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Strategic Interactions in Environmental Regulation: Evidence From Spatial Effects Across Chinese Cities

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Developing countries are notorious for their enforcement gap in environmental regulation. Despite policymakers and scholars focusing on this phenomenon in China, there is little literature to explore the cause for its prevalence. This paper aims to explain this occurrence from the perspective of strategic interactions among the local governments in China based on the yardstick competition theory. Employing spatial panel data models, we use a panel dataset of Chinese cities to investigate strategic interactions in environmental regulation and identify their possible sources. The results depict a confirmative picture of strategic interactions in environmental regulation among Chinese cities, suggesting that the cities tend to imitate their neighbours and implement looser environmental regulation in response to the decreasing stringency in neighbouring cities. This transmission effect demonstrates the prevalence of incomplete implementation of environmental regulation. Moreover, the imitative actions vary across Chinese cities, as they are observed in eastern and western cities but not in central cities. In addition, the imitative actions are significantly weaker when environmental governance gains a higher degree of salience, indicating that green performance appraisals reduce strategic interactions among local governments. Finally, strategic interactions are found to originate from the fiscal decentralization system, and are strengthened by the turnover of the municipal party secretary or a younger one.

Keywords: environmental regulation, strategic interaction, imitation, Fiscal decentralization, younger secretary

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INTRODUCTION

There has been increasing concern about severe environmental pollution in China. The Chinese government has focused on pollution reduction through several policies (Zheng and Kahn, 2017; Greenstone et al., 2021). Environmental regulation is a viable and powerful tool to readily address environmental problems during economic development (Xie et al., 2017; Song et al., 2022a). By 2013, China enacted 30 state laws and 1,400 industrial environmental standards, whereas local governments implemented 314 local regulations related to environmental governance (Zheng and Shi, 2017). A stringent environmental protection law was implemented in 2015, and subsequently, a basic environmental regulation system was established. However, the existing environmental regulations in China are inadequate, as environmental problems occur frequently. China was ranked No. 120 in air quality based on the environmental indices of 180 countries worldwide and the 2020 Global Environmental Performance Index (EPI) report jointly released by Yale and Columbia universities.

However, the Chinese central government continues to face serious environmental problems, which the existing environmental governance has failed to resolve, despite increased efforts. These problems are related to China's development stage, and primarily occur due to the incomplete implementation of environmental policies established by the central government for local governments (Wang and Jin, 2007; Cai et al., 2016; Zheng and Kahn, 2017; Tu et al., 2019). This is widely known as the implementation gap of environmental regulation (Lo, 2014; Zhao et al., 2022), described as "decrees only exist in the House", and is a key environmental governance issue widespread across China.

Based on the official data of the Ministry of Environmental Protection of China, the total sewage and storage charges in the country from 2007 to 2011 were ~CNY92.728 billion and ~CNY88.218 billion, respectively, indicating a difference of CNY4.51 billion. The difference between the billing and warehousing totals of key monitoring enterprises in 2010–2013 was ~CNY7.938 billion. Tax differences not only emphasize the deviation between the implementation of sewage charges and regulatory objectives, but also reflect the common overall incomplete implementation of environmental regulation, which lead to suspension of central policies. Consequently, most local governments in China have shifted their policy implementation strategies from improvement to minimal mitigation.

Theoretically, the implementation gap of environmental regulation is caused by the Chinese political system, where local governments are the executor, while the central government is the decision maker. This implies that local governments have the flexibility in enforcing environmental regulations, which results in incomplete policy implementation. The central and local governments have different objectives, particularly in developing countries (Qian and Weingas, 1997; Garzarelli, 2004; Millimet, 2013). The profit-seeking motives of local governments lead to the symbolic implementation of regulations, which may reduce the fiscal revenue or lead to non-implementation of certain regulations. Profit-seekers with sufficient discretionary space drive the incomplete regulation implementation of the local government in the neo-liberal environmental governance system (Lo, 2015; Song et al., 2022b). However, the common overall implementation gap within the Chinese political system is difficult to explain. Therefore, the research perspective is shifted to strategic interactions among local governments, which has been an important issue in public economics (Huang and Du, 2017).

Because environmental regulation is an important tool for local governments to attract liquid capital, their intensity of implementation by one local government depends on the neighboring local governments. This is essentially due to the competition between neighboring regions, which originates from dual decentralization, that is, Chinese-style decentralization and environmental decentralization. The former refers to political centralization and economic decentralization (Li and Zhou, 2005; Xu, 2011; Caldeira, 2012; Wang and Lei, 2021), whereas the latter indicates that environmental management in China is based on a territorial management system (Ran et al., 2020; Hao et al., 2021; Li et al., 2021). In this context, the following questions arise: 1) Are there strategic interactions in environmental regulation among cities? 2) If so, what factors drive these interactions? Answering these questions will help us understand the critical characteristics of regulation and provide a decision-making basis for the establishment of rational environmental policies.

In this study, we utilized spatial panel data models based on the panel dataset for 260 Chinese cities during 2003–2016 to investigate strategic interactions among different cities on their environmental regulations and understand the common overall implementation gap. Based on the panel dataset for 260 Chinese cities for the period 2003–2016, we provide evidence for the existence of significant strategic interactions regarding environmental regulation in different Chinese cities. These interactions are mainly imitations, that is, cities tend to mimic their neighbors and implement looser environmental regulation in response to the decreasing environmental regulation stringency in neighboring cities. We also explore the heterogeneous effect of imitative interactions among different cities and different years and observe such effects in eastern and western cities, as well as before 2010. Finally, we conclude that strategic interactions are due to the fiscal decentralization system and are strengthened by the turnover of the secretary of the municipal party or a younger one.

Our study provides three primary contributions to the literature. First, we discuss the sources of environmental regulation enforcement gap in China. In previous studies, it has been suggested that the local government is responsible for the incomplete implementation of environmental regulation and several concepts are established, which describe the incomplete implementation of environmental regulation from the perspective of local government behavior, such as selective policy implementation, symbolic execution, negative execution, and policy implementation deviation (Wang and Jin, 2007; Liang and Langbein, 2015). However, previous studies mostly focus on the self-motivation of local governments, overlooking strategic interactions among local governments and dual decentralization in China. Therefore, we provide a new interpretation from the perspective of strategic interactions.

Second, we focus on prefecture-level municipal governments rather than provincial governments. Previous studies that are closely related to strategic interactions regarding environmental regulation (e.g., Renard and Xiong, 2012; Wu et al., 2019; Song et al., 2020a; Zhang et al., 2020a, 2021) and environmental expenditure (Deng et al., 2012; Chen et al., 2019; Pan et al., 2020), have mostly focused on the interactions among provincial governments. Our selection of prefecture-level municipal governments was based on two reasons. On the one hand, in China's five-level government system, which includes the central, provincial, prefecture-level city, county (district), and town governments (Li et al., 2016; Ma et al., 2022), prefecture-level municipal governments represent the third level, linking superior government and grassroots government. Owing to the special system of political centralization and fiscal decentralization in China (Xu, 2011; Caldeira, 2012; Yu et al., 2016; He et al., 2021), a lower-level government has greater responsibility, which indicates that prefecture-level city governments are more responsible for environmental finance, compared to provincial governments. This correlation provides insights into the roles and behaviors of intermediate governments in environmental protection and governance. On the other hand, compared with the literature on provincial governments, our empirical analyses are based on a larger sample size that provides more convincing findings.

Third, we explore the sources of strategic interactions from the perspective of fiscal decentralization and the personal characteristics of local government leaders. The driving forces of these interactions have only been explored in few existing studies (Renard and Xiong, 2012; Song et al., 2020b; Zhang et al., 2020a; 2021; Ge et al., 2020). Thus, to clarify the sources of strategic interactions of local governments on the implementation of environmental regulations to optimize related policies and alleviate negative effects of these interactions, the following two aspects are considered in this study. First, fiscal decentralization can be a source because it enables local governments to make decisions on fiscal taxes and expenditures and independently determine the sizes and structures of budget revenues and expenditures (Jia, 2014; Hao et al., 2020). This ultimately leads local governments to "race to the bottom" in environmental regulation to attract resources and capital. Second, considering the crucial role of the municipal party secretary in resource distribution, the personal characteristics of the secretary can be the source of strategic interactions. In particular, under a system where local officials assume the overall responsibility in China, the municipal party secretary is responsible for local economic development and social order maintenance, and has the decision-making power regarding land acquisition, loan guarantees, preferential policies, resources, and environment allocation. Thus, the turnover of the municipal party secretaries and their age will affect the implementation of various policies in the district, including environmental regulation.

The remainder of this paper is organized as follows: the theoretical hypotheses are discussed in *Theoretical Hypothesis*; the empirical framework, including the econometric model, data, variables, and spatial weight matrices, is presented in *Empirical Design*; empirical results are provided in *Empirical Results*, followed by their discussion in *Further Discussion: Sources of Strategic Interaction*; and finally, the conclusions and policy implications are summarized in *Conclusions and Policy Implications*.

THEORETICAL HYPOTHESIS

The National People's Congress and the central government formulate China's environmental regulation, and the municipal congress and committee establish and promulgate environmental regulations according to local conditions. To some extent, local governments' self-interest motivation for the incomplete implementation of environmental regulation is due to interjurisdictional competition under the Chinese-style decentralization system. Thus, strategic interactions in environmental regulation should be traced to this competition between local governments. Tiebout (1956) first proposed the theory of interjurisdictional competition and suggested that this type of competition can improve government efficiency. However, Oates (1972) emphasized that local government competition may cause undesirable effects, such as an insufficient supply of public goods.

Regard to the form of inter-jurisdictional competition, Revelli (2005) suggested that local governments influence each other through three channels, preferences, constraints, and expectations, and these correspond to Brueckner. (2003) of spillover, resource flow, and yardstick competition (Besley and Case, 1992). To clarify the interaction among cities in environmental regulation and their influence factors, we constructed an evolutionary game model by considering preferences, constraints and expectations, to simulate the strategic interaction of local government. Under the environmental decentralization, the strategy set on environmental regulation of the local government A and B are {strict enforcement, loose implement}. With the context of green economic transformation, the priority of a local government includes economic growth and environmental protection. It is known that different priorities lead to different implementation on environmental regulation and revenues. The **Table 1** list the parameters setting for the following analysis on the action of government A and B.

There are four kinds of strategy profile: both government A and B strictly enforce environmental regulation, both government A and B take loose enforcement in environmental regulation, only government A take strict enforcement in environmental regulation, and only government B strictly enforce environmental regulation. According to the parameters setting, a utility matrix of local government A and B is given in **Table 2**.

For local government A, if the possibility of taking "strict enforcement" is $x\,(0 < x < 1)$, then the possibility of taking "loose enforcement" is $1 - x$. Likewise, for local government B, if the possibility of taking "strict enforcement" is $y\,(0 < y < 1)$, then the possibility of taking "loose enforcement" is $1 - y$. Thereafter, the expected revenue of government A with taking "strict enforcement" in environmental regulation is U_{AC}, the expected revenue with "loose enforcement" is U_{AD}, and the average revenue of government A is $\bar{U}_A$, where

$$U_{AC} = y(-C_A + R_A + TR_A + H_A + I_A - L_A) + (1-y)(-C_A + R_A + TR_A + H_A + I_B - L_A)$$

$$U_{AD} = y(-\gamma C_A + P_A - H_A - \theta L_A - I_A - L_A) + (1-y)(-\gamma C_A + P_A - H_A - \theta L_A - I_A - L_A)$$

$$\bar{U}_A = xU_{AC} + (1-x)U_{AD}$$

According to the dynamic replication equation, herein set $\dot{x}/x$ as the growth speed of the possibility of taking "strict enforcement" by government A. Hence, the corresponding Mlthusian equation appears to be:

TABLE 1 | The parameters setting.

Parameters	Descriptions
C_i	The cost of "strict enforcement" in environmental regulation of local government i ($i \in (A,B)$)
γC_i	The cost of "loose enforcement" in environmental regulation of local government i ($i \in (A,B)$) and $0 \le \gamma \le 1$, where $\gamma = 1$ means "strict enforcement" in environmental regulation, $\gamma = 0$ means no environmental regulation in the region i.
R_i	The revenue of "strict enforcement" in environmental regulation of local government i ($i \in (A,B)$)
TR_i	The transfer payment from central government for encouraging the "strict enforcement" in environmental regulation of local government i ($i \in (A,B)$)
L_i	The direct loss caused by environmental pollution with "loose enforcement" in environmental regulation of local government i ($i \in (A,B)$)
P_i	A short- term economic growth under "loose enforcement" in environmental regulation of local government i ($i \in (A,B)$)
G	Considering the negative externality of environment pollution, the loose enforcement government should pay G for the negative effect of its neighbors, where $G = \theta L_i$, θ is the coefficient of negative externality and $0 \le \theta \le 1$
H_i	The utility of residents' happiness under different environmental regulation, if $\gamma = 1$, local government i get a $+ H_i$, otherwise a $-H_i$.
I_i	The indirect loss caused by human capita outflowing under "loose enforcement" in environmental regulation of local government i ($i \in (A,B)$)

TABLE 2 | The utility matrix of government A and B under different strategies.

Local government A	Local government B	
	Strict enforcement S	Loose enforcement F
Strict enforcement C	$-C_A + R_A + TR_A + H_A + I_A - L_A,\ -C_B + R_B + TR_B + H_B + I_B - L_B$	$-C_A + R_A + TR_A + H_A + \theta L_B + I_B - L_A,\ -\gamma C_B + P_B - H_B - \theta L_B - I_B - L_B$
Loose enforcement D	$-\gamma C_A + P_A - H_A - \theta L_A - I_A - L_A,\ -C_B + R_B + TR_B + H_B + \theta L_A + I_A - L_B$	$-\gamma C_A + P_A - H_A - \theta L_A - I_A - L_A,\ -\gamma C_B + P_B - H_B - \theta L_B - I_B - L_B$

$$\dot{x} = \frac{dx}{dt} = x\left(U_{AC} - \bar{U}_A\right) = x(1-x)\{y[(\gamma-1)C_A + R_A + TR_A - P_A + 2H_A + 2I_A] + (1-y)[(\gamma-1)C_A + R_A + TR_A - P_A + 2H_A + I_A + I_B + \theta L_A]\} \tag{1}$$

Equivalently, the expected revenue of government B with taking "strict enforcement" in environmental regulation is U_{BS}, the expected revenue with "loose enforcement" is U_{BF}, and the average revenue of government B is $\bar{U}_B$, where

$$U_{Bs} = x(-C_B + R_B + TR_B + H_B + I_B - L_B) + (1-x)(-C_B + R_B + TR_B + H_B + \theta L_A + I_A - L_B)$$

$$U_{BF} = x(-\gamma C_B + P_B - H_B - \theta L_B - I_B - L_B) + (1-x)(-\gamma C_B + P_B - H_B - \theta L_B - I_B - L_B)$$

$$\bar{U}_B = yU_{BS} + (1-y)U_{BF}$$

According to the dynamic replication equation, herein set $\dot{y}/y$ as the growth speed of the possibility of taking "strict enforcement" by government B. Hence, the corresponding Mlthusian equation appears to be:

$$\dot{y} = \frac{dy}{dt} = y\left(U_{Bs} - \bar{U}_B\right) = y(1-y)\{x[(\gamma-1)C_B + R_B + TR_B - P_B + 2H_B + 2I_B + \theta L_B] + (1-x)[(\gamma-1)C_B + R_B + TR_B - P_B + 2H_B + \theta L_B + \theta L_A + I_A + I_B]\} \tag{2}$$

A two-dimensional dynamic model can be got by combining the equation (A1) and (A2):

$$\begin{cases} \frac{dx}{dt} = x(U_{AC} - \bar{U}_A) = x(1-x)\left\{y[(\gamma-1)C_A + R_A + TR_A - P_A + 2H_A + 2I_A] + (1-y)[(\gamma-1)C_A + R_A + TR_A - P_A + 2H_A + I_A + I_B + \theta L_A]\right\} \\ \frac{dy}{dt} = y(U_{Bs} - \bar{U}_B) = y(1-y)\left\{x[(\gamma-1)C_B + R_B + TR_B - P_B + 2H_B + 2I_B + \theta L_B] + (1-x)[(\gamma-1)C_B + R_B + TR_B - P_B + 2H_B + \theta L_B + \theta L_A + I_A + I_B]\right\} \end{cases} \tag{3}$$

Thereafter, for gaining the equilibrium point, assuming $\dot{x} = 0$, then we have $x = 0, x = 1$, $y = \frac{(1-\gamma)C_A - R_A - TR_A + P_A - I_A - I_B - \theta L_A - 2H_A}{I_A - I_B - \theta L_A}$. Likewise, assuming $\dot{y} = 0$, $y = 0$, $y = 1$, $x = \frac{(1-\gamma)C_B - R_B - TR_B + P_B - I_A - I_B - \theta L_A - \theta L_B - 2H_B}{I_B - I_A - \theta L_A}$. If $X_a = \frac{(1-\gamma)C_B - R_B - TR_B + P_B - I_A - I_B - \theta L_A - \theta L_B - 2H_B}{I_B - I_A - \theta L_A}$, $X_b = \frac{(1-\gamma)C_A - R_A - TR_A + P_A - I_A - I_B - \theta L_A - 2H_A}{I_A - I_B - \theta L_A}$, thereby, the equilibrium point of the dynamic model include (0,0), (0,1), (1,0), (1,1) and (X_a, X_b) where $0 < X_a < 1$, $0 < X_b < 1$, and $\frac{R_B + TR_B - P_B + I_A + I_B + \theta L_B + \theta L_A + 2H_B}{1-\gamma} < C_B < \frac{R_B + TR_B - P_B + \theta L_B + 2H_B + 2I_B}{1-\gamma}$, $\frac{R_A + TR_A - P_A + I_A + I_B + \theta L_A + 2H_A}{1-\gamma} < C_A < \frac{R_A + TR_A - P_A + 2I_A + 2H_A}{1-\gamma}$.

According to **Table 2**, we can simplify the revenue matrix by just considering the revenue and cost. Thereafter, it can be concluded that if $R_i + TR_i + H_i + I_i > C_i + L_i$, both government A and B take "strict enforcement" as the dominant strategy; if $P_i > \gamma C_i + \theta L_i + I_i + L_i$, both government A and B choose "loose enforcement" in environmental regulation and reach Nash equilibrium. Additionally, there is a mixed strategy which is also a Nash equilibrium and showed as **Figure 1**. It is obviously that there is strategic interaction in environmental regulation among local governments and the strategy choosing

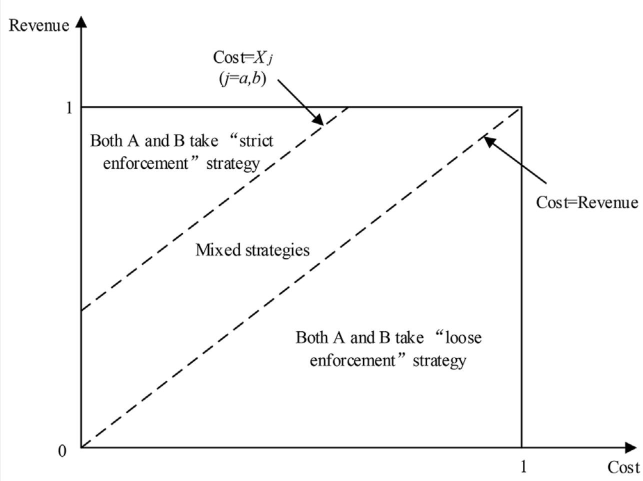

FIGURE 1 | The strategies of local governments under different conditions. The mixed strategy means under a certain possibility government A take "strict enforcement" and B take "loose enforcement", alternative, B take "strict enforcement" and A take "loose enforcement".

is immediately determined by the cost and revenue of environmental regulation of local governments. Thus, hypothesis 1 was proposed as follows:

Hypothesis 1. Within the decentralization system, there is strategic interaction in environmental regulation among local governments.

Originally, the cost and revenue of environmental regulation of a government is determined by the preferences and constraints. Giving the aim of the strategic interaction, local governments devote to maximize their utility. According to the assumption in **Table 1**, most of the variables in the objective functions are depended on the constraints from central government. Among them, the transfer payment from central government TR_i, the transfer payment from dirty neighbors' government θL_i, the indirect revenue caused by human capita inflowing I_i are the "flow factors" that local governments want to control and fight for. Fiscal decentralization gives local governments the possibility to win over these resources. Fiscal decentralization provides local governments' financial autonomy and the "residual claim" of fiscal revenue (Qian and Roland, 1998). To compete for flow resources, local governments can autonomously implement proper public policies according to local conditions. In other words, fiscal decentralization has spawned local government competition and promoted the continuation of such competition (Oates, 1972; Oates and Portney, 2003). Within the decentralization system, local governments procure the loose-feet resources by decreasing the fiscal, taxation, land, and other regulations. The tax federalism reform characterized by fiscal revenue centralization in 1994 significantly increases the actual expenditure responsibilities of local governments, reflecting the essence of the "receipt of finance and retention of power". As a result, local governments attempt to increase local financial resources to fill the large gap in income and expenditure, followed by competition among local governments to attract flow resources. Thus, Hypothesis 2 is proposed.

Hypothesis 2. Fiscal decentralization strengthens strategic interactions in environmental regulation of local governments.

Similarly, from **Table 1**, we can find that only the cost of environmental regulation and the possibility of taking "strict enforcement" strategy x (y) are determined by the regional governments' preferences. Visually, the preference is influenced by both the internal and external factors. Among them, the assessment system for local officials and the following officials' turnover are the main factors. In China, the officials' performance assessment system adopted a multi-evaluation approach, which guides local government officials' action. In 2006, the central government firstly established the energy intensity and total pollution discharge being reduced by 20 and 10% as a binding indicator for economic development. Subsequently, a series of various endeavors and policies implementation, including "Measures for the Assessment of Major Pollutant Emission Reductions" in 2007 and the "Measures for the Emission Reduction of Major Pollutants in the 12th Five-year Plan" in 2013, gradually increase the significance of environmental protection in the official assessment system. The strengthening of environmental protection in the official assessment system rise the preference of "strict enforcement" of local officials, and increase the possibility of "strict enforcement" x (or y), which ultimately going to the equilibrium point (1, 1), a both "strict enforcement" strategy. Thus, Hypothesis 3 is proposed.

Hypothesis 3. The inclusion of diversified and green government performance assessment reduces local governments' "loose enforcement" strategic interaction on environmental regulation.

Giving the official organization, as the top leader, the municipal party secretary play vital role on the local resources allocation and policies implementation. The secretary's turnover frequently would cause the discontinuity, instability, and uncertainty of policies implementation including environmental regulation. Essentially, the secretary's turnover means the change of preferences as different people have different pursuits and preferences. Theoretically, the change of preference should be neutral, that is with the same probability of "strict enforcement" or "loose enforcement". However, successors often expect to surpass the achievements of their predecessors for further promotion. New officials prefer infrastructure construction rather than promoting people's livelihood, and thus invest more in public goods production to achieve rapid local economic growth. In contrast, investment in environmental protection is often omitted by local officials due to its hysteretic and invisible nature on performance. Wu et al. (2013) confirmed that the proportion of environmental expenditures to gross domestic product (GDP) increases by 1%, whereas the promotion probability of secretaries and mayors decreases by 8.5 and 6.5%, respectively. In conclusion, a frequent secretary turnover change the preference and induce the probability of "strict enforcement" x(or y), ultimately increase the chance to the equilibrium point (0,0), which means both local government A and B take "loose enforcement" strategy. Thus, Hypothesis 4 is formed as follows:

Hypothesis 4. Secretary turnover strengthens the "loose enforcement" strategic interactions in environmental regulation of local government.

As to the internal factors, the demographic characteristics of the officials are proved to show important effect on the preferences and the following actions. As aforementioned analysis, the secretary is very important in regional development. Hence, the following analysis detect the effect of the internal factor - demographics on local strategic interaction form the viewpoint of municipal party secretaries. Secretaries with different ages have different motivations for promotion. From 1982, the carrying of the juvenilization of the cadre policy established a retirement age for all levels leading cadres. The retirement age of officials at the bureau level was set to ≤60 years and that of officials at the provincial and ministerial levels was set to 65 years. A younger party secretary is more likely to be promoted than an older one (Kung and Chen, 2011; Kahn et al., 2015), and shows a stronger motivation to stimulate local economic growth. Thus, an older official, has smaller incentives of political promotion, weaker motivation to promote economic growth by "nearsightedness behaviors", and stronger motivation for improving public services (e.g., environmental quality) in the jurisdiction. A younger party secretary has a stronger motivation to pursue local economic growth (Guo et al., 2013) and is more likely to reduce the possibility of "strict enforcement" x(or y), ultimately increase the chance to the equilibrium point (0,0), a "race to bottom" situation. Thus, Hypothesis 5 is as follows:

Hypothesis 5. A younger municipal party secretary stimulates "loose enforcement" strategic interactions in environmental regulation of local governments.

EMPIRICAL DESIGN

Empirical Specification

To investigate the pattern of strategic interactions in environmental regulation, we employ the spatial autoregressive (SAR) model to identify competition among local governments. Following previous studies (Renard and Xiong, 2012; Shi and Xi, 2018; Pan et al., 2020), we specify the econometric model as follows:

$$ER_{it} = \delta_0 + \rho W \times ER_{it} + \beta X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{4}$$

where i and t denote the city and year, respectively; ER_{it} is the environmental regulation intensity; W is a spatial weight matrix; and W_{ij} describes the relative importance of region i to region j. Moreover, $W \times ER_{it}$ is the spatial lag term of environmental regulation, satisfying $WER_{it} = \sum_{j \neq i} w_{ijt} ER_{jt}$. ρ is the spatial autoregressive coefficient; X_{it} indicates other control variables that affect environmental regulation; α_i denotes the city fixed effects; λ_t denotes the year effects; and ε_{it} is the error term. To address potential heteroskedasticity, time series correlation, and cross-sectional correlation, the standard errors are clustered at the city level.

The key coefficient of interest, ρ, estimates the intensity of interregional strategic interactions in environmental regulation. If $\rho \neq 0$, the intensity of environmental regulation in a region is affected by that in the neighboring regions. If $\rho > 0$, interregional environmental regulation has imitative strategic interactions, called strategic complementarity; whereas, if $\rho < 0$, interregional environmental regulation has differentiated strategic interactions, called strategy substitution. If $\rho > 0$, Hypothesis 1 is considered valid. To verify Hypothesis 1a, we divided the sample into two subsamples, that is, before and after 2010. If ρ is smaller in the latter stage (after 2010) than that of the previous stage (before 2010), or the significance is reduced, or the value of ρ changes from positive to negative, greening performance assessment benefits the alleviation of strategic interactions in environmental regulation, and Hypothesis 1a is confirmed. **Figure 2** illustrates the relationship between the coefficient of the spatial lag term and strategic interactions in environmental regulation.

Data and Variables

In this study, balance panel data for 260 cities during 2003–2016 is used for empirical analysis. The sample do not include the following four municipality cities: Beijing, Tianjin, Shanghai, and Chongqing. The data are obtained from the China City Yearbook, China Regional Economic Statistical Yearbook, and China Statistical Yearbook. Owing to the lack of a price index at the city level, the nominal variables in monetary units are subjected to inflation at the corresponding provincial-level price index and adjusted to the price in 2000.

Measures of Environmental Regulation

Referring to Peng (2020) and Zhang et al. (2020b), we design a comprehensive index of environmental pollution to measure the intensity of environmental regulation. The city's environmental pollution control efforts and environmental regulation intensity are measured by constructing different pollutant emission intensities across the country and then weighting the relative levels of pollution emission intensities of various cities. The equation is expressed as follows:

$$ER_{it} = \frac{1}{P_{it}}, P_{it} = \frac{1}{3}\left(px_{1it} + px_{2it} + px_{3it}\right), \text{where} \, px_{l,it} = \frac{px_{l,it}}{\bar{p}_{l,t}} \tag{5}$$

where ER_{it} is the reciprocal of the comprehensive pollution discharge index P_{it}. It is worth noting that our regression models use the logarithm of ER as the dependent variable. The underlying implication of **Eq. 5** is that the lower the comprehensive pollution discharge index, the more effort the local government will undertake to control environmental pollution, and the more stringent the environmental regulation intensity, and vice versa. The parameter $\bar{p}_{l,t}$ is the national average emission intensity of pollutants l (industrial wastewater, industrial SO_2, and industrial dust) in year t and $px_{l,it}$ is the emission index of pollutants l in year t of city i, which is higher than the national average level. A higher $px_{l,it}$ indicates a higher emission level of l pollutants in t year of i city compared with the national level. As SO_2 emission changes can reflect a country's efforts to reduce environmental pollution (Barla and Perelman, 2005), the removal rate of industrial SO_2 can be used as a proxy for environmental regulation in the robustness test (Zhang et al., 2017).

Time-Variant Prefectural Characteristics

According to previous studies (Konisky, 2007; Renard and Xiong, 2012; Chen et al., 2019; Song et al., 2020a; Ge et al., 2020; Zhang et al., 2021), we select the following explanatory variables: *Fiscal decentralization*, *GDP per capita*, *Financial deficit*, *Population*

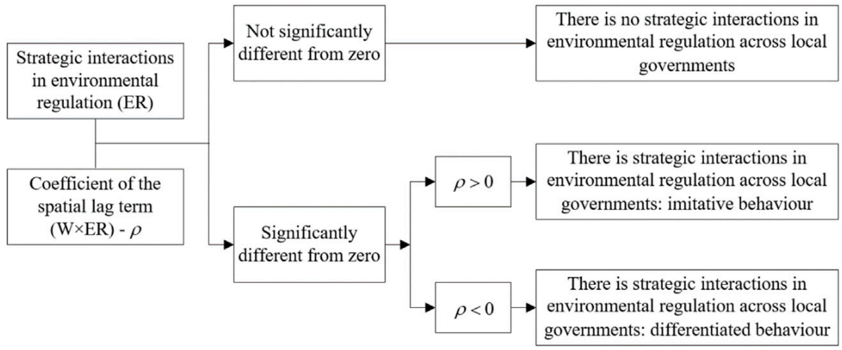

FIGURE 2 | The relationship between the coefficient of the spatial lag term and strategic interactions in environmental regulation.

TABLE 3 | Definition and descriptive statistics for the main variables.

Variables	Definition	Mean	S.D.	Obs.
ER	Environmental regulation	0.33	0.76	3,640
ER_2	SO_2 removal rate (%)	0.44	0.27	3,640
Fiscal decentralization[a]	Fiscal expenditure decentralization index (%)	0.38	0.10	3,640
GDP per capita	Log of real GDP per capita in each region (RMB yuan)	9.01	0.65	3,640
Financial deficit	Ratio of financial expenditure minus revenue to GDP (%)	8.37	6.93	3,640
Population density	Log of ratio of the total population to the administrative area (persons per sq. km)	5.77	0.87	3,640
Unemployment rate[b]	Percentage of urban unemployment in the workforce (%)	3.34	1.98	3,640
Ratio of secondary industry	Proportion of added value of the secondary industry to GDP (%)	48.82	10.33	3,640
Ratio of FDI	Ratio of FDI actually utilized to GDP (%)	2.14	2.34	3,640
Ratio of college students	Ratio of college and university students to the total population of the region (%)	1.58	2.18	3,640

[a]*Fiscal decentralization is calculated using the following equation: (prefectural government expenditure per capita)/(prefectural government expenditure per capita + provincial government expenditure per capita + central government expenditure per capita).*

[b]*Unemployment rate is defined as urban registered unemployed persons/(urban registered unemployed persons + private and individual employees + urban registered unemployed persons).*

density, *Unemployment rate*, *Ratio of second industry*, *Ratio of FDI* (foreign direct investment), *Ratio of college students*. Following Jia et al. (2014), Li et al. (2016), Hao et al. (2020) and Song et al. (2020a), **Table 3** presents the definitions and descriptive statistics for the main variables. Insignificant differences are observed in the distribution of variables, which are within reasonable limits, ensuring the reliability of the research data.

Specification of Spatial Weight Matrices

To analyze the strategic interactions in environmental regulation among Chinese cities, we should accurately define "adjacent regions". In this study, the geospatial and socioeconomic relations of different regions are simultaneously considered in defining these areas, ensuring that the results are not affected by the prior determination of the weight scheme. Following previous studies (Chen et al., 2019; Wu et al., 2019; Song et al., 2020b; Zhang et al., 2020b), we design three types of spatial weight matrices: 0–1, geographical distance, and economic distance. Based on the first two types, two cities have the same characteristics in terms of resource endowments, regional advantages, and cultural practices if they are geographically adjacent or nearby. Hence, other preferential policies are more likely used to attract flow resources, such as reducing the intensity of environmental regulation. The third type of spatial weight matrix is based on China's relative economic performance promotion assessment system. The more similar the economic development of a city, the more likely it is to become a competitor. Therefore, it is reasonable to implement similar environmental regulation standards and strategies in mutually competitive regions. The three types of spatial weight matrices are standardized and designed as follows:

1) 0–1 type spatial weight matrix *Wcont*. If the two regions are geographically adjacent, $d_{ij} = 1$; otherwise, $d_{ij} = 0$.
2) Geographic distance-type spatial weight matrix *Wdis2*. The weight element is set to $W_{ij} = 1/d_{ij}^2$, where d_{ij} is the spherical distance between the city *i* and city *j*, which is calculated based on the latitude and longitude of the location of municipal government.
3) Economic distance-type spatial weight matrix *Wpgdp*. The matrix integrates economic and geographical distance. The weight element is set to $W_{ij} = [1/|pgdp_i - pgdp_j| + 1] \times exp(-d_{ij})$ where $pgdp_i$ is the average of the economic development level of the region *i* during the sample period, and d_{ij} is the spherical distance between the cities.

TABLE 4 | Baseline results for three types of spatial weight matrices.

	(1)	(2)	(3)	(4)	(5)	(6)
	Wcont		*Wdist2*		*Wpgdp*	
W×ER	0.3729***	0.3436***	0.3915***	0.3257***	0.6815***	0.5805***
	(0.0456)	(0.0471)	(0.0547)	(0.0587)	(0.0590)	(0.0834)
Fiscal decentralization	−0.8503	−0.5485	−0.9915*	−0.7312	−1.1694**	−0.8757
	(0.5849)	(0.5798)	(0.5751)	(0.5754)	(0.5886)	(0.5816)
GDP per capita	0.6656***	0.8712***	0.6576***	0.8612***	0.6818***	0.9032***
	(0.1299)	(0.1543)	(0.1304)	(0.1551)	(0.1350)	(0.1593)
Financial deficit	−0.0019	0.0025	−0.0018	0.0025	−0.0004	0.0044
	(0.0040)	(0.0045)	(0.0043)	(0.0048)	(0.0044)	(0.0049)
Population density	−0.1838	0.1824	−0.1525	0.1844	−0.2301	0.1515
	(0.2649)	(0.2742)	(0.2718)	(0.2781)	(0.2744)	(0.2789)
Unemployment rate	0.0110*	0.0060	0.0093	0.0049	0.0092	0.0048
	(0.0061)	(0.0062)	(0.0063)	(0.0064)	(0.0063)	(0.0064)
Ratio of secondary industry	−0.0038	−0.0020	−0.0034	−0.0015	−0.0032	−0.0010
	(0.0030)	(0.0034)	(0.0031)	(0.0035)	(0.0031)	(0.0035)
Ratio of FDI	0.0066	0.0050	0.0088	0.0073	0.0101	0.0081
	(0.0090)	(0.0084)	(0.0093)	(0.0087)	(0.0095)	(0.0087)
Ratio of college students	0.0091	0.0326	0.0051	0.0277	0.0056	0.0304
	(0.0224)	(0.0226)	(0.0212)	(0.0221)	(0.0218)	(0.0227)
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	No	Yes	No	Yes	No	Yes
Observations	3,640	3,640	3,640	3,640	3,640	3,640
R-squared	0.0423	0.1270	0.0551	0.1457	0.0397	0.1597
Log-pseudolikelihood	−1,107.0436	−1,057.6004	−1,148.7238	−1,104.5034	−1,178.0524	−1,129.1433

Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.

EMPIRICAL RESULTS

Baseline Results

Table 4 presents the results for strategic interactions in environmental regulation among Chinese cities. Columns (1) and (2) are based on the spatial weight matrix *Wcont*. Columns (3) and (4) are based on the spatial weight matrix *Wdis2*, and columns (5) and (6) are based on the spatial weight matrix *Wpgdp*. With the three types of spatial weight matrices, the coefficients of $W \times ER$ are significantly positive at the 1% level, indicating the existence and mutual imitation of strategic interactions in environmental regulation among cities in China. Thus, the optimal strategy for local government officials is to reduce the intensity of environmental regulation when the competitors relax their own environmental regulation, which leads to a low-level equilibrium and loss of social welfare (Fredriksson et al., 2006; Sjöberg, 2016). This result validates Hypothesis 1a and is consistent with the results of previous studies (Renard and Xiong, 2012; Chen et al., 2019; Song et al., 2020a, 2021; Ge et al., 2020).

The coefficients of $W \times ER$ in *Wpgdp* models are higher than that in the other models, which demonstrate that a similar economic development level is the main factor affecting the strategic competition in environmental regulation of local governments. This may be because the promotion system of Chinese local officials is mainly based on relative economic performance assessment. The more similar the economic development of the cities, the more likely that local officials become competitors. To get promoted, local officials struggle to improve performance by treating environmental regulation as a viable tool to attract flow resources and expect increased economic growth, which is the main factor in performance assessment. In the dynamic game process, officials tend to adopt the random choice tactic of following competitors and formulate a rolling revision plan. Once the opponent acts, local officials respond and undertake similar actions. This is revealed as a strategic imitation in environmental regulation among local governments.

Regarding the control variables, the coefficient of *GDP per capita* is significantly positive, indicating that the economic growth has led to an increase in the environmental regulation. The higher the economic development level, the higher the environmental demands of the public, which facilitates local governments to intensify the environmental regulation. The coefficients of the other control variables were insignificant.

Spatiotemporal Heterogeneity

Spatial Heterogeneity

Considering the regional differences in resource endowment, geographical location, technical progress, and political and economic system, we further explore the spatial heterogeneity of strategic interactions in environmental regulation. Based on the traditional geographical position, we categorize the sample cities into three subsamples, including eastern, central and western cities. As seen in **Table 5**, the coefficients of $W \times ER$ are positive in the subsamples of the eastern and western cities, and most of them are significant at the 1% level, while the corresponding coefficients in the subsamples of the central cities are not significant. This reveals that imitative strategic interactions in environmental regulation occur in the eastern and western cities, but not in central cities. This is because the eastern cities with good endowments, notable location

TABLE 5 | Estimates for different regions.

	Eastern city			Central city			Western city		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Wcont	***Wdist2***	***Wpgdp***	***Wcont***	***Wdist2***	***Wpgdp***	***Wcont***	***Wdist2***	***Wpgdp***
W×ER	0.1326***	0.2279***	0.1832	0.1115	−0.0182	−0.0570	0.4404***	0.3533***	0.5246***
	(0.0492)	(0.0840)	(0.1371)	(0.0754)	(0.0489)	(0.1295)	(0.0583)	(0.0770)	(0.0961)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,358	1,358	1,358	1,386	1,386	1,386	896	896	896
R-squared	0.1972	0.1819	0.2039	0.0555	0.0543	0.0543	0.0174	0.0279	0.0250
Log-pseudolikelihood	−204.9964	−197.8759	−208.1999	−279.4795	−281.4136	−281.3656	−404.2088	−431.1802	−438.9742

*Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.*

advantages, and high-level of economic development provide higher probability of promotion for local officials and higher incentive for economic development. The imitative strategic interactions in environmental regulation is one of the dominant strategies for local officials in eastern cities. In contrast, the location disadvantages and lagged economy in western cities compel local officials to increase economic development by decreasing environmental regulation and attracting industrial transfer. Therefore, a spatial heterogeneity of strategic interactions in environmental regulation occur within the eastern, central, and western regions.

Temporal Heterogeneity

Changes in the performance assessment system can alter the behavior of local officials. After 2010, the central government gradually weakened the role of the GDP in the performance appraisal and enhanced the weight of environmental performance. A series of endeavor and policies have been exerted to reinforce the diversification and greening of official performance assessment. Thus, the sample is divided into two phases, 2003–2010 and 2011–2016 subsamples, to examine the temporal heterogeneity of strategic interactions in environmental regulation with the induction of environment protection into the official performance assessment system. The corresponding results are presented in **Table 6**.

As provided in **Table 6**, in the two periods' regressions, the coefficients of $W \times ER$ decrease from 0.2581, 0.3754, and 0.6263 to 0.1728, 0.0749, and 0.2025, respectively. The coefficients are all significant at the 1% level in the 2003–2010 subsample, whereas the coefficients of *Wdist2* and *Wpgdp* models in the 2011–2016 subsample are insignificant. Thus, imitative strategic interactions became significantly weaker after 2010. With the endeavor of the central government, the inclusion of diversified and green official performance assessment has gradually changed the behavior of local governments and considerably impeded their imitative interactions in environmental regulation. Since 2010, China has implemented stringent environmental regulation through various policies and endeavors. For example, lifelong investigation system for ecological environmental damage in 2015 and the red line of ecological protection, upper limit of pollutant discharge, and bottom line of environmental access in 2016. It means the start of the era with the most stringent environmental protection system (Wang and Lei, 2021). Correspondingly, the environmental performance of the local officials constitutes a hard-adjustment of promotion (Wu and Cao, 2021). The highlighting role of continuously environmental performance in assessment system stimulates local governments to adjust their strategic interactions in environmental regulation. Therefore, these govern the scientific choices of local officials and weaken the strategic interactions in environmental regulation, thereby verifying Hypothesis 1b.

Robustness Tests

Alternative Estimation Methods

To test the robustness of the previous results, we refer to the existing studies (Caldeira, 2012; Yu et al., 2016; Chen et al., 2017; Galinato and Chouinard, 2018; Gallo and Ndiaye, 2021) and employ the spatial Durbin model (SDM) and the dynamic spatial panel model (DSPM). The SDM includes the spatial lag terms of explanatory variables that can alleviate omitted variable bias to some extent. The DSPM includes the lag term of the interpreted variable as an explanatory variable and thus can depict the temporal dependence of environmental regulation and alleviate endogeneity bias caused by endogenous control variables and simultaneous dependent variables. The results are presented in **Table 7**. The coefficients of $W \times ER$ are significantly positive at the 1% level, which is consistent with the previous results. In addition, the coefficients of *ER(t−1)* are significantly positive, indicating that the intensity of environmental regulation has a notable continuity and viscosity. Thus, the improvement of environmental regulation in one year leads to further enhancement in the next year, creating a benign self-enhancing process.

Alternative Spatial Weight Matrices

To avoid the interference of priori spatial weight matrices, we refer to the previous studies (Feng and Wang, 2019; Yuan et al., 2019, 2020; Song et al., 2020a) and conduct four other types of spatial weight matrices. The first one is an ordinary geographical distance-type spatial weight matrix *Wdist1*, with $W_{ij} = 1/d_{ij}$, where d_{ij} is the spherical distance between cities. The other three are the economic distance-type spatial weight matrices *Windu*, *Wpd*, and *Wfd*, with $W_{ij} = [1/|econ_i - econ_j| + 1] \times exp(-d_{ij})$. Here, $econ_i$ represents the average industrial structure, population density, and financial self-sufficiency rate of city i in the sample

TABLE 6 | Estimates for different periods.

	2003–2010			2011–2016		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wcont	*Wdist2*	*Wpgdp*	*Wcont*	*Wdist2*	*Wpgdp*
W×ER	0.2581***	0.3754***	0.6263***	0.1728***	0.0749	0.2025
	(0.0619)	(0.0832)	(0.0916)	(0.0456)	(0.0570)	(0.1605)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2080	2080	2080	1,560	1,560	1,560
R-squared	0.1546	0.1684	0.1828	0.1700	0.1630	0.1706
Log-pseudolikelihood	181.9364	187.8537	166.8739	-99.9738	–106.4701	–106.7165

Standard errors, clustered at the city level, are provided in the parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

TABLE 7 | Estimates for the spatial Durbin model (SDM) and the dynamic spatial panel data models (DSPM).

	Wcont		Wdist2		Wpgdp	
	(1)	(2)	(3)	(4)	(5)	(6)
	SDM	DSPM	SDM	DSPM	SDM	DSPM
W×ER	0.3540***	0.1888***	0.2875***	0.1410***	0.4582***	0.4366***
	(0.0410)	(0.0389)	(0.0642)	(0.0375)	(0.0962)	(0.0857)
ER(t-1)		0.6619***		0.6766***		0.6830***
		(0.0483)		(0.0489)		(0.0493)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
W×Control variables	Yes		Yes		Yes	
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,640	3,380	3,640	3,380	3,640	3,380
R-squared	0.1061	0.3740	0.1104	0.3693	0.1016	0.3666
Log-pseudolikelihood	–372.2617	–339.0724	–339.0724	–362.5588	–362.5588	–372.2617

Standard errors, clustered at the city level, are provided in the parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

period, respectively. The industrial structure and population density are described in *Time-Variant Prefectural Characteristics*. The financial self-sufficiency rate is the ratio of the fiscal revenue to fiscal expenditure. The corresponding results of the regressions are listed in **Table 8**. The coefficients of $W \times ER$ are significantly positive at the 1% level, which verify the existence of significant imitative interactions in environmental regulation. Therefore, the results of this study are not affected by the spatial weight matrix.

Alternative Environmental Regulation Measure

To reduce the impact of environmental regulation measurement on the empirical results, we use the industrial SO_2 removal rate as the proxy of environmental regulation (ER_2), as shown in **Table 9**. The coefficients of $W \times ER_2$ are significantly positive at the 1% level, verifying that strategic interactions in environmental regulation evidently exist among local governments.

Further Discussion: Sources of Strategic Interaction

Role of Fiscal Decentralization

To examine the effect of fiscal decentralization on the strategic interactions in environmental regulation, we follow previous studies (Renard and Xiong, 2012; Shi and Xi, 2018) and incorporate the interaction between *fiscal decentralization* and $W \times ER$ into the baseline model. As illustrated in **Table 10**, the coefficients for the interaction item *(W × ER)×Fiscal decentralization* are significantly positive, suggesting that fiscal decentralization strengthens the strategic interactions in environmental regulation among cities. This confirms Hypothesis 2 and echoes the findings of Fredriksson et al. (2006), Farzanegan and Mennel (2012), and Sigman (2014). Thus, fiscal decentralization leads to financial incentives for local officials to independently implement the suitable environmental regulation to attract flow resources, and ultimately strengthen the strategic interactions in environmental regulation. As emphasized by Van der Kamp et al. (2017), a disadvantage of decentralization is that it enables local authorities to decrease or restrict the implementation of central government policies. Furthermore, the coefficients of fiscal decentralization are significantly negative, indicating that fiscal decentralization exacerbate local government competition and further reduce the intensity of environmental regulation.

Role of the Municipal Party Secretary

Effect of Secretary Turnover

To detect the effect of secretary turnover on the strategic interactions in environmental regulation, we incorporate *Secretary Turnover* and the interaction with $W \times ER$ into the

TABLE 8 | Estimates for other spatial weight matrices.

	(1)	(2)	(3)	(4)
	Wdist1	*Windu*	*Wpd*	*Wfd*
W×ER	0.6946***	0.6978***	0.6758***	0.6758***
	(0.0667)	(0.0645)	(0.0822)	(0.0693)
Control variables	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	3,640	3,640	3,640	3,640
R-squared	0.1389	0.1401	0.1430	0.1445
Log-pseudolikelihood	−1,118.0262	−1,117.5953	−1,117.5667	−1,119.9933

*Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.*

TABLE 9 | Estimates for the SO_2 removal rate.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Wcont	*Wdist1*	*Wdist2*	*Wpgdp*	*Windu*	*Wpd*	*Wfd*
$W\times ER_2$	0.2636***	0.6729***	0.3101***	0.6129***	0.6665***	0.5314***	0.6586***
	(0.0406)	(0.0602)	(0.0448)	(0.0629)	(0.0602)	(0.0840)	(0.0604)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,640	3,640	3,640	3,640	3,640	3,640	3,640
R-squared	0.2896	0.2923	0.2902	0.2664	0.2828	0.2829	0.2878
Log-pseudolikelihood	1,676.3133	1,660.2741	1,671.7182	1,657.3278	1,659.4817	1,646.4057	1,658.8339

*Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.*

TABLE 10 | Estimates for fiscal decentralization and strategic interactions in environmental regulation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Wcont	*Wdist1*	*Wdist2*	*Wpgdp*	*Windu*	*Wpd*	*Wfd*
W×ER	0.1183**	0.5057***	0.1958***	0.3558***	0.5004***	0.5031***	0.4510***
	(0.0564)	(0.0812)	(0.0550)	(0.0977)	(0.0832)	(0.0938)	(0.0845)
(W×ER)×Fiscal decentralization	1.0006***	1.9340***	0.6378**	1.6494***	2.0341***	1.6092**	2.0057***
	(0.2479)	(0.7393)	(0.2887)	(0.6235)	(0.7310)	(0.7272)	(0.7016)
Fiscal decentralization	−0.7783	−1.3035**	−0.8927	−1.6609**	−1.3006**	−1.3241**	−1.4850**
	(0.5880)	(0.6243)	(0.5787)	(0.6592)	(0.6199)	(0.6628)	(0.6450)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,640	3,640	3,640	3,640	3,640	3,640	3,640
R-squared	0.2417	0.1582	0.1721	0.1640	0.1602	0.1542	0.1617
Log-pseudolikelihood	−1,025.2198	−1,107.0735	−1,096.8729	−1,120.4695	−1,105.6226	−1,109.5231	−1,108.2136

*Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.*

baseline model. The corresponding results are reported in **Table 11**. Most coefficients of the interaction item *(W×ER)×Secretary Turnover* are significantly positive, indicating that secretary turnover intensifies strategic interactions in environmental regulation among cities and verifying Hypothesis 3. That is to say, the newly appointed secretary is more motivated to win the assessment of performance and the further promotion by loosening environmental regulation and attracting capital for gaining quickly local economic growth. The motivation intensifies the strategic interactions in environmental regulation among cities.

Influence of a Young Secretary

To explore the influence of a young secretary, we divide the secretaries into two groups using a critical value of 50 years. A dummy variable *Young secretary* is set as *Young secretary* equals 1 if the city secretary is younger than 50 years, and 0 otherwise. Similarly, we incorporate *Young Secretary* and the interaction with $W \times ER$ into the baseline model. As reported in **Table 12**, most coefficients of *(W × ER)×Young secretary* are significantly positive, implying that a young secretary intensifies the interregional environmental interactions and verifying Hypothesis 4. It may attribute to China's cadre management

TABLE 11 | Estimates for secretary turnover and strategic interactions in environmental regulation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Wcont	*Wdist1*	*Wdist2*	*Wpgdp*	*Windu*	*Wpd*	*Wfd*
W×ER	0.3362***	0.6850***	0.3181***	0.5769***	0.6879***	0.6648***	0.6682***
	(0.0464)	(0.0669)	(0.0559)	(0.0831)	(0.0646)	(0.0816)	(0.0691)
(W×ER)×Secretary Turnover	0.0757**	0.2078*	0.0601	0.0772	0.2130*	0.1559*	0.1608*
	(0.0350)	(0.1090)	(0.0399)	(0.0529)	(0.1103)	(0.0888)	(0.0962)
Secretary Turnover	−0.0307*	−0.0760**	−0.0282	−0.0497	−0.0731**	−0.0813*	−0.0736*
	(0.0172)	(0.0380)	(0.0180)	(0.0318)	(0.0360)	(0.0438)	(0.0415)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,640	3,640	3,640	3,640	3,640	3,640	3,640
R-squared	0.1340	0.1411	0.1483	0.1610	0.1423	0.1449	0.1464
Log-pseudolikelihood	−1,053.8698	−1,116.4128	−1,103.3468	−1,128.4459	−1,115.8879	−1,116.2534	−1,118.8344

*Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.*

TABLE 12 | Estimates for a young secretary and strategic interactions in environmental regulation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Wcont	*Wdist1*	*Wdist2*	*Wpgdp*	*Windu*	*Wpd*	*Wfd*
W×ER	0.3196***	0.6737***	0.2938***	0.5712***	0.6747***	0.6467***	0.6557***
	(0.0464)	(0.0687)	(0.0541)	(0.0842)	(0.0667)	(0.0836)	(0.0718)
(W×ER)×Young secretary	0.1462**	0.3818*	0.1892**	0.1524	0.4024**	0.3238*	0.3791**
	(0.0641)	(0.2026)	(0.0749)	(0.1083)	(0.2044)	(0.1688)	(0.1912)
Young secretary	−0.0290	−0.1048	−0.0420	−0.0629	−0.1030	−0.1323	−0.1347*
	(0.0304)	(0.0695)	(0.0322)	(0.0621)	(0.0661)	(0.0819)	(0.0798)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,640	3,640	3,640	3,640	3,640	3,640	3,640
R-squared	0.1409	0.1417	0.1524	0.1614	0.1429	0.1463	0.1473
Log-pseudolikelihood	−1,045.8731	−1,112.2703	−1,094.5854	−1,126.0687	−1,111.2520	−1,111.3425	−1,113.7326

*Standard errors, clustered at the city level, are provided in the parenthesis. ***p < 0.01, **p < 0.05, *p < 0.1.*

system, which imposes specific restrictions on the promotion and age of local senior officials as well as on their tenure. Political promotion is more difficult for older local officials once they pass a certain age threshold than for younger local officials. Consequently, younger officials have stronger incentives for promotion to intensify strategic interactions in environmental regulation.

CONCLUSIONS AND POLICY IMPLICATIONS

This study primarily aims to investigate strategic interactions in environmental regulation among cities and their influencing factors in China. We adopt spatial panel data models with a panel dataset of 260 Chinese cities during 2003–2016, and obtain the following conclusions:

1) Significant imitative interactions exist in environmental regulation, which imply that competitors imitate each other's environmental regulation, resulting in a low-level equilibrium called "race to the bottom". 2) A temporal heterogeneity exists which shows that strategic interactions in environmental regulation is present in eastern and western cities, but absent in central cities. 3) After 2010, the imitative interactions in environmental regulation significantly decreased, indicating that the greening of the performance appraisal reduces strategic interactions of local governments. 4) Fiscal decentralization enhances promotion incentives for local officials and strengthens strategic interactions in environmental regulation. 5) The turnover of the municipal party secretary or a younger one intensifies strategic interactions in environmental regulation among cities.

Based on these conclusions, the following policy implications are proposed. First, environmental friendly regulation competition should be promoted and centrally controlled environmental governance enhanced. Regarding the "low-level equilibrium" of China's regional environmental regulation, on one hand, it is imperative to impel virtuous competition in environmental regulation and reverse the "pollution effect" to a "ratcheting effect" to obtain a "high-level equilibrium" of regional environmental regulation. Further, the behaviors of provincial governments must be altered, and local governments should participate in environmental protection over only focusing on economic growth. On the other hand, the centralization of China's environmental management should be strengthened to balance the financial and administrative rights by improving the vertical management system for environmental policy enforcement at or below the provincial level, compressing regional administrative discretionary power, and expanding the scope of central government investments on environmental protection.

Second, the frequent turnover of regional officials should be avoided to ensure the continuity of environmental policy implementation. Frequent changes in local leadership can promote local officials to prioritize economic growth over environmental protection for rapid success. The intensity of environmental regulation is weakened due to discontinuity, instability, and deviant implementation. Therefore, environmental policies should be executed in the context of a stable tenure for officials and frequent turnovers of local governors should be avoided, thereby ensuring the institutional, legal, and systematic allotment of leading posts.

Third, the current governor motivation system must be urgently optimized, and the ambitions of young officials regarding promotion be guided scientifically. A reasonable and green political assessment system can alleviate strategic interactions. Hence, the financial effect should be decreased, and the weight of the environment protection should be increased to establish a multi-evaluation system. The optimization of the political incentive system can lead to an equilibrium between environmental protection and economic development and promote the intention of local governments to protect environment. The environment must not be sacrificed for an improved GDP or personal benefit, which also ensures a planned sustainable development at present for increased benefits in the future.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

Conceptualization XZ; Data curation HZ; Formal analysis XZ; Funding acquisition XZ, HZ, TX; Investigation XZ; Methodology HZ; Project administration XZ; Resources HZ; Software HZ; Supervision XZ, YZ; Validation TX; Visualization; Writing—original draft XZ; writing—review and editing TX.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2022.823838/full#supplementary-material

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