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Environmental Policy Overlays and Urban Pollution and Carbon Reduction—Evidence from China

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Abstract: The in-depth promotion of environmental pollution prevention and control is a must for China to move towards green development, and the effectiveness of urban environmental pollution control largely depends on the selection of these environmental policies and the synergistic application of these policies. This paper empirically tests three environmental policies' mixed and synergistic effects using Chinese urban data from 2000 to 2017. This study found that (1) the three environmental policies significantly curb urban environmental pollution and show synergistic effects. (2) The three types of environmental policies can have a superimposing effect by strengthening financial inputs and increasing environmental concern, as well as a complementary effect by improving the efficiency of environmental protection enforcement and the institutional environment. The synergy between the central environmental protection inspection policy and the environmental information disclosure policy is more of a superposition effect than a complementary effect due to the similarity of the policy objectives. (3) The synergistic effect of environmental policies is affected by factors such as the age of the principal officials and financial pressure. The younger the age of the principal officials and the cities with less financial pressure are more capable of utilizing the synergistic effect of environmental policies to form a situation where the market, the government, the public, and the enterprises work together to govern the city. This paper provides new ideas for exploring the synergies and mechanisms of environmental policies and theoretical references for the design, implementation, and effects of environmental policy portfolios in the 14th Five-Year Plan period.

Keywords: environmental policy; pollution control; superimposed effect; complementary effect; policy synergy

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1. Introduction

Global warming has posed a severe test for the survival and development of humanity. More and more countries are pursuing market-based, command-based, and public-participation environmental policies as an essential means for the international community to cope with climate change and play a vital role in environmental governance. The Kyoto Protocol and the Paris Agreement adopted by the United Nations, among other initiatives, provide a unified arrangement for global action against climate change. As a latecomer economy, China has also adopted increasingly stringent environmental policies in response to environmental problems, attempting to reverse the environmental degradation caused by economic development. These include the carbon market pilot policy (CMP), which uses market incentives to optimize the allocation of emission rights, the central environmental protection inspection policy (CEPI), which is characterized by "supervision", and the environmental information disclosure policy (EID), which focuses on the public and non-governmental organizations [1]. However, environmental policy requires a comprehensive synergy of elements, and policy effectiveness depends mainly on selecting, matching, and coordinating multiple policy elements. In reality, there are still some problems in the synergy of environmental policies: on the one hand, conflicting policies have led local governments to go their way; on the other hand, the duplication and singularity of

policy instruments have led to insufficient incentives for environmental pollution control. The extensive use of subsidies and other means of promoting environmental policy has led to problems such as duplication of resource inputs, inadequate market-oriented mechanisms, and a single policy instrument. Thus, environmental pollution has yet to be effectively improved [2]. In this context, do China's market-based, command-based, and public-participation-based environmental policies have different effects depending on their objectives and mechanisms of action? Can there be effective synergies between different environmental policies? These major practical questions need to be further explored and answered, not only about the effectiveness of China's environmental policies but also about the ability of cities to realize green development.

In a review of the existing literature, existing studies are more likely to analyze the effects of a single policy based on a typical policy perspective but less likely to consider the interactions between multiple policies and to analyze the effects of market-based, command-based, and public-participation environmental policies. They also argue that the effects of policies are inconsistent. First, the effects of a particular environmental policy are analyzed. The existing literature suggests that CMP can reduce regional carbon emissions [3]. However, some scholars have suggested that carbon emission reductions are more at the expense of the economy [4]. Scholars have already analyzed CMP in the European Union, Switzerland, the United States, Canada, New Zealand, Korea, and China [5]. They concluded that the role of carbon market policies would be difficult to achieve without institutional learning and administrative prudence [3]. In terms of command-based environmental policies, established studies have argued that command-based environmental policies have effectively strengthened the environmental responsibilities of local party committees, putting dual pressure on local governments for environmental performance and political responsibility [6]. In particular, CEPI, which transformed the traditional "government supervision" into "party and government responsibility", has had a significant deterrent effect on local governments and emission control enterprises, significantly improving environmental performance [7]. However, a small body of literature suggests that the deterrent effect is mostly a temporary environmental improvement [8] and that the resumption of production by "scattered" enterprises after the inspectors' departure leads to a retaliatory deterioration in environmental quality. Finally, in terms of public-participation-based environmental policies, established studies have identified environmental information disclosure policies as one of the most effective typical policies [9] that can increase public awareness of environmental protection and governmental motivation to govern, form internal and external monitoring mechanisms for environmental protection, and thus effectively improve the efficiency of environmental governance. However, some scholars believe that the process of EID in China still suffers from management and technical problems, as well as imperfect system construction, resulting in the policy effect not being effectively played. Second, the effects of different environmental policy instruments have been compared but not uniformly agreed upon. However, a small number of studies have argued that direct regulation can produce more significant environmental benefits. In contrast, environmental policies based on market mechanisms struggle to have a positive effect on green innovation due to problems such as inadequate market mechanisms [10]. Public-participation-based environmental regulation may have difficulty producing a significant effect on environmental pollution due to problems such as insufficient public awareness of environmental protection. Third, exploring the synergistic effects of policy combinations. This part of the literature is mostly based on a policy text perspective, analyzing the environmental benefits of differences in the instruments of different environmental policy types. Most of the literature argues that a single sector cannot effectively respond to complex environmental problems and that there is a strong relationship between policies to mitigate the energy crisis and policies to address ecological changes, which can positively affect the ecology through mechanisms such as correcting market failures and strengthening policy oversight [11]. However, divergent policy goals and poor communication between departments may lead to "policy fights" [12]. Research by [13] shows that the various

environmental policies introduced by regional, state, and local governments in the U.S. create conflicts that significantly increase institutional transaction costs and diminish the effectiveness of environmental policies for climate governance. In summary, established studies have focused on the effects of environmental policies. Still, most of them treat single or multiple policies as an independent existence, and few focus on the mixed effects of different environmental policies implemented simultaneously in cities on pollution control. There is also a lack of systematic analysis of the mechanisms of urban environmental pollution impacts from the perspective of different types of policy synergies. In response to the CMP centered on the market mechanism, CEPI based on command-and-control type, and EID policy based on public supervision, whether these three policies can show significant synergistic effects as the representatives of market-type, command-type, and public-participation-type environmental policies need to be further investigated. In view of this, this paper first considers the policy objectives and logic of CMP, CEPI, and EID and constructs the theoretical mechanism of the synergistic impact of environmental policies on urban environmental pollution, in order to analyze the mechanism of environmental policies from the perspective of superimposed effects and complementary effects.

The contribution of this paper may be reflected in the following three aspects: First, established studies have either assessed the effects of environmental policies from a single perspective or compared the differences in the impacts of different environmental policies, ignoring the fact that the Chinese government's diversified environmental policies for urban environmental pollution management will subject cities to different types of environmental policies at the same time, which is likely to lead to biased assessments and systematic judgments about environmental policies. The research in this paper from the perspective of the mixed and synergistic effects of various environmental policies, such as market-type, command-type, and public-participation-type, to a certain extent makes up for the shortcomings of the existing studies that mainly focus on a single environmental policy.

Second, this paper explains the synergistic effects of environmental policies from two perspectives, the superposition effect and the complementary effect, and finds that the synergistic mechanisms of environmental policies show significant differences. It reflects the complex characteristics of China's environmental policies on urban pollution management and provides methodological support and intuitive empirical evidence for comprehensively recognizing and evaluating the real-world effects of China's environmental policies in the new era.

Third, we construct a structural econometric equation suitable for the context of China and a control function method (CF) estimation framework designed according to the logic of Chinese reality. They can not only integrate the three environmental policies at the city level into the same econometric model framework but also effectively deal with the resulting endogeneity problems and ensure the reliability of the core findings of this paper as much as possible.

The rest of this paper is organized as follows. Section 2 presents the theory and research hypotheses. Section 3 presents the data sources, model, and variable descriptions. Section 4 describes the impacts of different environmental policies on urban environmental pollution control, and Section 5 analyzes their superposition and complementary effects, and further explores the heterogeneity of the age of principal officials and financial pressure on this basis. Section 6 summarizes and discusses the main findings of this study and gives relevant policy recommendations.

2. Theoretical and Research Hypothesis

2.1. Environmental Policy Synergies

CMP and CEPI policy synergy: The core of CMP is to achieve carbon emission reduction through market-based approaches. Combining the experience of developed countries and the actual situation in China, the carbon market policy is to determine the annual emission allowance targets according to the actual economic development of the region and to allocate the carbon emission allowances by considering the historical emissions of

enterprises, so that the carbon emission rights can be commodified [14]. Firms can meet carbon emission targets by selling and buying carbon credits [15]. However, as China is a late-developing economy, the market mechanism still needs to be sound, and the carbon market has low development and operational efficiency. If local governments can play the role of a tangible hand by strengthening control, they can urge emission control entities to comply. CEPI has the characteristics of "party and government share responsibility" and "one post, two responsibilities", which requires each local government to take the overall responsibility for ecological environmental protection and ecological environment quality in its administrative region, and its strict inspection system can precisely protect the operation of the carbon market. The strict inspection system can escort the operation of the carbon market. CEPI alleviates the information asymmetry between the central government and local governments and can effectively grasp the operation of CMP in each city. Implementing CEPI enables the central government to directly inspect local governments' environmental management behavior and understand more intuitively the local air pollution situation and local problems in environmental protection [16]. Both integrate the interaction between the market and the government and realize the organic combination of market mechanism and government effectiveness, thus effectively reducing air pollution. The Solid Hypothesis H1a is as follows.

H1a. *Carbon market policy can create synergy with the central environmental protection inspector policy to reduce urban environmental pollution.*

The synergy between CMP and EID: Environmental pollution control in cities depends on a sound policy system and supportable external conditions. The staggered implementation of CMP and EID shows the expectation and determination of the country to promote green development in cities. Environmental pollution control is the result of the joint action of government, market, and public forces. EID, as an informal environmental policy, is mainly based on the public and NGOs and does not have a compulsory binding force, which transmits environmental pressure to emission control subjects through the protest and negotiation behaviors of the public or groups [17]. EIDs are more often expressed as connecting internal and external stakeholders of polluting companies to provide incentives and monitoring of environmental pollution management for emission control companies. In this case, the emission behavior of polluters is subject to both public and governmental supervision, resulting in the need for enterprises to invest more human, material, and financial resources in emission reduction, which indirectly makes the cost of green technology innovation appear cheaper compared to the past and reduces the relative cost of enterprise technology innovation [18]. At this time, the emission control subject, in order to avoid penalties and save costs, will choose technological innovation under the dual role of CMP and EID. The Solid Hypothesis H1b is as follows.

H1b. *Carbon market policies can create synergy with environmental information disclosure policies to reduce urban environmental pollution.*

CEPI and EID synergy: Both policy subject synergy and policy instrument synergy are necessary for environmental policies to play an influential role. When policy subjects coordinate and cooperate, an excellent inter-governmental relationship provides a solid basis for communication and consultation among multiple departments in policy implementation. The high degree of synergy of policy tools. On the other hand, the high degree of synergy of policy tools helps various sectors establish consistent policy objectives and adopt a diversified approach to reach an agreement. The organic combination of multiple policy subjects and tools helps to mobilize the enthusiasm of participating subjects but also helps to integrate the advantages of multiple elements to maximize the policy effect. CEPI has the dual characteristics of "supervising enterprises" and "supervising government", and the evaluation of environmental inspection teams is related to the performance and promotion opportunities of local governments [19]. In the context of the implementation of

the environmental information disclosure system, various cities have also published the pollution source supervision information disclosure index. Clear environmental indicators can effectively reduce public perception bias. It can provide the public with a more objective and convenient evaluation basis and stimulate public concern about the environmental pollution situation [20]. Therefore, although the targets of CEPI and EID are different, they strengthen the regulatory mechanisms of local governments and emission control subjects. As cities are an important subject of energy conservation and emission reduction, policies targeting the same city to implement CEPI and EID will have a corresponding overlap of policy initiatives due to the synergy of policy objectives, which will be more helpful in achieving the accumulation and integration of resources and provide incentives and constraints for urban environmental pollution management. The implementation of EID can provide a reliable basis for CEPI to monitor environmental pollution in each region, and the "communication-warning-punishment" regulatory mechanism implemented by the central environmental protection inspector policy can also reinforce the public monitoring effect of EID. The combined implementation of the two policy measures increases communication opportunities between departments and reduces coordination costs between governments, thus generating a resource-pooling effect. Moreover, under the dual policy, the goal of competition among local governments for the environment is further amplified. The reputation effect is highlighted [21]. Local governments will spare no effort to improve their ranking to avoid falling behind in the environmental competition, thus promoting urban environmental pollution control. The Solid Hypothesis H1c is as follows.

H1c. *The central environmental policy can create synergy with the environmental information disclosure policy to reduce urban environmental pollution.*

2.2. Analysis of Environmental Policy Coordination Mechanism

Superposition effect: Environmental policy synergy does not act directly on urban environmental pollution, and instead acts indirectly through specific supporting measures and initiatives to combat urban environmental pollution. Although the three types of environmental policy instruments act on urban environmental pollution from different perspectives, there may be a superposition effect due to the heterogeneity of the objectives or the similarity of the policy instruments, resulting in a synergistic impact on urban environmental pollution. This paper argues that this superimposed effect is mainly reflected in the enhanced financial investment and elevated environmental concern. On the one hand, the synergy of environmental policies will help strengthen financial investment, and the resources for coping with energy saving and emission reduction will be more abundant, which, in turn, will lead to the effective management of urban environmental pollution. In the early stage of carbon market development, local governments usually stimulate the participation of emission control entities by issuing some quotas for free, and financial support is an important initiative in the operation of carbon market policies. Similarly, for the central environmental protection inspector policy and environmental information disclosure policy, government departments will take measures such as direct financial subsidies and indirect tax relief to reduce the pressure of emission reduction on enterprises in order to help emission control subjects achieve effective emission reduction. As a result, environmental policy synergy will further strengthen the financial investment of local governments and promote urban environmental pollution control through a multiplier effect. Therefore, the superposition of policy measures brings double competitive pressure on local officials at all levels, which leads local governments to take more measures to control the environment to build up reputation capital and strengthen their attention to the environment to avoid being in a disadvantageous position in the environmental protection qualification, thus promoting urban environmental pollution control to a certain extent. The Solid Hypothesis H2 is as follows.

H2. *Cities enjoy dual policy support with similar initiatives, creating synergistic environmental policy effects through enhanced financial investment and increased environmental attention overlapping.*

Complementary effects: The implementation of environmental policies includes improving the efficiency of environmental protection enforcement and sound environmental protection supervision mechanisms, and the aforementioned externality initiatives provide facilities for urban environmental pollution management. The carbon market pilot policy, the central environmental protection inspector policy, and the environmental information disclosure policy facilitate coordination and cooperation among government departments due to the synergistic nature of their objectives and provide more resources and complementary policies for urban environmental pollution management. To this end, this paper analyzes the mechanisms underlying the synergistic effects of environmental policies from the perspective of policy complementarity.

On the one hand, the synergy of environmental policies can improve the efficiency of local environmental enforcement through complementary mechanisms. Although the implementation of carbon market policies can restrain emission control entities through market mechanisms, if they do not effectively participate in compliance, environmental policies will be greatly compromised [22]. The implementation of CEPI and EID not only strengthens the awareness of environmental responsibility of local party governments but also significantly increases the motivation of local governments for environmental governance and provides a complementary mechanism for compliance by emission control entities under CMP. On the other hand, environmental policies have changed the traditional one-way government governance model through a sound environmental monitoring mechanism, creating a synergistic effect of environmental policies through internal pressure and external monitoring. The implementation of CEPI and EID provides the possibility for the central government to effectively monitor environmental pollution in each region, and the pollution source regulatory information disclosure index provides a reliable basis for local governments to rank their environmental management [20]. The cost of local governments to conceal environmental pollution information is further pushed up, and environmental pollution problems are able to break through geographical restrictions, which undoubtedly increases the environmental pressure on local governments. The Solid Hypothesis H3 is as follows.

H3. *Cities enjoy dual policy support with consistent goals, creating synergies in environmental policy with complementary initiatives by improving the efficiency of environmental enforcement and improving the regional institutional environment.*

3. Study Design

3.1. Data

The selection of data for 2000–2017 in this paper is based on the following considerations. First, in 2000, China's Decision on Several Issues Concerning Environmental Protection explicitly proposed the implementation of the system of "the party and government chiefs are responsible for the overall responsibility of personal attention" in order to avoid urban environmental pollution being directly affected by this policy, this paper sets 2000 as the starting year of the sample. Second, China formally launched its carbon market pilot in 2013 but then launched its national carbon market policy in 2017. In order to exclude the impact of the national carbon market policy and accurately assess the external effects of the carbon market pilot policy, this paper takes 2017 as the cut-off year for the sample. The data in this paper were obtained from the following sources: carbon emission data were obtained from the CEADs database. *PM2.5* concentration data were obtained from aerosol optical thickness (AOD) measurements by satellite remote sensing published by the Center for Socioeconomic Data and Applications at Columbia University. Other

regional-level data were obtained from the China Urban Statistical Yearbook. Finally, this paper selected 285 cities for the study.

3.2. Models

To address, as far as possible, the endogeneity problem caused by possible reverse causation between the three types of environmental policies and the dependent variable, this paper carefully evaluates the three types of new environmental policies and finds that the correlation coefficients between the three innovation policy variables are small, indicating that they do not suffer from serious multicollinearity with each other. Therefore, it is possible to simultaneously include all three policy variables in the same econometric equation. In this paper, we draw on the study by [23].

$$Pollution_{i,t} = \alpha + \beta_1 CMP_{i,t} + \beta_2 CEPI_{i,t} + \beta_3 PITI_{i,t} + \beta_4 \text{control1}_{i,t} + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

$$CMP_{i,t} = \gamma_1 + \gamma_2 \text{control2}_{i,t} + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

$$CEPI_{i,t} = \lambda_1 + \lambda_2 \text{control3}_{i,t} + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (3)$$

$$PITI_{i,t} = \theta_1 + \theta_2 \text{control4}_{i,t} + \gamma_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

where i denotes city, t denotes time, and the first core equation $Pollution_{i,t}$ in the CF estimation framework is the core explanatory variable of this paper, representing urban environmental pollution. $CMP_{i,t}$, $CEPI_{i,t}$, and $PITI_{i,t}$ are dummy variables for carbon market policy initiation, central environmental protection inspector, and environmental information disclosure policy, respectively, while coefficients β_1, β_2, and β_3 respond to the mixed effects of market-based, command-based, and public-participation-based environmental policies. control2 is the CF estimation framework in which the explanatory variables are the control variables for carbon market policy initiation, mainly including the following: the level of economic development (*Economic*), expressed in terms of GDP per capita, and foreign capital dependence (*FDI*), measured as the ratio of actual foreign capital utilization to GDP; environmental supervision (*Supervise*), measured by the number of letters per 10,000 people on environmental issues; and environmental enforcement (*Enforce*), expressed using the number of administrative penalty cases per billion GDP on environmental issues. control3 is the control variable in the CF estimation framework in which the explanatory variables are the central environmental protection inspectors' policies, mainly including air quality level (*AQI*); industrial industry size (*Size*), expressed using the share of industrial value added in GDP; and industrial pollution degree (*IPD*), measured by industrial SO_2 emissions. control4 is the control variable in the CF estimation framework in which the explanatory variables are environmental information disclosure policies, mainly including the level of economic development (*Economic*); foreign investment dependence (*FDI*); fiscal decentralization (*FD*), expressed using the ratio of fiscal revenue to fiscal expenditure; environmental protection input intensity (*RD*), measured as the ratio of investment in environmental pollution control to GDP; and regional education level (*Edu*), measured using the number of college students per 10,000 students.

3.3. Variable Description

Dependent variable: In order to measure urban pollution, carbon emission level (CO_2) is selected as an indicator of urban pollution, and *PM2.5* concentration is selected as a robustness indicator in this paper. First, the level of carbon emissions is an important consideration for the achievement of the dual carbon goal, measuring urban environmental pollution in terms of CO_2 emissions (logarithm) for each prefecture-level city. Second, considering that *PM2.5* concentration is a current concern for the environmental sector and the population in developing countries [24], this paper uses it as another proxy variable for robustness testing. It is considered that compared with ground-based monitoring

data, satellite monitoring data can more comprehensively and accurately reflect urban *PM2.5* concentrations and their changing trends. Therefore, this paper measures *PM2.5* concentrations in each prefecture-level city in China [25].

Independent variable: This paper selects carbon market policy initiation, central environmental protection inspector, and environmental information disclosure policy as typical representatives of market-based, command-based, and public-participation-based environmental policies. For the measurement of CMP, the value is 1 if it is a pilot area and 0 otherwise. Regarding the measurement of CEPI, the dummy variable is determined according to the period when the inspector team is first stationed in the city, and the *CEPI* takes the value of 1 if the first arrival of the CEPI team occurs in a city; otherwise, it takes the value of 0. Regarding the measurement of *EID*, the dummy variable is determined based on the Pollutant Information Disclosure Index (*PITI*), which takes the value of 1 if the sample city is within the scope of environmental regulation and 0 otherwise.

Control1 variables: Considering the many factors affecting urban environmental pollution, the following control variables were selected [26]. First is economic variables, including the level of economic development (*Economic*); the level of industrial structure (*Industry*); the level of real utilization of foreign investment (*FDI*); the level of urban innovation (*Innovation*); and fiscal dependence (*Fin*); and population size (*Population*). Second are meteorological variables. In order to avoid the influence of meteorological factors on the level of air pollution control, three indicators are considered, including average urban temperature (*Temp*), humidity (*Humidity*), and precipitation (*Rain*). Third, considering that the degree of urban greening affects the absorption of pollutants such as carbon dioxide, this paper controls for the level of urban greening (*Green*). Descriptive statistics are shown in Table 1.

Table 1. Descriptive statistics of main variables.

Variables	Obs	Mean	S.D	Min	Max
CO_2	5130	5.620	1.305	0.333	9.508
PM2.5	5130	45.333	14.942	4.315	108.526
Economic	5130	9.852	1.036	3.664	13.056
Industry	5130	0.623	0.089	0.194	0.914
FDI	5130	9.299	2.016	2.565	14.947
Innovation	5130	3.359	1.894	0	9.888
Fin	5130	13.693	1.312	4.709	18.139
Population	5130	5.845	0.695	2.785	8.129
Temp	5130	14.854	5.260	−1.210	26.464
Humidity	5130	69.251	9.088	35.632	84.397
Rain	5130	1011.010	537.805	48.714	2812.444
Green	5130	7.774	1.178	0.214	11.886

4. Empirical Analysis

4.1. Test for Mixed Effects of Environmental Policies

The regression results obtained from the CF method estimation framework are reported in Table 2. It is easy to find that all three types of environmental policies can significantly curb urban environmental pollution when controlling for meteorological, economic, temporal, and urban factors. Regarding the degree of impact of the three environmental policies, CMP has the most prominent inhibiting effect on urban environmental pollution, followed by the effect of CEPI and the weakest effect of EID. The possible reason for this is that the carbon market pilot policy internalizes the externalities of environmental pollution mainly through the price mechanism. Thus, it improves urban environmental performance [27].

Table 2. Test results of mixed effects of three environmental policies on urban environmental pollution.

	(1)	(2)	(3)	(4)
	CO_2	*PM2.5*	CO_2	*PM2.5*
CEPI	−0.431 ***	−5.976 ***	−0.101 ***	−6.423 ***
	(0.048)	(0.202)	(0.026)	(0.251)
CMP	−0.516 ***	−6.392 ***	−0.119 ***	−6.849 ***
	(0.042)	(0.381)	(0.003)	(0.359)
PITI	−0.723 ***	−3.824 ***	−0.093 ***	−0.578 **
	(0.022)	(0.240)	(0.022)	(0.245)
Cons	8.277 ***	20.061 ***	1.879 **	13.796 *
	(0.124)	(1.699)	(0.803)	(8.225)
Control	NO	NO	YES	YES
City–Year Fixed	YES	YES	YES	YES
R^2	0.505	0.587	0.512	0.518
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

4.2. Testing the Synergistic Effects of Environmental Policies

To further analyze the possible complementary and mutually exclusive effects of the three environmental policies, this paper includes the interaction terms of the three environmental policies in equation (1) of the CF analytical framework, and the regression results are reported in Table 3. The regression results in Columns (1) to (2) show that the coefficient of the interaction term (CMP × CEPI) between CMP and CEPI is significantly negative, indicating that a more prominent synergy effect is formed between the carbon market pilot policy and the central environmental protection inspector policy. The possible reason CEPI, as a typical command-based environmental policy, is more directional. Assumption 1a is valid. Columns (3) to (4) respond to the cross-effects of CMP and EID, and it is not difficult to find that the coefficient of the interaction term (CMP × PITI) between carbon market policies and environmental information disclosure policies is significantly negative, indicating that the two types of environmental policies can form an effective synergy. However, the coefficient of the interaction term is smaller when compared with the sum of the coefficients of single policies. Assumption 1b is valid. Columns (5) to (6) respond to the cross-effect of CEPI and EID, and it can be found that the coefficient of the interaction term (CEPI × PITI) is significantly negative. The absolute value of the interaction term's coefficient is significantly higher than the single coefficient, indicating that the joint effect of CEPI and EID can further amplify the inhibitory effect on urban environmental pollution. Assumption 1c is valid.

Table 3. Test results of synergistic effects of three environmental policies on urban environmental pollution.

	(1)	(2)	(3)	(4)	(5)	(6)
	CO_2	*PM2.5*	CO_2	*PM2.5*	CO_2	*PM2.5*
CEPI	−0.102 ***	−6.526 ***	−0.101 ***	−6.433 ***	−0.084 **	−6.289 ***
	(0.028)	(0.269)	(0.026)	(0.252)	(0.034)	(0.297)
CMP	−0.112 ***	−6.931 ***	−0.145 ***	−6.983 ***	−0.118 ***	−6.847 ***
	(0.021)	(0.504)	(0.034)	(0.382)	(0.036)	(0.459)
PITI	−0.093 ***	−0.575 **	−0.090 ***	−0.563 **	−0.088 ***	−0.612 **
	(0.022)	(0.246)	(0.022)	(0.249)	(0.022)	(0.255)
CMP × *CEPI*	−0.007 ***	−0.798 ***				
	(0.002)	(0.154)				
CMP × *PITI*			−0.007 ***	−0.333 ***		
			(0.002)	(0.015)		
CEPI × *PITI*					−0.141 ***	−0.653 ***
					(0.035)	(0.121)
R^2	0.512	0.618	0.513	0.518	0.513	0.517
Obs	5130	5130	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** and ** indicate significant at the 1%, 5%, and 10% levels, respectively.

4.3. Robustness Tests

4.3.1. Remove Policy Interference

In this paper, policy shocks that may affect urban environmental pollution are excluded one by one. These include (1) the "five provinces and eight cities" carbon market pilot policy implemented by the National Development and Reform Commission (NDRC) in July 2010; (2) considering that municipalities have an important position in China's politics, economy, science, culture and transportation, the four municipalities in this paper; and (3) pilot emissions trading policy carried out by the Ministry of Finance, the former Ministry of Environmental Protection and the National Development and Reform Commission in 2007 in 11 provinces. According to the above three types of policies, the results are reported in Columns (1) to (2) of Table 4 after excluding some cities from this paper. Thus, the mixed effects of all three environmental policies on urban pollution are mostly the same.

Table 4. Robustness test results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CO_2	*PM2.5*	SO_2	CO_2	*PM2.5*	CO_2	*PM2.5*
CEPI	−0.042 ***	−5.525 ***	−0.899 ***	−0.051 ***	−4.425 ***		
	(0.005)	(0.421)	(0.044)	(0.007)	(0.614)		
CMP	−0.049 ***	−5.590 ***	−0.144 **	−0.035 ***	−4.729 ***		
	(0.006)	(0.462)	(0.057)	(0.004)	(0.516)		
PITI	−0.146 ***	−1.395 ***	−0.207 **	−0.087 ***	−0.503 ***		
	(0.032)	(0.381)	(0.027)	(0.012)	(0.021)		
L.CEPI						−0.047 ***	−4.329 ***
						(0.011)	(0.370)
L.CMP						−0.033 ***	−5.147 ***
						(0.005)	(0.428)
L.PITI						−0.103 ***	−0.251 ***
						(0.019)	(0.031)
R^2	0.599	0.512	0.525	0.567	0.697	0.339	0.448
Obs	2286	2286	4189	5130	5130	4841	4841

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** and ** indicate significant at the 1%, 5%, and 10% levels, respectively.

4.3.2. Substitution of Explanatory Variables

To ensure the robustness of the paper's conclusions, we replace the measure of urban pollution with industrial SO_2, and the regression results are reported in Column (3) of Table 4. Significant mixed effects of the three environmental policies.

4.3.3. Propensity Score Matching

Considering the earliest implementation of the environmental information disclosure policy and that its policy effects were already apparent before the systematic assessment of the quality of 113 environmental information disclosures in China in 2008, this paper only matches the samples from 2000–2008 year by year in a multi-period DID. The results are reported in Columns (4) and (5) of Table 4. The underlying regression results hold.

4.3.4. Addressing Endogenous Issues

Endogeneity problems may adversely affect the reliability of the estimation results. In this study, the three environmental policies are emergent and strongly exogenous to the city, so the likelihood of endogeneity problems due to bidirectional causality is low. However, taking into account that although certain cities were not selected as pilot cities, the likelihood of these provinces being inspected in the next round of pilots and inspections has increased, causing government officials in these areas to actively prepare for the next round of inspections so that pollution emissions will be lowered, which will lead to endogenous problems. Ref. [28] showed that local governments generally refer to their preexisting

pollution to make current production plans and that it is difficult for government officials to quickly adjust air pollution in their jurisdictions based on changing realities. For this reason, this paper introduces a lagged period for the three environmental policies to examine the relationship between pre- and post-examination urban pollution. The results are reported in Columns 6 and 7 of Table 4, again confirming the existence of policy effects.

5. Further Discussion

5.1. Superimposed Effect

Whether the three environmental policies overlap by strengthening financial, environmental investment (*Financial*), and environmental concern (*Concern*) under reputation certification, thus effectively reducing urban environmental pollution. Table 5 reports the synergistic mechanism of CMP and CEPI. It is easy to find that under the joint effect of CMP and CEPI strengthening financial investment in environmental protection, enhancing the government's environmental concern, and reducing energy intensity are the main mechanisms through which CMP and CEPI exert synergistic effects.

Table 5. CMP and CEPI superimposed effect results.

	(1)	(2)	(3)	(4)
	Financial	***CO_2***	***Concern***	***CO_2***
$CMP \times CEPI$	0.022 ***	−0.053 ***	2.689 **	−0.057 ***
	(0.005)	(0.011)	(1.226)	(1.226)
Financial		−0.370 **		
		(0.157)		
Concern				−0.003 ***
				(0.001)
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** and ** indicate significant at the 1%, 5%, and 10% levels, respectively.

Table 6 reports on the synergistic mechanism between CMP and EID. It finds that under the influence of the dual policies, the superposition effect of strong financial input (*Financial*) and environmental concern (*Concern*) under the reputation certification is the main mechanism for the synergistic effect of CMP and CEPI, or CMP and EID.

Table 6. CMP and EID superimposed effect results.

	(1)	(2)	(3)	(4)
	Financial	***CO_2***	***Concern***	***CO_2***
$CMP \times PITI$	0.026 **	−0.086 *	0.835 ***	−0.004 ***
	(0.009)	(0.049)	(0.114)	(0.001)
Financial		−0.379 **		
		(0.157)		
Concern				−0.079 ***
				(0.008)
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

Table 7 reports the synergistic mechanism between CEPI and EID. It is found that the financial investment and environmental concern mediation mechanism of local governments does not hold under the influence of dual policies. Assumption 2 is valid.

Table 7. CEPI and EID superimposed effect results.

	(1)	(2)	(3)	(4)
	Financial	***CO_2***	***Concern***	***CO_2***
CEPI × *PITI*	0.010	−0.129 ***	−0.692	−0.123 ***
	(0.012)	(0.033)	(0.772)	(0.033)
Financial		−0.394 **		
		(0.156)		
Concern				−0.003 ***
				(0.000)
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** and ** indicate significant at the 1%, 5%, and 10% levels, respectively.

5.2. Complementary Effects

Multiple environmental policy implementations are more likely to have significant complementary effects in policy goal setting, policy rule setting, and policy implementation than a single environmental policy. This section focuses on testing whether the three environmental policies have complementary effects on urban environmental pollution management by improving the efficiency of environmental enforcement (*Enforce*) and improving the institutional environment (*System*) mechanisms, thus creating synergistic effects. The results are reported in Table 8, which reports the complementary effects of CMP and CEPI. We find that CMP and CEPI can have complementary effects by improving the efficiency of environmental enforcement.

Table 8. CMP and CEPI complementary effect results.

	(1)	(2)	(3)	(4)
	Enforce	***CO_2***	***System***	***CO_2***
CMP × *CEPI*	2.097 ***	−0.017 ***	0.527 ***	−0.055 ***
	(0.138)	(0.003)	(0.090)	(0.008)
Enforce		−0.025 ***		
		(0.007)		
System				−0.015 ***
				(0.004)
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** indicate significant at the 1%, 5%, and 10% levels, respectively.

Table 9 reports the complementary effects of CMP and EID. We find that CMP and EID can have complementary effects by improving the efficiency of environmental enforcement.

Table 9. CMP and EID complementary effect results.

	(1)	(2)	(3)	(4)
	Enforce	***CO_2***	***System***	***CO_2***
CMP × *PITI*	2.451 ***	−0.020 ***	0.597 ***	−0.069 ***
	(0.201)	(0.005)	(0.105)	(0.012)
Enforce		−0.024 ***		
		(0.007)		
System				−0.018 ***
				(0.003)
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** indicate significant at the 1%, 5%, and 10% levels, respectively.

Table 10 reports the complementary effects of CEPI and EID. It is found that the synergistic mechanisms of policies have significant complementary effects. The combination

of the two environmental policies can produce complementary effects by improving the efficiency of environmental protection enforcement and improving the institutional environment, thus producing a significant inhibitory effect on urban environmental pollution. Synergies between the three environmental policies can have the effect of "one plus one is greater than two". Assumption 3 is valid.

Table 10. CEPI and EID complementary effect results.

	(1)	(2)	(3)	(4)
	Enforce	***CO_2***	***System***	***CO_2***
$CEPI \times PITI$	2.447	−0.085 **	0.780	−0.141 ***
	(3.215)	(0.037)	(0.712)	(0.034)
Enforce		−0.017 **		
		(0.008)		
System				−0.019 *
				(0.011)
Obs	5130	5130	5130	5130

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

5.3. Heterogeneity Test

5.3.1. Age of Principal Officials

Typically, vice-provincial officials face the "seven-up, eight-down" rule of "retiring to the second tier", i.e., at age 57, they can still hold a substantive post until retirement at age 60. For municipal party secretaries and mayors at the directorate level, the chances of being promoted after the age of 54–55 are significantly reduced, and the incentives for promotion diminish significantly [29]. Thus, the three environmental policies may have different impacts depending on the age group of the officials in charge. In this paper, the age of municipal party secretaries in prefecture-level cities in China is obtained manually by using municipal party secretaries as the principal officials of the cities. Since the task completion period of municipal party secretaries is usually five years, this paper uses three age groups, less than 50 years old, 50 to 55 years old, and more than 55 years old, as the basis of sample division to explore the influence of the age of the principal officials on the cross-effect of environmental policies. The results are reported in Table 11. It is easy to find that officials under the age of 50 are more able to actively reduce urban air pollution in response to the national call, which is consistent with the findings of existing studies [30]. The likely reason for this is that younger officials are more inclined to avoid pollution penalties and increase local environmental governance out of a strong need for promotion. Older officials with limited tenure and retirement age are less motivated to build an ecological environment and are more likely to favor "growth preservation". Combining these two factors may lead to a "decoupling" of promotion incentives and environmental governance for older officials.

Table 11. Results of age heterogeneity test for principal officials.

	Age < 50			**50 ≤ Age ≤ 55**			**Age > 50**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
$CMP \times CEPI$	−0.024 ***			−0.099 ***			−0.072		
	(0.006)			(0.024)			(0.091)		
$CMP \times PITI$		−0.016 **			−0.141 *			−0.078	−0.101
		(0.007)			(0.082)			(0.253)	(0.081)
$CEPI \times PITI$			−0.084 ***			−0.083			
			(0.015)			(0.063)			
R^2	0.539	0.575	0.537	0.617	0.517	0.613	0.734	0.736	0.735
Obs	1260	1260	1260	2803	2803	2803	1067	1067	1067

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

5.3.2. Financial Pressure

The "political person" attribute of local government officials will lead them to use various means to increase fiscal revenue to avoid falling behind in the "GDP" race [31]. When faced with environmental policies, local government officials are likely to make strategic choices due to fiscal pressures. In this paper, based on the mean of the fiscal pressure, the group above the mean is defined as the high fiscal pressure group, denoted by *Financial* = 1, and the group below the median is defined as the low fiscal pressure group, denoted by *Financial* = 0. The regression results are reported in Table 12. It is easy to find that the synergistic effect of all three environmental policies is not significant for cities with higher fiscal pressure. In terms of the degree of impact, the synergistic effect of the CEPI policy and the environmental information disclosure policy is weakest in cities with higher fiscal pressures. For cities with less financial pressure, the synergistic effect of the three environmental policies can be effectively realized, and the synergistic effect of CMP and CEPI is the most significant. It shows that only by making a two-way effort to enhance environmental awareness and improve environmental investment, it is possible to effectively play a synergistic role in environmental policies, thus realizing the governance of urban environmental pollution.

Table 12. Results of the test for heterogeneity of financial pressure.

	(1)	(2)	(3)	(4)	(5)	(6)
	Financial = 0			***Financial = 1***		
$CMP \times CEPI$	−0.020 ***			0.003		
	(0.004)			(0.036)		
$CMP \times PITI$		−0.017 ***			−0.026	
		(0.005)			(0.038)	
$CEPI \times PITI$			−0.583 **			−0.052
			(0.234)			(0.041)
R^2	0.501	0.462	0.601	0.553	0.524	0.553
Obs	2412	2412	2412	2718	2718	2718

Note: Control variable coefficients are not reported. Robust standard errors are in parentheses; *** and ** indicate significant at the 1%, 5%, and 10% levels, respectively.

6. Conclusions and Policy Recommendations

Whether the market-based environmental policies represented by CMP, the command-based environmental policies represented by CEPI, and the public-participation-based EID implemented by the Chinese government can produce the expected effects and synergy is an important question that needs to be answered. The results show that (1) CMP, CEPI, and EID can significantly curb urban environmental pollution, and the policies have synergistic effects. (2) The three policies have the same objectives and similar functions, which can have a superimposed effect by strengthening financial investment and raising environmental concern, as well as a complementary effect by improving the efficiency of environmental protection enforcement and the institutional environment. (3) Among the officials of different ages, younger officials are more likely to contribute to the synergistic effect of environmental policies due to the dual incentives of environmental protection awareness and promotion. Among the different financial pressure constraints, cities with less financial pressure are more likely to invest more money in environmental management so that the "visible hand" of the government can promote the synergistic effect of environmental policies and form a situation where the market, the government, the public, and the enterprises can jointly manage the environment.

To this end, we propose the following policy: (1) The government should change the traditional concept of a single policy as the leading environmental policy and play a good policy "combination" to control urban environmental pollution effectively. The CEPI is effective in the short term but ineffective in the long term; the effect of EID is gradually weakening over time, and the CMP is effective in the long term. The synergy of the three

environmental policies can improve the situation of "implementation blockage" through complementary advantages. Therefore, in selecting and implementing environmental policies, it is necessary to integrate multiple resources, focus on the coordination and cooperation of multiple sectors, and form multiple incentives and constraints through the combination of multiple policies to improve the urban environmental pollution situation comprehensively. (2) Before the market mechanism is perfect, strengthening control through command-and-control environmental policies is an effective means to achieve the goal of energy conservation and emission reduction. The conclusion of this paper does not mean that more government intervention is better. Thus, the boundary between government and market behavior should be scientifically and reasonably defined to control urban pollution effectively. (3) In implementing environmental policies, attention should be paid to the complementary and superimposed effects among policies. The mutual stimulation effect of differentiated policies eventually forms a synergy among the market, government, and the public to promote and coordinate each other. It needs to strengthen the superimposed effect of dual environmental policies to stimulate energy-saving enthusiasm effectively.

Expandable areas for future research. First, this study uses urban data to explore the synergistic effects of environmental policies and the logic behind them, but it needs to introduce the case of firms. Future studies can conduct in-depth investigations of representative governments to provide more detailed empirical evidence of the impact of different environmental policies on urban pollution management. Second, due to the limitations of data and related policies, this paper only examines the age characteristics of urban officials in exploring the impact of three types of environmental policies on urban pollution management and does not comprehensively explore the impact of the characteristics of different types of officials; future research can further analyze the heterogeneous impacts of the tenure experience of principal officials, gender characteristics, and other characteristics of the central government officials on green innovation.

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