



Dynamic Relationship Between China's Environmental Protection Investment and Regional Environmental Pollution

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ABSTRACT

The carrying capacity of China's resources and environment has reached a limit. The economic development of different regions has been forced to abandon the original economic development mode manifesting high pollution, high energy consumption, and high emission and to step forward to the new economic development model promoting low energy consumption, low emission, and low pollution. Environmental issues are typical manifestations of market mechanism failure. Government investment in environmental protection, which effectively improves environmental quality, is necessary to achieve sustainable economic development. An index system of the influencing factors that affect regional environmental pollutant emissions was established first in this study to measure accurately the relationship between environmental protection investment in different provinces in China and regional environmental pollution. System GMM (Generalized Method of Moment) method was used to analyze the impact of environmental protection investment on pollutant emissions in 30 provinces in China from 2007 to 2016. Results show that the system GMM method can effectively solve variable endogeneity. Environmental protection investment of explanatory variables has a significant negative effect on pollutant emissions. Among the control variables, per capita GDP (Gross Domestic Product), industrial structure, resident consumption level, and technology market turnover have a significant inhibitory effect on pollutant emissions. Among the control variables, investment in fixed assets and import and export trade is vital in promoting pollutant emission growth. Conclusions provide a reference for improving the governance level of environmental protection investment in China's provinces, controlling environmental pollution and ecological damage, and realizing a green economic development method.

INTRODUCTION

China is a developing country in the process of industrialization. Hence, environmental problems and pressures exist, but the occurrence of these setbacks is a common phenomenon. Moreover, these problems and pressures are determined by the specific development stage and socioeconomic structure. It hasn't been compensated the value of natural resources despite the constant request from nature's resources, thereby bringing a series of environmental problems to mankind, such as air pollution, soil erosion, water pollution, and solid waste pollution. The environmental problems in China mainly include environmental pollution and ecological damage. The following is a rough intuitive judgment on China's environmental problems. Environmental pollution and ecological damage are relatively severe and have been maintained at this relatively serious level for a long time. Neither a sharp deterioration nor a significant improvement exists. The general trend involves partial improvements. Most of these improvements are still deteriorating. As a "poor" output of China's economic growth, environmental issues have now

become the bottleneck of global economic growth while bringing many inconveniences to human society.

Environmental problems are a typical manifestation of market mechanism failure. Government investment in environmental protection is an effective means to improve environmental quality. Fig. 1 shows that China's total investment in environmental pollution control increased annually from 2001 to 2017. In particular, 110.67 billion CNY in 2001 increased to 953.895 billion CNY in 2017, with an average annual increase of 47.62%. Environmental protection investment is the main driving force of environmental protection. Investment size and investment efficiency are directly related to pollution control, environmental construction, ecological protection, and environmental quality improvement. Environmental protection investment is ultimately related to the degree to which the environment bears and supports economic development. However, production investment is an essential source of economic growth. Environmental protection investment is originally part of economic construction. The increase in environmental protection investment

has a crowding-out effect on productive funds. This effect inevitably has a certain negative impact on economic growth. However, environmental protection is also an investment after all, and it has a productive side, with both a supply effect and a demand effect.

PAST STUDIES

The increasing global environmental problems make many people aware of the important role of environmental protection investment in improving and protecting the environment and developing the economy. Many researchers have shown that environmental protection investment has an impact on the sustainable development of enterprises and the reduction of environmental pollutant emissions. Sustainable economic and environmental developments are also important. Porter et al. (1995) showed that the amount of investment in environmental protection by enterprises has increased, and the ability of this investment to control pollution and technical levels has improved. Even if the funds are used for environmental protection, the investment of enterprises in their products and services will still increase. The resources of China are affected, but in the long run, this scenario will be beneficial in environmental protection and the sustainable development of enterprises. Madsen (2009) showed that attracting business investment and protecting local environmental quality are two aspects that must be considered simultaneously. Moreover, environmental protection cannot be ignored because of a large amount of investment and construction. Nakamura (2011) used the data set of 3237 Japanese companies. A regression was conducted to explore the impact of environmental investment on corporate performance. The results showed that environmental investment does not significantly affect corporate performance in the short term, but it significantly improves corporate performance in the long run. Lavrinenko (2013) believed that environmental protection investment

has gradually shifted from corporate interests and public opinion pressure on environmental protection by the state or the public to prevent possible losses caused by environmental pollution, improvement of regional economic development, and improvement of people. Living conditions have also changed, and employment mobility has been reduced. Krajewski (2016) showed that public environmental protection expenditure has no negative impact on economic growth. Its positive impact is the largest among the economies affected by the global financial crisis. The correlation of the country's corporate research and development (R&D) investment and environmental performance of major developed economies have been studied (Alam et al. 2019). Results indicated that the companies actively implementing R&D and innovation activities through their resources are conducive to improving environmental performance and achieving sustainable competitiveness. Yang et al. (2020) determined from Research and Utilization 2009 that in 2018, the data of listed companies in China's A-share heavy pollution industry explored the relationship among internal control quality, corporate environmental protection investment, and financial performance. Moreover, corporate environmental protection investment has a significant positive impact on financial performance. Results provided a basis for the government to issue relevant environmental protection policies, strengthen corporate internal control construction guidelines, and encourage third-party organizations to evaluate the effectiveness of corporate internal control.

The above literature indicated that the early research on environmental issues mainly focused on the environment and economic growth and the impact of environmental protection investment on economic growth. However, the study on the pollution reduction effect and efficiency of environmental protection investment appeared late. Most of the literature research results support that environmental protection

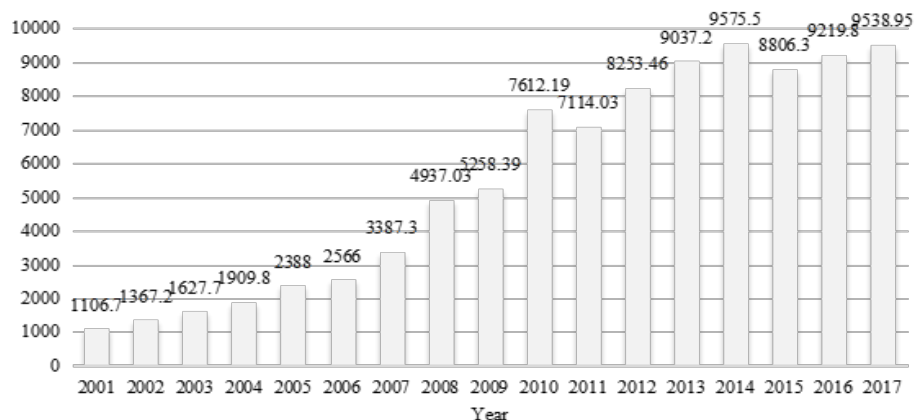


Fig. 1: China's total investment in environmental pollution government in 2001-2017 (100 million CNY).

investment can effectively solve environmental pollution problems. Environmental pollution control investment has a positive effect on environmental pollution control. The role of fiscal environmental protection investment varies greatly in different regions, mainly because the sample objects and the length of time do not necessarily cause some research conclusions to be different. Therefore, this study uses the Generalized Method of Moment (GMM) model method and takes 30 provinces in China (excluding Tibet) as samples to explore environmental pollution control investment by measuring the impact of their environmental protection investment on environmental pollution levels from 2007 to 2016. It provides policy suggestions on the path of pollutant emission reduction and how to use environmental pollution control investment rationally to improve environmental protection investment efficiency and sustainable economic and social development.

MATERIALS AND METHODS

Measurement Model

The influencing factors of environmental pollution in different provinces are relatively complex, and ordinary methods cannot be analyzed systematically. In particular, the selection of factor indicators has always been the focus and difficulty in the research. The author established the index system shown in Table 1 by combining the influencing factors from the existing research literature.

The development of the environmental system itself has a significant time accumulation characteristic. Thus, the level of development in the early stage will have a certain impact in the later stage. Therefore, the lag of the explained variable is added to the model as an explanatory variable, and the

regression result obtained by the dynamic panel model will be more practical. The current period is roughly affected by the lag period of the explained variable. According to the system GMM estimation method, the dynamic panel data regression model used in this study is shown in formula (1) by considering the availability, scientificity, and systematicness of the data. The use of the ordinary least squares method and fixed-effects model causes biased and inconsistent regression results mainly because of the endogeneity in the model. Dynamic panel GMM reduces the impact of endogeneity on the regression by selecting appropriate instrument variables. The regression equation is established as in the following formula (1).

$$y_{ij,t} = \beta_0 + \beta_1 x_{1ij,t} + \beta_2 x_{2ij,t} + \beta_3 x_{3ij,t} + \beta_4 x_{4ij,t} + \beta_5 x_{5ij,t} + \beta_6 x_{6ij,t} + \beta_7 x_{7ij,t} + \beta_8 y_{ij,t-1} + \varepsilon_{ij,t} \quad \dots(1)$$

In formula (1), $y_{ij,t}$ represents the explained variable. $y_{ij,t-1}$ shows the one-period lagging value of the explained variable. $x_{1ij,t}$ is an explanatory variable. The remaining variables $x_{2ij,t}$, $x_{3ij,t}$, $x_{4ij,t}$, $x_{5ij,t}$, $x_{6ij,t}$, $x_{7ij,t}$ represents 6 control variables. b_0 represents the constant term of the regression equation. b_1 to b_8 are the regression equation coefficients. $e_{ij,t}$ represents the error term.

Data

The panel data of 30 provinces (cities, autonomous regions) across the country from 2007 to 2016 are used as the empirical analysis sample based on the availability of actual data. Some indicators of Tibet are not complete; thus, they are excluded. All data can be directly obtained through the Easy Professional Superior data platform. The results of descriptive statistical analysis of all variables are shown in Table 2.

Table 1: Influencing factors of environmental pollution.

Influencing factors	Variable name	Specific index(unit)	Variable type
Exhaust	Y_1	Industrial wastewater discharge (10,000 tons)	Explained variable
Wastewater	Y_2	Industrial sulfur dioxide emissions (10,000 tons)	Explained variable
Dust	Y_3	Industrial smoke (dust) emissions (ten thousand tons)	Explained variable
Environment Protection Investment	X_1	Three Simultaneous Environmental Protection Investment (100 million CNY)	Explanatory variables
Economic Extent	X_2	GDP per capita (CNY)	Control variable
Industry Structure	X_3	The proportion of tertiary industry (%)	Control variable
Consumption Ability	X_4	Resident consumption level (CNY)	Control variable
National Investments	X_5	Total investment in fixed assets of the whole society (100 million CNY)	Control variable
Import and export trade	X_6	Import and export trade volume (ten-thousand dollars)	Control variable
Technology Innovation	X_7	Technical market turnover (ten thousand CNY)	Control variable

RESULT ANALYSIS

This study uses EViews10.0 software to conduct systematic GMM estimation on the model composed of panel data of 30 provinces (municipalities, autonomous regions) across the country from 2007 to 2016. The specific results are shown in Table 3.

Table 3 shows that the corresponding probabilities of the Sargan statistic (J-statistic) of Models 1, 2, and 3 are 0.2196, 0.1727, and 0.2060, respectively, which are all greater than the significance level of 0.05. This finding indicates that the reason for accepting excessive constraints is correct. The

remaining results are as follows:

1. Three simultaneous environmental protection investments have a significant negative effect on industrial wastewater discharge and industrial smoke (dust) emissions, with influence coefficients of -0.0795 and -0.1098, respectively. They are significant at the 1% significance level. The investment in environmental pollution control has a limited effect on the mitigation of environmental pollution discharge in the current period, and most of its effect is on the control of environmental pollution discharge in the previous period. The development of environmental protection industrialization of environ-

Table 2: Descriptive statistical results of each variable.

Variable	Average	Standard deviation	Max	Min
Y_1	72459.21	61640.34	268762.00	5782.00
Y_2	63.91	38.95	182.74	1.70
Y_3	43.27	31.05	179.77	1.31
X_1	68.25	69.56	438.20	0.50
X_2	40654.47	22702.47	118198.00	6915.00
X_3	42.08	9.07	80.23	28.60
X_4	14034.61	8136.11	49617.00	4057.00
X_5	11884.64	9602.38	53322.94	482.84
X_6	5553357.30	11264952.05	59207052.70	414.65
X_7	1897631.40	4592537.70	39409751.79	5556.27

Table 3: Regression results.

Model 1			Model 2			Model 3		
Variable	Coefficient	t-Statistic	Variable	Coefficient	t-Statistic	Variable	Coefficient	t-Statistic
$Y_1(-I)$	0.2882**	2.3420	$Y_2(-I)$	0.7201***	7.1401	$Y_3(-I)$	0.5924***	11.1607
X_1	-0.0795***	-8.3624	X_1	0.0045	0.3978	X_1	-0.1098***	-3.0484
X_2	-0.1757	-0.5421	X_2	-0.6169	-1.1672	X_2	-1.0863*	-1.8725
X_3	-1.5298***	-3.3797	X_3	-0.9928***	-2.5927	X_3	-2.9224***	-7.2434
X_4	-0.4529*	-1.6802	X_4	-1.1341***	-5.9682	X_4	0.3446	0.7726
X_5	0.6155***	4.5205	X_5	1.2714***	5.5752	X_5	1.2350***	5.1087
X_6	0.0265	0.3427	X_6	0.6123***	6.3960	X_6	0.0765	1.5496
X_7	-0.0345*	-1.6624	X_7	-0.2682***	-10.7897	X_7	-0.2064***	-3.4846
Mean dependent var		-0.0484	Mean dependent var		-0.0763	Mean dependent var		-0.0250
S.E. of regression		0.2236	S.E. of regression		0.3177	S.E. of regression		0.3351
J-statistic		26.7831	J-statistic		28.0892	J-statistic		27.1388
Prob(J-statistic)		0.2196	Prob(J-statistic)		0.1727	Prob(J-statistic)		0.2060
S.D. dependent var		0.1931	S.D. dependent var		0.2305	S.D. dependent var		0.2641
Sum squared resid		11.6037	Sum squared resid		23.4117	Sum squared resid		26.0578
Instrument rank		30	Instrument rank		30	Instrument rank		30

Note: ***, **, * indicate significance at the significance level of 1%, 5%, and 10% respectively

mental protection investment should be promoted, and the increase of employment should be promoted. The end treatment of environmental protection investment, such as the construction of sewage treatment plants or the purchase of pollution treatment equipment, should be strengthened to promote the industrialization of environmental protection by developing environmental protection industries and pursuing corresponding employment. The application of environmental protection investment in process control or source prevention, such as improving production technology to reduce the intensity of pollution emissions and using environmental protection investment to improve the level of technology, should be promoted to drive an increase in employment.

2. Per capita GDP has a negative effect on the growth of environmental pollutant emissions. However, this negative effect is not significant. The growth of per capita GDP is not the main factor leading to environmental pollution. Economic development can be effectively achieved with the growth of per capita GDP, and financial resources can be invested in treating environmental pollutants to reduce pollutant emissions effectively.
3. The industrial structure harms the growth of industrial wastewater emissions, industrial sulfur dioxide emissions, and industrial smoke (dust) emissions, and it is significant at the 1% significance level. The optimization and upgrading of the industrial structure have restrained China's environmental pollution to a certain extent by increasing the proportion of tertiary industry in the industrial structure, realizing the industrialization and marketization of science and technology, improving the ability to digest, absorb, and re-innovate imported technologies, and effectively reducing the proportion of primary and secondary industries and industrial emissions.
4. Resident consumption level hurts the growth of industrial wastewater discharge and industrial sulfur dioxide discharge, and it is significant at the 10% significance level. The increase in the consumption level of residents can make residents pay considerable attention to the consumption of environmentally friendly products, such as high and new technology. This scenario has a certain effect on the improvement of environmental pollution.
5. Investment in fixed assets has a positive effect on the growth of industrial wastewater emissions, industrial sulfur dioxide emissions, and industrial smoke (dust) emissions, and it is significant at the 1% significance level. The increasingly large-scale construction investment indicates that the demand for upstream steel,

cement, plastics, electrolytic aluminum, and many chemical products increases. These products belong to high energy-consuming industries. The increase has led to a rapid rise in energy consumption. This pattern is difficult to change because of China's relative lack of oil and natural gas resources and coal-based energy structure. The pollution caused by the burning of coal is the heaviest among all conventional energy sources. The huge scale of energy consumption and the coal-based energy consumption structure are the most important factors affecting the growth of China's environmental pollution emissions.

6. Import and export trade has a positive effect on the growth of industrial wastewater emissions, industrial sulfur dioxide emissions, and industrial smoke (dust) emissions, but it is not significant. This finding fully shows that international trade has a positive role in promoting environmental pollutant emissions. China is a large exporting country. Many products consumed by developed countries can be imported from other countries through international trade. Therefore, the origin of the products and the corresponding pollutant emission regions are also related. The consuming country has moved to the exporting country, thereby changing the spatial distribution of global pollutant emissions.
7. The technical market turnover has a negative effect on the growth of industrial wastewater emissions, industrial sulfur dioxide emissions, and industrial smoke (dust) emissions, and it is significant at the 10% significance level. Technological progress can effectively reduce the discharge of environmental pollutants, and it can weaken the negative impact of the current environmental protection investment of heavily polluting enterprises on the market value through green technological innovation. Strengthening green technology innovation in China's provinces will also help enterprises improve their technological innovation capabilities, assist non-high-tech enterprises to enter the ranks of high-tech enterprises, and help alleviate the increase in environmental pollution emissions caused by environmental protection investment, which is difficult for heavily polluting enterprises. Sustainable development has many benefits.

POLICY RECOMMENDATION

Increase Investment in Environmental Protection and Optimize the Structure of Environmental Protection Investment

Environmental protection investment has not been able to achieve emission reductions through economies of scale. All

provinces in China must increase environmental protection investment to provide financial guarantees for pollution control. With regard to increasing the government's financial investment, the government should include environmental protection funds into the fiscal annual budget and gradually increase investment in this area. According to the principle, "who pollutes, who pays", the environmental protection investment of enterprises should increase. On the one hand, enterprises can play a role in the market economy. On the other hand, the enthusiasm of enterprises to control industrial waste gas will increase. The used structure of environmental protection investment is a way of resource allocation, and different structures will inevitably lead to different pollution control effects. For a long time, China's primary pollution emissions have come from industrial production. However, the investment in urban environmental infrastructure construction is the largest in environmental protection investment, followed by the "three simultaneous" projects in construction projects. The investment in industrial pollution source treatment has the smallest proportion. Therefore, each province should increase the proportion of industrial pollution source treatment investment in environmental protection investment to match the former with the growth of the industrial economy and ultimately achieve the goal of industrial waste gas emission reduction.

Improve Public Financial Investment in Environmental Protection and Implement Pollution Control Funds

Investment is the focus of public fiscal expenditures to ensure that the total environmental protection investment grows. The growth rate of fiscal environmental protection investment can refer to the growth rates of the economy, fixed-asset investment in the whole society, or central and local fiscal revenues. The investment capacity of local governments in environmental protection must be improved, and the budgetary investment of local finances in environmental protection must be strengthened. Market mechanisms must be fully utilized to increase investment guidance and supervision of environmental pollution control. According to the "whoever develops protection, who destroys who restores, who benefits who compensates, who discharges pollution who pays" principle, the use of market mechanisms should be increased to promote pollution control, the law should be strictly enforced to guide enterprises to invest, and government investment should be encouraged to stimulate social investment. Economic policies mobilize market resources and fully implement pollution control funds.

Accelerate the Transformation of Economic Growth Mode and Strengthen Supervision of Key Polluting Industries

At present, most provinces in China are in the middle and late stages of industrialization. The process of industrialization

is accelerating, and the proportion of the industry in the industrial structure remains large. The traditional model of economic growth only considers the speed of economic growth but ignores its quality. The economic growth pattern should be transformed by following the pace of supply-side reforms. The path of sustainable development should be followed. A circular economy should be developed by recycling resources and improving utilization efficiency, thereby reducing the discharge of pollutants and achieving the sustainable development of the use of resources in the entire society. The vigorously developing tertiary industry must realize that the tertiary industry is the future direction of economic development and the green driving mode of economic development to reduce environmental pollution. The control and management of heavy pollution industries must be strengthened because these industries considerably contribute to the total industrial waste gas emissions. Output control in the cement, steel and chemical industries should be strengthened. If these heavily polluting industries are brought under control, the pressure on China's industrial emissions will be eased to a large extent.

Improve the Government's Ability to Monitor the Environment and Increase Corporate Pollution Control Through R&D Investment

Polluters lack environmental awareness and the initiative to invest in environmental protection because of the external characteristics of the environment. Therefore, the government and society should improve enterprise pollution supervision and the role of government regulation. The construction of the monitoring system should be strengthened to support the operation and maintenance of the automatic monitoring system for industrial waste gas pollution sources. Pollution control should persist in accordance with the law, and law enforcement capabilities should be strengthened. R&D investment can promote the emergence of advanced production equipment and production technology, increase the efficiency of resource use, and reduce the pollution output of production. Therefore, policymakers should guide companies to increase investment in R&D and fundamentally reduce the generation and emissions of pollutants. Tax policies should be used to reduce corporate R&D costs. Reasonable and feasible tax incentive policies should be formulated to encourage enterprises to increase investment in R&D. In terms of the establishment of enterprise R&D investment reward funds, certain rewards will be given to enterprises according to the proportion of enterprise R&D investment.

CONCLUSION

China's environmental pollution and ecological damage are relatively severe and have been maintained at this relatively

serious level for a long time. Environmental problems are typical manifestations of market mechanism failure. Government investment in environmental protection can effectively improve environmental quality. In this study, an index system of influencing factors that affect regional environmental pollutant emissions was established and the system GMM method was used to analyze the impact of environmental protection investment in 30 provinces in China on the pollutant emissions from 2007 to 2016. Conclusions could be drawn: the environmental protection investment of the explanatory variables has a significant effect on the reduction of pollutant emissions. The per capita GDP, industrial structure, resident consumption level, and technological market turnover in the control variables have a significant inhibitory effect on pollutant emissions. Fixed-asset investment and import and export trade have a significant role in promoting the growth of pollutant emissions. Environmental pollution can be further achieved by increasing investment in environmental protection, improving public financial investment in environmental protection, accelerating the transformation of economic growth mode, and improving the government's ability to monitor the material emission reduction in the environment. Future research can continue to conduct in-depth research

on enriching the variable index system, extending the time series of research objects, and using spatial measurement to analyze the homogeneity and heterogeneity among different provinces.

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