002*** (0.0001)	-8.0557*** (0.2196)
D			7.1784*** (0.3714)			-2990.2412*** (38.0302)

Notes: *, **, *** denote a significance of 10%, 5% and 1%, respectively.

$$M_{it} = \sigma_0 + \sigma_1 M_{it\text{-}1} + \sigma_2 policy_{it} + \sigma_3 Y_{it} + \tau_{it} \quad (3)$$

3. In the third step, the coefficients ω_3 of the intermediary variables could be obtained by incorporating them into Model (5). If ω_3 was significant, then the completeness of the mediating effects could be judged by the coefficients ω_2 of the core explanatory variables. In other words, if ω_2 was no longer significant, then the intermediary variable was a complete intermediary. Otherwise, it was an incomplete intermediary.

$$P_{it} = \omega_0 + \omega_1 P_{it\text{-}1} + \omega_2 policy_{it} + \omega_3 M_{it} + \omega_4 Y_{it} + \pi_{it} \quad (4)$$

The results of mediation effects based on a system GMM dynamic model are detailed in Table 5. It can be seen in the table that the coefficients β_1 were significant during the first step. Therefore, the intermediary analysis could be continued. In the second step, the coefficients σ_2 of the core explanatory variables on the intermediary effect variables, which were represented by government environmental behavior (*gove*) and marketization process (*market*), respectively, were still observed to be significant. Furthermore, when the intermediary variables were added to regression Eq. (5), it was found that their coefficients were very significant and that the coefficients ω_2 had not changed significantly. Therefore, it was concluded that the government environmental behaviors and marketization processes resulted in incomplete intermediary effects with regard to reducing pollution emissions.

On one hand, the promulgation of the environmental policies had changed the behaviors of governments with regard to environmental protection practices and had also prompted the continuous strengthening of the implementations of environmental control policies with the purpose of reducing regional pollution emissions. On the other hand, it was found that it had caused a chain reaction of market subjects at the macro level, which inherently affected the regional marketization processes and eventually restricted the original pollution emission behaviors. Therefore, the above-mentioned results validated the theoretical Hypotheses 2 and 3.

Furthermore, it could be seen from the aforementioned results that, based on the special mechanisms of performance appraisals and political promotions in China, local officials hoped to achieve the goals of accelerating economic development and expanding fiscal revenue when introducing and implementing environmental policies. Therefore, in order to achieve the expected "win-win" effects between the local economic development and environmental protection processes, the environmental policies require market forces to allocate effective resources according

to the signals given by government policies in China. In such cases, cleaner production technology will be perceived as being superior; the ability of environmental pollution control will become stronger; and the entry threshold standards will be higher. Consequently, the regional ecological environment can be effectively restored and improved.

Conclusions and Policy Implications

The present research investigation used provincial legislations related to environmental protection to quantitatively identify environmental policies. The quantitative perspectives in the empirical assessments of the effects of environmental policies were expanded. Finally, the influencing effects of environmental policies on pollution emission reduction and their mechanisms were empirically tested using China's provincial panel data. The main conclusions reached in this study were as follows:

Environmental policies, which were characterized by effective numbers of provincial legislations related to environmental protection, were found to significantly inhibit the discharge of industrial gas waste, wastewater, and solid waste. The results of the sub-regional samples showed that the effects of the environmental policies on pollution reduction were closely related to the regional environmental quality. In addition, the analysis results of the mechanisms showed that marketization processes and government environmental behaviors were important factors which influenced the effectiveness of the environmental policies on reducing pollution emission levels.

The above-mentioned conclusions had important policy implications as follows:

First of all, the environmental policies were found to have the ability to improve the regional environmental quality, which confirmed the general effectiveness of the environmental policies. It was thereby suggested that during the process of daily work and the formulation of economic policies, governments at all levels should establish a strong awareness of environmental protection, as well as a scientific understanding of the important role of environmental policies in environmental protection and pollution control. Furthermore, improvements should be made to the systems of environmental policies in order to address increasing environmental pressure.

Secondly, there were some differences observed in the effects of environmental policies on pollution reduction in the different samples with regard to environmental quality. These findings indicated that the use of environmental policies should be chosen by category and context. It is recommended that the effective exertions of the inhibitory effects of environmental policies on different pollutant emissions, along with the implementation of regional environmental information sharing and joint early warning processes, would be very beneficial in improving the efficiency of environmental governance in China.

The third implication was that the effects of environmental policies on pollution emissions rested with processes related to the marketization and environmental behaviors of the governments involved. Therefore, during the process of implementing environmental pollution control measures, not only the "effective markets" factors should be emphasized, giving play to the fundamental role of market allocation of resources, but also "effective government" should be underlined. In that way, the reform processes of government systems can be deepened in order to enhance their capacity and efficiency. As a result, environmental policies will be able to effectively restrain pollution emissions in the future.

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Conflicts of Interest

The authors declare no conflicts of interest.

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