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Evaluation of the Effects of the Ecological Environmental Damage Compensation System on Air Quality

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Abstract: This study constructs comprehensive panel data based on the China City Statistical Yearbook and environmental indicators disclosed by the Ministry of Ecology and Environment from 2013 to 2017, using a difference-in-difference (DID) model to empirically validate the effects of the ecological environmental damage compensation system on urban air quality, followed by a further analysis of the system's effect mechanism, namely, how the system has generated effects on reducing environmental pollution. This study finds that: (1) the ecological environmental damage compensation system can significantly improve urban air quality, and small cities are more sensitive to the pilot policy; and (2) the main impact is that the pilot policy mechanism improved the urban pollutant treatment capacity and reduced the proportion of the secondary industry. After multiple robustness tests, this conclusion still holds. This study provides empirical evidence for fully implementing an ecological environmental damage compensation system.

Keywords: pollution prevention and control; policy assessment; ecological environmental damage compensation system; difference-in-difference

Citation: Wu, M.; Zhan, Y.; Liu, Y.; Tian, Y. Evaluation of the Effects of the Ecological Environmental Damage Compensation System on Air Quality. *Forests* **2022**, *13*, 982. https://doi.org/10.3390/f13070982

Academic Editors: Tatiana Minkina, Svetlana Sushkova and Vishnu Rajput

Received: 18 May 2022
Accepted: 18 June 2022
Published: 23 June 2022

1. Introduction

Since its reform and opening up, China has been accelerating its industrialization, urbanization, and modernization. Although the average annual growth rate of China's gross domestic product (GDP) is as high as 10% in the first decade of the 21st century, huge resource and environmental costs have been incurred, and the air pollution problem has become increasingly serious. The 2020 Environmental Performance Index (EPI) pointed out that China's environmental performance index ranked 120 out of 180 countries or regions surveyed with an EPI score of 37.3, while its air quality ranked 137th with 27.1 points for air quality [1]. The World Bank estimates that air pollution's annual economic cost could be as high as 1.2% of China's GDP based on the cost of disease valuation [2]. Improving air quality has become an inevitable requirement for protecting human health and improving the quality and efficiency of economic growth.

The Chinese government attaches great importance to the construction of an ecological civilization. The report of the 19th Party Congress lists air pollution prevention and control as one of the three major battles to win to gain victory in building a moderately prosperous society. This requires efforts to solve outstanding environmental problems and promote green development. The effective prevention and control of air pollution has become a major issue of concern for academic and practical communities.

For this reason, this study starts with the policy of "Experimental Reform of Compensation System for Environmental Damage". It focuses on the air pollution prevention and control effect of the ecological environmental damage compensation system implemented by the government. Specifically, based on rigorous empirical research, this study attempts to explore and answer the following core questions that have not been well answered: Is the ecological environmental damage compensation system able to prevent pollution and improve urban air quality? Does it work the same way in different cities? What is the mechanism's impact on urban air quality?

To answer these questions, this study constructs a comprehensive panel database of environmental quality indicators published by the Ministry of Ecological Environment and China's Urban Statistics Yearbook from 2013 to 2017, which regards the ecological environmental damage compensation system implemented in seven pilot areas in different provinces at the end of 2015 as a "quasi-natural experiment". It uses the DID method to evaluate the air quality benefits of the ecological environmental damage compensation system.

This study finds that the ecological environmental damage compensation system significantly improved the air quality of cities, and small cities were more sensitive to the pilot policy. Further impact mechanisms show that the ecological environmental damage compensation system has improved the urban pollutant treatment capacity, reduced the proportion of secondary industry, and promoted the structural reform of urban economic growth. This shows that the reform of the ecological environmental damage compensation system achieves the policy design's original intention, effectively improves the quality of the ecological environment, and promotes the healthy development of the local economy.

There are two main strands of the literature closely related to this study. The first strand literature focuses on the relationship between air pollution and economic and social development. There is a large body of research in this area, including the relationship between air pollution and economic development [3–6] and the impact of air pollution on public health [7,8]. Sajjad et al. (2014) studied the causal relationship between air pollution and tourism development and found that air pollution and climate change negatively affected the development of tourist areas [9]. Martinez et al. (2018) found that in addition to the health effects of increased premature mortality and hospital admission rates, air pollution has significant economic costs for the Skopje population [10]. In the COVID-19 era, researchers found that long-term exposure to air pollution increased the risk of viral infection and more severe symptoms at the time of infection [11,12].

The second strand of the literature relevant to this study focuses on environmental policy evaluation. Current academic research on environmental policy evaluation is typically conducted from management and economic perspectives. First, from a management perspective, Swanson et al. (2001) assessed the implementation of environmental policies in Zhejiang Province through field studies regarding policy objectives, institutional frameworks, and implementation mechanisms [13]. Quantitative research methods are primarily used in the field of economics, focusing on the assessment of environmental policies' economic value. Wolff (2014) used the difference-in-differences (DID) method to construct the regional and temporal double differences, as well as to assess the impact of the European low-carbon zone policy on German air quality in recent years, and found the low-carbon zone policy would reduce German particulate matter emissions by 9% [14]. Feng et al. (2019) used regression analysis to examine the effectiveness of the implementation of China's Air Pollution Prevention and Control Law on air quality improvement from 2013 to 2017, and found that air quality was significantly improved [15].

It should be noted that most research on the impact of the ecological environmental damage compensation system is based on theoretical assumptions and simulation predictions rather than empirical studies, which cannot reflect the true effect of implementing environmental punishment policies in China. Therefore, based on previous studies, this study adopts the difference-in-difference approach to assess the actual environmental effects of the ecological environmental damage compensation system.

The contribution of this study is embodied in the following two aspects.

First, previous literature on the ecological environmental damage compensation system has mostly conducted qualitative analysis from the perspective of the concept itself and legislative perfection, which suffers from a lack of objectivity and other problems. This study conducts an empirical evaluation of the ecological environmental damage compensation system from the perspective of air quality benefits. It analyzes its heterogeneity and the impact mechanism, further improving the research on the ecological environmental damage compensation system.

Second, we construct city-level data from 2013 to 2017 using a causal identification approach with a pilot policy for the ecological environmental damage compensation system as a quasi-natural experiment, which to some extent addresses the limitations and endogeneity of the data and makes the policy evaluation effect more scientific and accurate.

The study from here is organized as follows: the second part is the policy background, the third part is the data construction and model setting, the fourth part is the empirical analysis, reporting the empirical results and conducting a series of robustness tests, the fifth part is the heterogeneity analysis and mechanism analysis, and the last part is the conclusion and policy recommendations.

2. Policy Background

As China continues to urbanize and industrialize, air pollution becomes increasingly serious. In this context, China has introduced a series of environmental control policies and requirements to improve air quality. In 2015, the General Office of the State Council of China issued the Experimental Reform of Compensation System for Environmental Damage, proposing a compensation system for those responsible for causing damage to the environment. The first batch of pilots were implemented in 2016 in seven provinces and cities in Jilin, Jiangsu, Shandong, Hunan, Chongqing, Guizhou, and Yunnan; from 2018, the ecological environmental damage compensation system will be implemented on a trial basis across the country. By 2021, China had handled more than 7600 ecological and environmental damage compensation cases, involving a compensation amount of more than 9 billion RMB, promoting the treatment and repair of several damaged ecological environments.

The main purpose of the ecological environmental damage compensation system is to improve the ecological environment by clarifying the scope of compensation, responsible subjects, claim subjects, and damage compensation settlement channels. It also involves conducting compensation negotiations with units or individuals who cause damage to ecological and environmental elements or structural functions of the ecosystem due to violations of laws and regulations to raise the cost of pollution. According to the pilot program, the scope of application of the policy includes ecological damage or environmental pollution caused by the degradation of soil, atmosphere, water resources, and other environmental elements, and biological elements such as plants, animals, microorganisms, and other biological elements occurring in decline, as well as environmental elements and biological elements constituting adverse changes in the function of the ecosystem. Large sudden environmental incidents caused by pollution, environmental pollution, and destruction in key ecological reserves are key objects of concern for damage penalties.

There are two main ways in which the ecological environmental damage compensation system affects air quality. First, it adjusts the industrial structure. Reasonable environmental regulations can stimulate enterprises to transform and upgrade themselves. Enterprises with high pollution levels are eliminated through the survival of the fittest mechanism, which promotes the transfer of resources from primary and secondary industries to tertiary industries, thus optimizing the industrial structure and improving urban air quality [16]. Second, it improves pollutant treatment capacity. The ecological environmental damage compensation system adheres to the principle of "who pollutes, who treats" and "who destroys, who restores", which raises the cost of pollution emissions and promotes enterprises to reduce their pollution emissions by strengthening their solid waste disposal capacity and technological innovation.

The top ten cases of typical ecological and environmental damage compensation consultation released in 2020 involve solving prominent environmental problems such as air, water, and soil pollution (strongly reflected by the people), along with the illegal dumping of waste slag in Guizhou Province, the water pollution ecological and environmental damage compensation case in Anhui Province, the illegal dumping of concrete in Chongqing City, and the air pollution damage compensation case in Zhejiang Province. These cases explore consultation mechanisms while warning and guiding enterprises to improve environmental quality by reducing pollution emissions and enhancing their own pollutant treatment capacity.

3. Data Construction and Model Design

3.1. Data Construction

To comprehensively investigate the impact of the ecological environment damage compensation system on urban air pollution and its impact mechanism, this study uses the 2013–2017 China City Statistical Yearbook data and the Air Quality Index disclosed by the Environmental Protection Bureau as the main research samples. The first step is the construction of air pollution data. The dependent variable in this study is urban air quality, which is measured using the maximum annual air quality index (AQI). This is mainly based on the following considerations: the ecological environment damage compensation system is focused on major environmental pollution events, which have the greatest impact on the annual maximum value of air quality. In addition, in the robustness test, the urban PM2.5 concentration and NO_2 concentration are used as other air pollution indicators to test the robustness of the model and the estimated results. The utilization rate of general solid industrial waste and the proportion of the three major industries in the GDP appear as explained variables in the transmission mechanism analysis.

In addition, urban air quality is affected by external economic factors [17,18]. To reduce bias in the model estimation, we control for variables related to urban characteristics, urban pollution conditions, and urban pollution governance levels. The control variables for urban characteristics include the urban GDP, green coverage area of the built-up area, general public budget expenditure of the city, average salary of employees, and the total amount of social consumer goods. The control variables for urban pollution include industrial sulfur dioxide emissions, soot and dust emissions, and industrial nitrogen oxide emissions. The control variable for the level of urban pollution control is the comprehensive utilization rate of industrial solid waste. Table 1 lists the information for the main variables.

Table 1. Variables Description.

Symbol	Meaning
Indication of Environmental Pollution	
M_AQI	Maximum Air Quality Index for the whole year
M_NO2	Maximum NO2 Concentration for the whole year
M_PM2.5	Maximum PM2.5 Concentration for the whole year
Urban Characteristics	
In_GDP	Gross Domestic Product (log)
In_green	Green Coverage Area of The Built-up Area (log)
In_outcome	General Public Budget Expenditure (log)
In_salary	Average Salary of Employees (log)
In_goods	Total Amount of Social Consumer Goods (log)
Urban Pollution Condition	
In_sulfur	Industrial Sulfur Dioxide Emissions (log)
In_soot	Soot and Dust Emissions (log)
In_ nitrogen	Industrial Nitrogen Oxide Emissions (log)
Urban Pollution Governance Level	
Solid waste	Comprehensive Utilization Rate of Industrial Solid Waste (%)
Urban Industrial Structure	
In_primary industry	The proportion of the primary industry in GDP (%)
In_secondary industry	The proportion of the secondary industry in GDP (%)
In_tertiary industry	The proportion of the tertiary industry in GDP (%)

3.2. Model Design

The main objective of our empirical analysis was to investigate the impact of the ecological environmental damage compensation system on air quality, and we used the difference-in-differences (DID) method to obtain this estimate. The basic principle of the DID method is to construct dual differences: urban differences and year differences, dividing the sample into a "treatment group" affected by the policy and a "control group" not affected by the policy. Likewise, it controls for other related factors to examine the differences between the two groups before and after implementing the policy [19,20]. In the field of environmental policy, this method has been widely used to test the effect of environmental regulation on environmental quality improvement [21]. The specific measurement model is as follows:

$$\text{Condition} = \alpha + \beta \times DID_{ct} + \varphi \times X_{ct} + \eta_c + \gamma_t + \varepsilon \quad (1)$$

In this model, c represents the city, and t denotes time. DID_{ct} is the interaction term between the policy time and policy grouping dummy variables. When $DID_{ct} = 1$, city c belongs to the pilot city of the ecological environment damage compensation system in year t. When $DID_{ct} = 0$, city c is not a pilot city in year t. Condition is the explained variable of this study, which represents the urban air quality and is measured by the city's annual maximum AQI. X_{ct} represents the control variables related to the city level, as mentioned above, the urban GDP, green coverage area of the built-up area, general public budget expenditure of the city, and so on; η_c represents the city fixed effect, which aims to control the city-level factors that do not change with time. γ_t represents the fixed effect of the year, and the purpose is to control for other influencing factors that change with time but not with the city. ε is the random disturbance term. α is the intercept of the regression equation, and β and φ are the coefficients of the interaction terms DID_{ct} and control variable X_{ct}, respectively. This study focuses on the β coefficient. If the final estimated value of β is less than zero and significant, the ecological environment damage compensation system can reduce urban air pollution and improve urban air quality in the pilot cities.

4. Empirical Analysis

First, we analyze the empirical regression results of the difference-in-difference (DID) method and then conduct a series of robustness tests on the empirical results.

4.1. Empirical Regression Results

Table 2 reports the baseline results. Each column displays the estimated results using Equation (1), with or without controls. The maximum value of the city's annual air quality index (AQI) is the dependent variable in Table 2.

Table 2. The Impact of Policy on AQI for Baseline Regression.

	M_ AQI			
	(1)	**(2)**	**(3)**	**(4)**
DID	−17.62 ***	−18.39 ***	−17.65 ***	−17.06 ***
	(3.576)	(3.751)	(4.288)	(4.230)
Urban Characteristics	No	Yes	Yes	Yes
Urban Pollution Condition	No	No	Yes	Yes
Urban Pollution Governance Level	No	No	No	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	3122	954	864	841
R^2	0.062	0.201	0.189	0.202

Standard errors listed in parentheses are clustered at the city level. *** $p < 0.01$.

We first control the city- and year-fixed effects in column 1. The estimation results show that the environmental regulation policy in 2015 resulted in a significant decrease in the maximum AQI value in the treatment group compared to the control group. More specifically, the policy caused a significant reduction of 17.62 $\mu g/m^3$ in the maximum

AQI value for the treatment group, which is statistically significant at the 1% level. In columns 2–4, we control for urban characteristics, urban pollution conditions, and urban pollution governance level and obtain an estimated coefficient of −17.06, indicating that the ecological environmental damage compensation system significantly reduced the maximum value of the urban AQI, even after controlling for the relevant variables.

4.2. Robustness Test

Because the regression model constructed by the DID method is based on a series of assumptions, to ensure the stability and credibility of the results, the following tests some important assumptions.

4.2.1. Parallel Trend Test

To ensure the validity of the DID method, the assumption of parallel trends is necessary; namely, in the absence of the implementation of the pilot policy of the ecological environment damage compensation system, the air quality trends of each city should be parallel. This study uses the event analysis method to test the parallel trend of the change in the dependent variable, with the model shown below:

$$\text{Condition} = \alpha + \sum_{k=-4}^{k=1} \beta_k \times D_{c,t_k} + \eta_c + \gamma_t + \varepsilon \quad (2)$$

In the above formula, D_{c,t_k} represents a set of dummy variables, and c, t_k represents the kth year when city c implements the pilot policy. Since the implementation time of the policy during the pilot period is only for 2016 and 2017, the data for the parallel trend test is from 2013 to 2017. β_k is the key coefficient, indicating the difference in pollution emissions between pilot and non-pilot cities in the kth year of policy initiation.

The results of the parallel trend test are shown in Figure 1. From the results of the parallel trend test, it can be seen that β showed a decreasing trend before the implementation of the policy, but the confidence interval contains 0, which shows no significant difference between the treatment group and the control group. One year after the implementation of the policy it began to decline significantly, and the confidence interval was far from 0, indicating that the ecological environment damage compensation system significantly reduced the maximum annual AQI of the pilot cities and improved air quality.

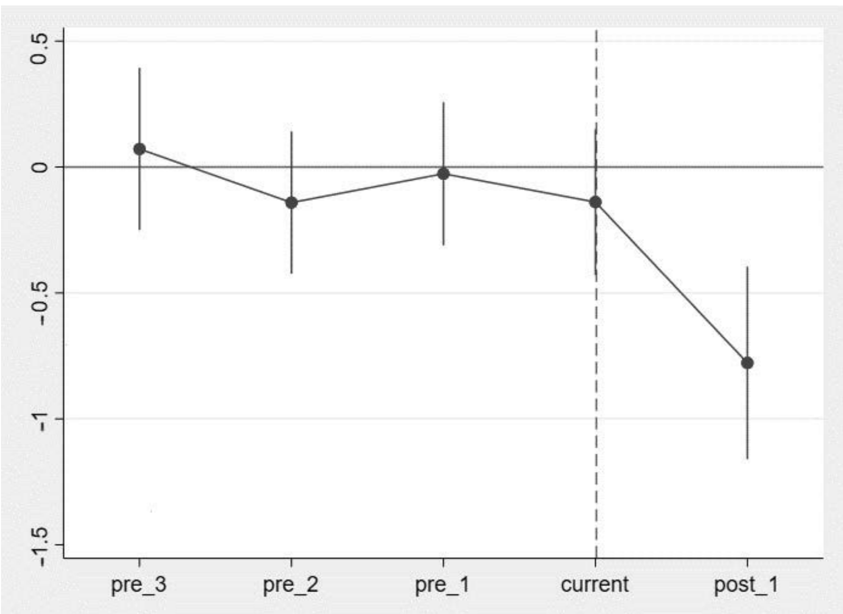

Figure 1. Parallel Trend Test.

4.2.2. Tests of Other Environmental Indicators

Because the urban AQI consists of multiple air pollutants, we chose the annual maxima of two of the major pollutant indices, NO_2 and PM2.5, as explanatory variables and use these two indicators to test the robustness of the results.

Table 3 reports the results of the robustness tests for the two air quality indicators. In column (1), the estimated coefficient of NO_2 concentration is −3.653, statistically significant at the 5% level. This indicates that the annual maximum concentration of NO_2 in the pilot cities in the ecological environmental damage compensation system decreased by 3.653 $\mu g/m^3$ on average. In column (2), the estimated coefficient of PM2.5 concentration is −15.31 and statistically significant at the 1% level. This represents a reduction of 15.31 $\mu g/m^3$ in the annual maximum PM2.5 concentration in the pilot cities.

Table 3. Alternative Dependent Variables.

	M_ NO_2	**M_ PM2.5**
DID	−3.653 ** (1.579)	−15.31 *** (3.777)
Urban Pollution Condition	Yes	Yes
Urban Pollution Condition	Yes	Yes
Urban Pollution Governance Level	Yes	Yes
Year FE	Yes	Yes
City FE	Yes	Yes
N	841	841
R^2	0.307	0.219

Standard errors listed in parentheses are clustered at the city level. ** $p < 0.05$, *** $p < 0.01$.

Overall, the estimated coefficients of all explained variables are significantly negative at the 5% statistical level, which proves that the ecological environmental damage compensation system can significantly reduce the maximum annual NO_2 concentration and the maximum annual PM2.5 concentration in the pilot cities, improving air quality. The above analysis demonstrates that the pilot policy could improve urban air quality even if the index used to measure air quality was changed, and more accurate urban data were used for analysis

4.2.3. Mitigating the Impact of Pilot Selection

The random selection of pilot cities is the ideal situation for the DID method. However, in reality, the selection of policy pilots, such as the actual economic and social development and openness of the region, is mostly not random, which is closely related to the actual situation. These differences between regions may develop simultaneously over time and have different effects on regional air pollution, resulting in an estimated bias in the research conclusions. To alleviate the influence of these factors, this study adopts the test methods of Song [22], adding the interaction term of the benchmark factors and time trends closely related to the actual situation of the city into the original regression equation and obtaining the following equation:

$$\text{Condition} = \alpha + \beta \times DID_{ct} + \varphi \times X_{ct} + Z_c \times trend_t + \eta_c + \gamma_t + \varepsilon \tag{3}$$

Z_c refers to the characteristics of the city, including its degree of economic and social development, geographical location, and openness. In this study, the geographic location factor is summarized as follows: whether it is a southern city (according to the concept of administrative division), a provincial capital city, or a municipality directly under the central government (as political factors), and whether it is a special economic zone as a degree of economic development.

The results of the analysis are presented in Table 4. After adding the interaction terms between these benchmark variables and time, the coefficient of DID is still significantly negative. This shows that even when considering the influence of the inherent regional differences between pilot and non-pilot cities on the explained variables over time, the estimated coefficient is decreased and is still significantly negative, indicating that the research estimates remain robust.

Table 4. Consider the Omitted Variables.

	M_ AQI
DID	−14.72 ***
	(4.431)
Economic Growth	−15.14 ***
	(4.470)
Political Factor	−14.96 ***
	(4.468)
Location of Area	−14.76 ***
	(4.363)
Other Control Variables	Yes
Year FE	Yes
City FE	Yes
N	947
R^2	0.197

Standard errors listed in parentheses are clustered at the city level. *** $p < 0.01$.

4.2.4. Other Environmental Policy Impacts

The process of estimating the impact of the ecological environmental damage compensation system on urban air quality will inevitably be affected by the implementation of other environmental policies, affecting the estimated results. In addition, we find that 2017, the second year of the policy pilot studied in this article, was the year of the outbreak of environmental protection policies. The "Thirteenth Five-Year" Development Plan for National Environmental Protection Standards fully promotes the formulation and revision of 900 environmental protection standards. Closely related to the research in this paper is the "Implementation Plan for the Control of Pollutant Discharge Permit System" issued by the General Office of the State Council in November 2016. In 2017, the Ministry of Environmental Protection issued the "Pilot Work Plan for the Management of Pollutant Discharge Permits in Key Industries," identifying 11 provinces and 6 cities as pilot areas. It established a permit system for controlling pollutant discharge, which is extremely important for corporate environmental protection and local development. This series of environmental protection policies impact the environmental pollution discharge of local cities and improves the air quality in various places, thus affecting the environmental protection effect estimation of the ecological environmental damage compensation system in this study. To identify and mitigate this effect, this study includes a dummy variable for the interaction of policy and time in 2017 in the baseline DID regression model. In addition, in 2016, the first batch of central environmental protection inspectors was launched. The inspection team entered the province and selected cities to conduct surveys on the implementation of the environmental protection policies. This study further controls the interaction terms between the first two rounds of province inspection and the corresponding times in 2016 and 2017.

The test results are listed in Table 5. The reduction in the maximum AQI value obtained in the previous study is a common effect of the two policies. Although the absolute value of the coefficient decreases after adding other policy benefits, the effect of the ecological environmental damage compensation system remains negative and significant, indicating that the pilot policy reduces urban air pollution and improves urban air quality.

In summary, the above multiple robustness tests show that the ecological environmental damage compensation system can effectively reduce the maximum urban air pollution and improve urban air quality.

Table 5. Other Simultaneous Policies.

	M_ AQI
DID	9.904 ***
	(4.167)
Reform of Pollution Right	2.490
	(5.295)
Environmental Inspector	2.938
	(3.726)
Urban Characteristics	YES
Urban Pollution Condition	YES
Urban Pollution Governance Level	YES
Year FE	YES
City FE	YES
N	947
R^2	0.141

Standard errors listed in parentheses are clustered at the city level. *** $p < 0.01$.

5. Heterogeneity Analysis and Mechanism Analysis

All of the above empirical research results show that the ecological environment damage compensation system significantly reduces pollution emissions in the region. However, does it have the same effect in different cities? How can pilot policy affect urban air pollution emissions? To answer the above questions, we will further explore the effects of the ecological damage compensation system on air pollution through heterogeneity analysis and a test of the impact mechanism.

5.1. Heterogeneity Analysis

The process of industrialization and urbanization is an important factor affecting urban environmental pollution, and the size of a city is an effective indicator for measuring the process of urbanization and the degree of urban industrialization [23–25]. To explore the role of the ecological environmental damage compensation system in cities of different scales, according to the 2014 State Council's "Notice on Adjusting the Criteria for the Division of Urban Planning," in which urban areas with a permanent population of more than 5 million are classified as big cities, they are collectively referred to as large cities. Cities with a population of less than 5 million are classified as small cities, and grouped regressions are performed to test the heterogeneity of policies.

From the results in Table 6, it can be seen that the ecological environmental damage compensation system has a significant impact on small cities, while the impact coefficient on large cities is negative but not statistically significant. Since smaller cities are mainly dominated by primary and secondary industries, the ecological environmental damage compensation system is more targeted at industrial pollution, leading to more significant pollution prevention benefits for smaller cities. In contrast, a possible reason why ecological damage compensation policies do not have a significant impact on large cities is that the concentration of population in large cities can improve air pollution by promoting technological innovation to reduce the amount of pollution and lower the cost of emissions [26–29].

5.2. Mechanism Analysis

5.2.1. Improve Pollutant Treatment Capacity

The comprehensive use of resources is an important element in implementing China's sustainable development strategy, and industrial bulk solid waste is a core area of comprehensive resource use because of its large volume and outstanding environmental impact [30–32]. The ecological environmental damage compensation system guides enterprises to improve their own pollution treatment capacity and give full play to the synergistic effect of comprehensive solid waste utilization on the achievement of pollution reduction and emission reduction targets. Because of this, we use the comprehensive utilization rate of industrial solid waste as a proxy variable for urban pollutant treatment capacity to explore how the ecological environmental damage compensation system influences air quality.

As shown in the first column of Table 7, the estimated coefficient of the comprehensive utilization rate of industrial solid waste is 2.676 and is statistically significant at the 1% level. More specifically, the key policy resulted in a significant 2.676% increase in the comprehensive utilization rate of industrial solid waste for the treatment group and is statistically significant at the 1% level. This shows that the ecological environmental damage compensation system can improve a city's overall pollution treatment capacity, thereby reducing urban air pollution and improving urban air quality.

Table 6. Heterogeneity Analysis.

	Big Cities	Small Cities
DID	13.66 (9.606)	16.87 ** (7.248)
Other Control Variables	Yes	Yes
Year FE	Yes	Yes
City FE	Yes	Yes
N	437	689
R^2	0.307	0.219

Standard errors listed in parentheses are clustered at the city level. ** $p < 0.05$.

Table 7. Mechanism Analysis.

	Comprehensive Utilization Rate of Industrial Solid Waste	The Primary Industry's Share of GDP (%)	The Secondary Industry's Share of GDP (%)	The Tertiary Industry's Share of GDP (%)
DID	2.676 *** (1.604)	0.437 (0.505)	−1.778 *** (0.793)	1.427 (0.837)
Other Control Variables	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	1833	1041	1044	1041
R^2	0.0306	0.510	0.377	0.186

Standard errors listed in parentheses are clustered at the city level. *** $p < 0.01$.

5.2.2. Change the Urban Industrial Structure

Another possible influence mechanism is that, as environmental regulations are strengthened, the government moves pollution-intensive industries to areas where environmental regulation is relatively loose, thus transforming the industrial structure and reducing environmental pollution in the area [33,34]. Given this, we analyze the effect of the ecological environmental damage compensation system on cities' industrial structure by using the share of the three industries in GDP as variables of the urban industrial structure.

The regression results are shown in Table 7. Columns 2 and 4 are regression analyses of traditional agriculture and service industries, respectively. The statistical analysis results are insignificant, indicating that the pilot policy has no significant impact on the proportion of primary and tertiary industries in the regional GDP. The secondary industries, particularly heavy industry and construction, are the main source of urban air pollution emissions; therefore, we mainly focus on the proportion of the industrial and construction industry in the regional GDP. In column 3, the coefficient of the share of the secondary sector is −1.778, which is statistically significant at the 1% level. This suggests that an ecological environmental damage compensation system can accelerate the transformation of urban industries by changing the industrial structure of the region, which in turn reduces urban air pollution.

In general, the ecological environmental damage compensation system can significantly improve the air quality in cities. This impact mechanism is achieved by increasing the capacity of cities to treat pollutants and improving their industrial structure.

6. Conclusions and Policy Implications

6.1. Conclusions

Based on a quasi-natural experiment of the ecological environmental damage compensation system, this study explores the benefits of the ecological environment damage penalty on the prevention and control of air pollution by examining the impact of the ecological environmental damage compensation system on air quality benefits and the impact mechanism of the system. The main findings are as follows: first, the ecological environmental damage compensation system significantly reduces the maximum values of urban AQI and has the same significant reduction effect on the annual maximum values of NO_2 and PM2.5; second, the ecological environmental damage compensation system has a significant effect on reducing the maximum values of the air quality index in small cities, while the effect on large cities is not significant. Finally, the main impact mechanism of the pilot policy on urban air quality comes from improving urban pollution treatment capacity and enhancing urban industrial structure.

The previous research on the ecological environment damage compensation system is mainly based on theoretical assumptions and simulation predictions. This paper conducts an empirical evaluation of the ecological environmental damage compensation system from the perspective of air quality benefit and enriches the relevant research on ecological environmental damage compensation system. Consistent with previous studies [35,36], as an environmental regulation policy, the ecological environment damage compensation system reduces not only urban air pollution and improves urban environmental quality but also promotes urban industrial upgrading and drives regional industrial structure transformation, which is conducive to winning the dual goals of environmental governance and high-quality economic development.

6.2. Policy Implications

(1) Strengthen the construction of a systematic environmental policy system. To achieve the action goal of "carbon peaking by 2030", it is necessary to improve the environmental policy system, adjust the policy direction in a timely manner according to the actual situation, and play the role of environmental regulation for a long time to promote the improvement of resource utilization in various regions, fields, and industries, to vigorously advance the circular economy, and to realize the green transformation of production and lifestyle [37,38].

(2) Develop differentiated regulatory policies. This study concludes that the ecological environmental damage compensation system is more effective for pollution prevention and control in small-scale cities. Therefore, its implementation should be based on local conditions rather than setting the intensity of the system implementation based on population size. For example, for areas with a rapid development of secondary industry, the intensity of implementation should be increased, and the system should be resolutely executed [39–41].

(3) Explore new paths for industrial transformation. To further promote the implementation of the strategy of innovation-driven development, the state encourages enterprises to innovate in environmental protection technologies through institutional grants, mechanism innovations, and policy incentives, and accelerate the transformation and upgrading of traditional resource-based enterprises, thereby promoting industrial transformation and upgrades [42–44].

Author Contributions: M.W. led and designed the study. Y.T. contributed significantly to analysis and manuscript preparation and conceived the idea of the study. Y.Z. performed the data analyses and wrote the manuscript. Y.L. is responsible for reviewing and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This article is funded by Sichuan Provincial Social Science Major Research Base System Science & Enterprise Development Research Center Major Project (No. Xq22B05), the major project funding for Graduate Education by the Association of Chinese Graduate Schools (No. 0082505502013), Sichuan Provincial Philosophy and Social Sciences Key Research Base Social Development and Social Risk Control Research Center Project (No. SR20A06), Sichuan University Postgraduate Cultivation and Education Reform Project (No. GSKCSZ2021012), and the Second Tibetan Plateau Scientific Expedition and Research Program (No. 2019QZKK0404).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data can be obtained at: https://data.cnki.net/trade/Yearbook/Single/N2022040095?zcode=Z007 (accessed on 25 May 2022).

Acknowledgments: We would like to express our gratitude to all those who helped us while writing this article.

Conflicts of Interest: The authors declare no conflict of interest.

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