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Fiscal Decentralization, Government Behavior, and Environmental Pollution: Evidence From China

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Environmental protection is a basic public service that the government must guarantee and is closely related to public health. An important driver of environmental pollution in China is the local government's pursuit of a rapid economic development while ignoring environmental protection under the Chinese-style fiscal decentralization system. On the basis of the principal–agent theory between the central and local governments, this study analyzes the environmental deterioration caused by the distortion of local government behavior under fiscal decentralization. In addition, using China's prefecture-level city data from 2014 to 2018, this study empirically estimates the impact of fiscal decentralization on environmental pollution. SO_2 emissions and $PM_{2.5}$ concentrations are used to measure the degree of environmental pollution. Results show that Chinese-style fiscal decentralization exacerbates environmental pollution and that the impact of fiscal decentralization on environmental pollution differs in regions with varying levels of economic development and cultural penetration. Moreover, fiscal decentralization does not significantly impact environmental pollution in eastern China and in those areas influenced by Confucian culture yet aggravates the environmental pollution in central and western China and in those areas that are not affected by Confucian culture. These results offer important policy implications. Clearly dividing the power and financial power between the central and local governments, establishing an environmental governance system compatible with economic incentives, and building an environmental public finance system can alleviate the impact of Chinese-style fiscal decentralization on environmental pollution.

Keywords: fiscal decentralization, environmental pollution, government behavior, public health, confucian culture, China

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1 INTRODUCTION

The quality of the environment is an important factor affecting public health (Yang and Liu, 2018; Tainio et al., 2021). Severe environmental pollution will greatly increase the probability of residents suffering from respiratory diseases, cardiovascular diseases, and cancer (Newby et al., 2015; Brook et al., 2017). The World Health Organization (WHO) has estimated that 12.6 million deaths are attributable to environmental pollution each year (World Health Organization, 2016). Therefore, reducing environmental pollution has become an important public affair of the government. As the largest developing country, China's environmental pollution problem is serious, which poses a

serious health threat to residents (Chen and Chang, 2020). To reduce environmental pollution, China has attached great importance to environmental governance in recent years. China's commitment at the 26th UN Climate Change Conference (COP 26) demonstrates the Chinese government's determination to reduce environmental pollution. The reduction of environmental pollution in China is of great significance to improve the environmental quality of China and the world.

Although China's economy has developed rapidly since the reform and opening up, it has brought serious environmental pollution. One cause of environmental pollution in China is the extensive economic development model formed by pursuing rapid economic development (Zhao et al., 2021). The essential driving force of development model in China is the behavior of local governments under fiscal decentralization (hereinafter referred to as FD) (Oi, 1992; Khan et al., 2021). Although FD has played a positive role in the rapid and sustained growth of China's economy in a particular historical period, it has distorted incentives for local governments, which in turn aggravates regional environmental pollution. Therefore, this study theoretically and empirically analyzes the impact of FD on environmental pollution in China from the perspective of local government behavior, and further compares the differences of the impact in different economic development and cultural regions.

Competition among local governments will distort public policies because of FD, which is not conducive to environmental pollution (Holmstrom and Milgrom, 1991; Silva and Caplan, 1997). Specifically, in developing the local economy, the local government attracts investment from high-polluting enterprises to accelerate economic development, thus neglecting environmental protection to develop the economy (Dean et al., 2005). Furthermore, the decentralized competition among local governments will lead to an insufficient supply of public goods and services in the region. Given the regional competition, the local government's standards for environmental protection will be lowered, which may increase environmental pollution (He, 2015). Unlike the official election system in some western countries, officials at all levels in China are appointed by higher-level officials (Blanchard and Shleifer, 2001; Yang et al., 2021). The main factor for higher-level officials to evaluate lower-level officials is regional economic growth, which motivates local officials to focus on local economic development and ignore environmental governance (Cheng et al., 2020).

As an institutional arrangement of public governance, FD has difficulty playing its role alone but needs to affect environmental pollution through each subject's behavior under the system. Thus, based on principal-agent theory, this study analyzes the impact of FD on the environmental pollution from the assumptions of "political man" and "rational economic man", the dual incentives of economy and politics, and the restraint mechanism of local governments. Meanwhile, we construct a principal-agent model between the central government and local governments under multi-tasking. Furthermore, based on the panel data of prefecture-level cities in China from 2013 to 2018, this study empirically examines the impact of FD on environmental pollution.

Unlike some studies that only use a single indicator to measure the degree of environmental pollution, we use two indicators (SO_2 emissions and $PM_{2.5}$ concentrations) to measure China's environmental pollution more comprehensively. Empirical results show that the Chinese-style FD system exacerbates environmental pollution. In addition, we divide FD into fiscal expenditure decentralization and fiscal revenue decentralization, and estimate the impact of different types of decentralization on environmental pollution. To address the endogeneity problem in empirical analysis, we construct instrumental variables and employ a two-stage least squares method. Robustness and endogeneity tests support our results.

Although existing studies have empirically tested the relationship between FD and environmental pollution, they have not reached consistent conclusions. Some studies have suggested that FD can exacerbate environmental pollution (Fell and Kaffine, 2014; Song et al., 2018), while others have held the opposite view (Ji et al., 2021; Tufail et al., 2021). The differences in research conclusions may be related to the institutional environment in different countries. China's fiscal decentralization is different from many western countries. Explaining why the impact of FD on environmental pollution in China differs from that in western countries enriches the existing literature. Based on China's unique institutional environment, this study examines the impact of Chinese-style FD on environmental pollution, and finds that Chinese-style FD aggravates environmental pollution, which provides empirical evidence for the relationship between FD and environmental pollution in developing countries.

This study also contributes to the heterogeneity research of FD and environmental pollution. We analyze the impact of Chinese-style FD on environmental pollution in regions with different levels of economic development. Meanwhile, this study analyzes the differences in the impact of FD on environmental pollution in regions affected by and not affected by Confucian culture, which is rarely analyzed in the existing literature. As the most profound culture affecting Chinese society, Confucian culture has had an important influence on the behavior of local officials. Based on the data collected manually on Confucian temples in prefecture-level cities in China, we examine the impact of Confucianism, the most deeply influential culture in China, on the relationship between FD and environmental pollution, which enriches the existing literature. Results show that the Chinese-style FD does not significantly affect environmental pollution in eastern China and areas influenced by Confucian culture but aggravated environmental pollution in central and western areas and areas not affected by Confucian culture.

In addition, this study enriches the literature on environmental pollution and public health. We establish a multi-task principal-agent framework and link the institutional arrangement of FD with environmental pollution through local government behavior, which analyzes the factors that lead to environmental pollution from an institutional perspective. Meanwhile, we examine the relationship between FD and environmental pollution in different economic and cultural contexts in China, the largest developing country. This study also contributes to the literature on FD. Existing studies on FD

mainly focus on its impact on economic and social development. There is a paucity of research on the effect of FD on environmental pollution, especially in developing countries. In addition, this study analyzes not only the decentralization of fiscal expenditure but also the decentralization of fiscal revenue, which is different from the existing literature which only analyzes one form of FD. In addition, this study enriches the existing literature by analyzing the differences in the impact of FD on environmental pollution in regions with different economic and cultural backgrounds.

The rest of the paper is organized as follows. **Section 2** is the literature review and hypothesis. **Section 3** is the theoretical analysis. **Section 4** constructs a principal-agent model. **Sections 5**, **6** introduce the research design. **Section 7** analyses the results. **Section 8** shows conclusions and implications.

2 LITERATURE REVIEW AND HYPOTHESIS

The proposal of "voting by foot" theory marks the rise of FD theory (Tiebout, 1956), which, together with optimal decentralization theory (Stigler, 1957), preference misunderstanding decentralization theory (Tresch, 1981) and Oates decentralization theory (Oates, 1972), constitute the first-generation FD theory. This theory posits that if local governments have more rights to allocate resources, then the preferences of residents or taxpayers can be well reflected in the competition among local governments. On the basis of their investigation on first-generation FD theory, some scholars introduced incentive compatibility and mechanism design, which constitutes the basis of second-generation FD theory (Seabright, 1996; Qian and Weingast, 1997; Wildasin, 1999).

Environmental federalism refers to the study of FD and environmental pollution. Research on the relationship between the two is mainly divided into two perspectives. The first perspective, "race to the top," suggests that FD reduces environmental pollution. Meanwhile, the second perspective, "race to the bottom," holds the opposite view. Early advocates of environmental federalism believed that FD can reduce environmental pollution (Tiebout, 1956; Oates and Portney, 2003). This theory holds that due to the existence of "voting by foot," local governments will improve the quality of regional public service supply, in which improving the environmental quality plays an important role. Local governments under FD have more information advantages and can better understand the preferences of residents within their jurisdictions for public goods (Silvana, 2006; Mu, 2018). In addition, FD can optimize resource allocation by increasing the efficiency of public spending (Oates, 1972). Some empirical studies support this view. For instance, in the investigation of seven developed countries with high FD, Ji et al. (2021) revealed that FD improves the environment by reducing carbon dioxide emissions. Tufail et al. (2021) obtained similar conclusions by using a cross-sectional autoregressive distributed lag model.

However, some researchers argue that FD exacerbates environmental pollution. FD can lead to competition among local governments, which in turn distorts public policy or government decision making (Fell and Kaffine, 2014). If local governments cannot implement environmental policies through financial means, then the decentralized competition among them may lead to an insufficient supply of public goods in the region (Tiebout, 1956; Oates, 1972). Given this competition, the local government's standards for environmental protection will be lowered, which is not conducive to environmental protection (Khan et al., 2021). Glazer argued that due to the "loose soles" of enterprises or capital, local governments will use taxation or other financial means to preferentially introduce enterprise investments based on competition with other locations (Glazer, 1999). In addition, environmental pollution has spillover effects, and local governments may choose transboundary high pollution emission levels when they do not need to consider the welfare of adjacent areas (Silva and Caplan, 1997). The positive externality of environmental governance may lead to "free riders" by local governments, thereby reducing their incentives to govern the environment and consequently aggravating environmental pollution (The Phan et al., 2021).

Although some studies have analyzed the relationship between FD and environmental governance, they have not obtained consistent conclusions. The impact of FD on environmental pollution in a country is closely related to its institutional conditions. The classical theory of FD assumes that residents can move freely between jurisdictions, that is, they can achieve "voting by foot." However, China's household registration system hinders its residents from moving freely (Meng, 2019). Furthermore, unlike many western countries, local officials in China are not selected but are rather appointed by high-level officials (He, 2015). Therefore, Chinese-style FD differs from western FD. As the promotion of local officials in China is associated with economic growth (Li and Zhou, 2005), local officials are distorted and compete for personal gains. To accelerate local economic development, local officials have exacerbated environmental pollution by attracting investments from high-polluting companies (Köllner et al., 2002; Chang et al., 2021). Therefore, the competition among local governments will distort public policies or government decisions due to FD, which is not conducive to regional environmental governance (Du and Sun, 2021). In addition, to promote economic growth, Chinese officials often invest more financial funds in areas that can promote economic development, such as infrastructure construction, while reducing their investment in environmental governance, which in turn increases the environmental pollution levels (Chen et al., 2018). On the basis of the above analysis, we hypothesize:

Hypothesis. *Chinese-style FD exacerbates environmental pollution.*

3 THEORETICAL MECHANISM

China's FD system gives local governments autonomy by the central government to manage affairs within their jurisdictions (Qian and Roland, 1998; Wang et al., 2021). Given the complex

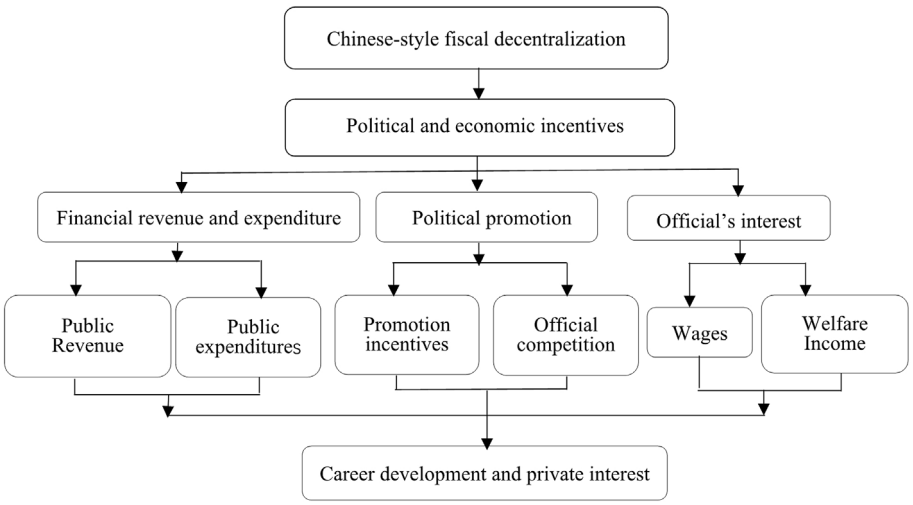

FIGURE 1 | Dual incentives of local governments.

policy objectives, high information asymmetry, and high transaction costs, the central government often authorizes lower-level governments to be responsible for various affairs in the jurisdiction to achieve economic goals and assume responsibility for the supply of basic public goods. It constitutes a principal-agent relationship. The principal is the central government and the agent is local governments. In addition, the incentive mechanism is the political promotion and reward of local officials and the restraint mechanism is the discipline of the high-level government and the budget constraint of the local government (Wong, 1991). In such a special principal-agent relationship, the inconsistency of the goals of the central and local governments and the financial and disciplinary constraints of the local governments have changed the behavior and expenditure structure of the local governments for environmental governance. Under the principal-agent framework, we analyze the impact of FD on environmental pollution from three aspects.

One is the assumption of the agent's "political man" and "rational economic man." As the main implementers of various policies, local governments accomplish specific goals, such as economics, politics, and public services under the supervision and management of the central government (Zhang et al., 2018). Thus, local governments can perform their functions as "political men." Local officials have the motivation to pursue their political future and official reputation and expand the scale of local government agencies to maximize their interests (Pu and Fu, 2018). Furthermore, when local officials perform various affairs arranged by the central government as "political men," they also act as "rational economic men" to choose among different goals, such as politics, economics, and environmental governance, to maximize their interests. Local officials use limited resources to promote economic growth in the areas they manage and continuously improve the welfare of residents in their jurisdictions by providing public services, including environmental governance. However, local governments' decision-making mainly depends on how to maximize the interests of government departments and officials (You et al., 2019). That is, local governments may make decisions that deviate from public interests out of the assumption of "economic man," resulting in biased behavior and reduced emphasis on environmental governance.

The second is the agent's dual incentive mechanism (As shown in **Figure 1**). Local officials have the dual incentives of politics and economy because of China's unique "economic decentralization and political centralization" system. In terms of political incentives, the central government often regards the level of economic growth as the primary indicator for assessing local officials (Chen et al., 2018). In 2014, the central government pointed out the necessity to assess the qualifications of local officials comprehensively to prevent local governments from excessively pursuing GDP growth and incorporate environmental protection into the assessment of local officials. However, in practice, local governments often have more information advantages than the central government to pursue the maximization of interests, resulting in local governments distorting these assessment indicators to pursue GDP growth (Li et al., 2018; Zhang et al., 2019). Thus, to seek political promotion, local officials have shifted their focus more to economic construction that can promote the rapid growth of local GDP. Furthermore, motivated by political promotion, local officials may reduce the control of environmental pollution standards and lower the access standards of certain enterprises in environmental assessment to attract investment from polluting enterprises and achieve the purpose of promoting local economic development (Dean et al., 2005). Officials' private interests are closely linked to the economic development of the regions they administer in China (Millimet, 2003). Therefore, local governments pay more attention to the region's economic development and ignore environmental governance (Que et al., 2018; Wen and Lee, 2020). Economic incentives are mainly reflected in the desire of local governments to obtain more fiscal revenue. Under

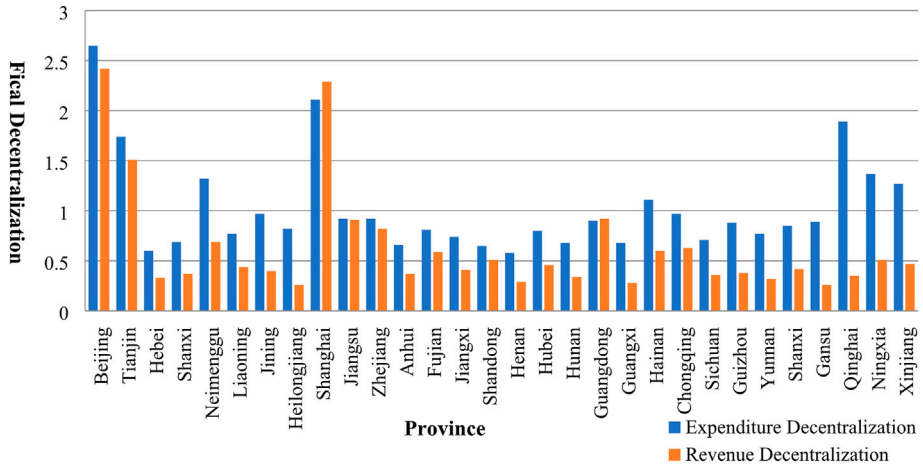

FIGURE 2 | The decentralization degree of expenditures and revenue in each province.

China's unique tax-sharing system, local governments must hand over part of their tax revenue to the central government (He, 2015). The retained tax revenue can still allow local governments to benefit from the economic development of their regions, which leads to regional competition among local governments to increase tax income.

The third is the constraint mechanism of agents in environmental governance. Under China's FD system, local governments are only responsible to the higher-level government but do not need to be responsible to the lower-level government (Qian and Roland, 1998). Thus, to promote local economic development, they tend to invest resources in activities that bring development to the local economy rather than public affairs, such as environmental protection (Wen and Lee, 2020). Furthermore, local governments in China need to undertake many affairs while the fiscal revenue is insufficient, resulting in a serious shortage of fiscal capacity. According to **Figure 2**, except for Shanghai and Guangdong Province, the decentralization of expenditures in other regions is greater than the decentralization of revenue. Therefore, Chinese-style FD has led to insufficient financial resources for local governments. At the same time, given the strong cross-regional nature of environmental pollution, relying on only one regional government to governance environment pollution is complicated (Zhang et al., 2020). However, multi-regional governments have difficulty cooperating in environmental governance in China (Cheng et al., 2021). Thus, the serious shortage of financial funds in environmental protection and the inherent spillover of environmental pollution have made it difficult for local governments to manage the environment.

4 PRINCIPAL-AGENT MODEL UNDER MULTI-TASKING

Following Zheng (2012), we construct a principal-agent model to analyze the impact of Chinese-style FD on environmental pollution. In the principal-agent model, the central government is the principal and the local government is the agent. We use this model to analyze the distortion of local government behavior under economic incentives. We assume that the central government entrusts only two tasks of economic development and environmental governance to local governments. The proportion of local governments investing resources into economic development and environmental protection is X_1 and X_2. The effort of local governments in economic development and environmental governance is Z_1 and Z_2, and the cost of efforts are $C(Z_1, Z_2)$. The outputs of the two tasks, economic development, and environmental governance, are Y_1 and Y_2, respectively. Therefore, the benefits obtained by local governments can be expressed as a function of output:

$$R(Y) = X_1Y_1 + X_2Y_2$$

In addition, we assume that the local government's efforts on economic development and environmental governance are linearly related to the output. we can get:

$$Y_1 = Z_1 + \alpha_1$$
$$Y_2 = Z_2 + \alpha_2$$

α_1 and α_2 represent other factors that affect economic development and environmental protection, such as resource endowment, in addition to the efforts of local governments. Both linear functions follow a normal distribution with mean 0 and variance δ_1^2 and δ_2^2. Therefore, the utility function of the central government is:

$$U_C(Y) = Z_1 + Z_2 - X_IY_1 - X_2Y_2$$

We assume that the local government has a constant absolute risk aversion coefficient S, then the utility function of the local government is:

$$U_L(Y) = X_1Y_1 + X_2Y_2 - \frac{1}{2}SX_1^2\delta_1^2 - \frac{1}{2}SX_2^2\delta_2^2 - C(Z_1, Z_2)$$

As rational "economic man", local governments maximize their utility. We take the partial derivatives of the efforts to

economic development and environmental governance in the local government's utility function:

$$\frac{\partial U_L(Y)}{\partial Z_1} = X_1 - \frac{\partial C(Z_1, Z_2)}{\partial Z_1}$$
$$\frac{\partial U_L(Y)}{\partial Z_2} = X_2 - \frac{\partial C(Z_1, Z_2)}{\partial Z_2}$$

Let a partial derivative equal to 0, then when the local government's utility is maximized, the resources allocated by the local government to economic development and environmental protection are:

$$X_1 = \frac{\partial C(Z_1, Z_2)}{\partial Z_1}$$
$$X_2 = \frac{\partial C(Z_1, Z_2)}{\partial Z_2}$$

Furthermore, we assume that the retained utility of the local government in the external market is Q. The utility of the central government is constrained by the retained utility of the local government in the external market:

$$X_1 Y_1 + X_2 Y_2 - \frac{1}{2} S X_1^2 \delta_1^2 - \frac{1}{2} S X_2^2 \delta_2^2 - C(Z_1, Z_2) \geq Q$$

The central government is also an economic man who maximizes its own utility. However, its utility is constrained by the allocation of local government resources. Therefore, to maximize the utility of the central government, it needs to satisfy:

$$\text{Max}\, Z_1 + Z_2 - \frac{1}{2} S X_1^2 \delta_1^2 - \frac{1}{2} S X_2^2 \delta_2^2 - C(Z_1, Z_2) \geq Q$$

Under the constraints, the partial derivatives of Z_1 and Z_2 can be obtained:

$$1 - X_1 - X_1 S \delta_1^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1^2} - X_2 S \delta_2^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1 Z_2} = 0$$
$$1 - X_2 - X_2 S \delta_2^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1^2} - X_1 S \delta_1^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1 Z_2} = 0$$

Then,

$$X_1 = \frac{1 - X_2 S \delta_2^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1 Z_2}}{1 + S \delta_1^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1^2}}$$
$$X_2 = \frac{1 - X_1 S \delta_1^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1 Z_2}}{1 + S \delta_2^2 \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_2^2}}$$

Here,

$$A = \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1^2} \; B = \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_2^2} \; \text{C} = \frac{\partial^2 C(Z_1, Z_2)}{\partial Z_1 Z_2} \; D = S \delta_1^2$$

Then,

$$X_1 = \frac{\frac{1}{S \delta_2^2 B} + 1 - \frac{C}{B}}{\frac{1}{S \delta_2^2 B} + \frac{\delta_1^2 A}{\delta_2^2 B} + 1 + D\left(A - \frac{C^2}{B}\right)}$$

As environmental protection is difficult to observe, $\delta_2^2 \to \infty$. Then,

$$X_1 = \frac{B - C}{B(1 + DA - DC^2)}$$

The two tasks of the local government to develop the economy and governance the environment are in conflict, resulting in C > 0, and the greater the conflict, the greater the C. However, both the numerator and denominator contain C. Therefore, the conflict between local governments in economic development and environmental governance determines the arrangement of resources for the two tasks.

5 RESEARCH DESIGN

5.1 Model

This study constructs the fixed effect model as follows:

$$polution_{it} = \beta_0 + \beta_1 Dec\_exp_{it} + \beta_2 lngdp_{it} + \beta_3 popu_{it} + \beta_4 rd_{it} + \beta_5 mkt_{it} + \beta_6 lnindus_{it} + \beta_7 lngreen_{it+}\alpha_i + \gamma_i + \varepsilon_{it} \quad (1)$$

where i represents the region, t represents the year, $pollution_{it}$ represents the level of environmental pollution, Dec_exp_{it} represents the degree of FD, α_i and γ_i are the regional fixed effects and time fixed effects. ε_{it} represents the random disturbance term.

6 DATA AND VARIABLES

All data are from the "China Statistical Yearbook," "China Environmental Statistical Yearbook," "China Fiscal Statistical Yearbook," and "China Science and Technology Statistical Yearbook" of the corresponding year. The sample includes 271 prefecture-level cities in China from 2014 to 2018. The total number of samples is 1149. The stata15 software was used for statistics and processing of data. The specific explanation of each variable is as follows:

6.1 Dependent Variable

The dependent variable is the level of environmental pollution. We employ the natural logarithm of SO_2 emissions and $PM_{2.5}$ concentration to measure the level of regional environmental pollution. China's energy reserves are dominated by coal, and burning coal produces a large amount of SO_2. SO_2 is an important source of environmental pollution in China (Greaney et al., 2017; Guo et al., 2020). Therefore, SO_2 emission is a key target for reducing environmental pollution in China, and it is one of the important air pollutants recorded in detail by the Chinese government (Zhang and Gong, 2005). In addition, in recent years, the haze weather in various regions of China has seriously threatened people's health, and the main reason for the haze is the high concentration of $PM_{2.5}$. $PM_{2.5}$ can float in the atmosphere for a long time and seriously affect the environment and public health (Zhang et al., 2017). Therefore, this study

TABLE 1 | Variable definitions.

Variables	Symbol	Definition
Environmental pollution	*pollution*	The natural logarithm of SO2 emissions and PM2.5 concentration are used to measure environmental pollution
Fiscal decentralization	*Dec_exp*	Fiscal expenditure decentralization. Dec_exp = per capita fiscal expenditure at the prefecture-level/(per capita fiscal expenditure at the prefecture-level + per capita fiscal expenditure at the provincial level + per capita fiscal expenditure at the central-level)
	Dec_inco	Fiscal income decentralization. *Dec_inco* = per capita fiscal revenue at the prefecture-level city/(per capita fiscal revenue at the prefecture-level + per capita fiscal revenue at the provincial-level + per capita fiscal revenue at the central-level)
Economic development	*lngdp*	GDP is used to measure economic development. GDP is adjusted based on 2014 CPI and taken the logarithm
Population density	*popu*	It is measured by dividing the total population by the total area of the region
Industrialization level	*lnindus*	It is measured by the logarithm of the number of industrial enterprises above designated size
Science and technology level	*rd*	It is measured by dividing the l science and technology expenditure by the total fiscal expenditure
Natural environment	*lngreen*	It is measured by the logarithm of the area of green space
Marketization level	*mkt*	It is measured by dividing the number of private and individual employees by the total number of employees

TABLE 2 | Descriptive statistics.

Variables	Obs	Mean	SD	Max	Min
Dec_exp	1149	0.502	0.319	0.999	0.127
$lnSO_2$	1149	10.187	0.999	12.553	5.660
lngdp	1149	15.136	2.391	19.231	5.221
popu	1149	3.333	6.363	62.120	0.055
rd	1149	0.016	0.016	0.207	0.001
mkt	1149	0.379	0.081	0.714	0.052
lnindus	1149	5.536	1.197	2.303	8.980
lngreen	1149	8.252	1.007	11.857	2.565

selects industrial SO_2 emissions and $PM_{2.5}$ concentrations to measure environmental pollution.

6.2 Core Independent Variable

The core independent variable is FD. We use the index of fiscal expenditure decentralization to measure: fiscal expenditure decentralization = per capita fiscal expenditure at the prefecture-level/(per capita fiscal expenditure at the prefecture-level + per capita fiscal expenditure at the provincial level + per capita fiscal expenditure at the central-level).

6.3 Control Variables

Economic development (lngdp): We adjust GDP based on 2014 CPI and take the logarithm. (Tainio et al., 2021). Population density (popu): It is measured by dividing the total population by the total area of the region. (Newby et al., 2015). Industrialization level (lnindus): It is measured by the logarithm of the number of industrial enterprises above designated size in the region. (Brook et al., 2017). Science and technology level (rd): It is measured by dividing the regional science and technology expenditure by the total regional fiscal expenditure. (World Health Organization, 2016). Natural environment (lngreen): It is measured by the logarithm of the area of green space in the region. (Chen and Chang, 2020). Marketization level (mkt): It is measured by dividing the number of private and individual employees by the total number of employees in the region. The variable definitions and descriptive statistics of each variable are shown in **Tables 1**, **2**, respectively.

TABLE 3 | Main results.

Independent variable	$lnSO_2$	$lnPM_{2.5}$
Dec_exp	1.456*** (0.497)	0.200* (0.111)
rd	2.329 (1.984)	1.241*** (0.454)
mkt	–0.077*** (0.028)	–0.016**(0.006)
lngdp	–1.776*** (0.137)	–0.480*** (0.031)
popu	0.023*(0.014)	0.010*** (0.003)
lnindus	0.841*** (0.117)	0.181*** (0.027)
lngreen	–0.717*** (0.107)	–0.117*** (0.024)
constant	37.617*** (1.720)	10.767*** (0.399)
Prefecture-level city FE	Yes	Yes
Year FE	Yes	Yes
R^2	0.3099	0.3473
Observations	1149	1149

, ** and * indicate the regression coefficient is significant at the statistical level of 10, 5 and 1%, respectively; the standard deviation is in parentheses.*

7 RESULTS

7.1 Main Results

The regression results in **Table 3** are obtained by estimating the model using the ordinary least squares method. **Table 3** shows that the degree of FD has a significant positive correlation with industrial SO_2 emissions and $PM_{2.5}$ concentration. Specifically, each unit of FD increases industrial SO_2 emissions and $PM_{2.5}$ concentrations by 1.46 and 0.20%, respectively. The result shows that Chinese-style FD exacerbates environmental pollution, which is consistent with the findings of Guo et al. (2020); Du and Sun (2021); Phan et al. (2021). However, this result is inconsistent with the traditional view of environmental federalism (Oates and Portney, 2003). This is because some of the assumptions of Western FD do not hold in China, resulting in a different impact of China's unique FD on environmental pollution than some Western countries. As mentioned above, local Chinese officials are constantly competing for economic growth for political advancement. Local governments may lower environmental access standards to attract more investors to promote local economic development and increase employment opportunities. At the same time, under the Chinese-style FD, local governments can use the fiscal autonomy they have obtained to invest funds and resources in

TABLE 4 | Robustness test.

Independent variable	$lnSO_2$	$lnPM_{2.5}$
Dec_ren	1.989*** (0.481)	0.223** (0.114)
Controls	Yes	Yes
Prefecture-level city FE	Yes	Yes
Year FE	Yes	Yes
R^2	0.3165	0.3478
Observations	1149	1149

same as ***Table 3****.*

areas that promote economic development. Furthermore, most local officials in China have a relatively short term of office, and the results of environmental governance are not easily reflected in a short period. Thus, local officials use the functions of FD to pursue short-term economic benefits excessively while ignoring basic public services, such as environmental governance.

In addition, the results in **Table 3** show that the degree of marketization, the economic development, and the area of regional green space are significantly negative at the statistical level of 1% with SO_2 emissions and $PM_{2.5}$ concentrations, which indicates that the increase of these three reduces environmental pollution. Although we mentioned earlier that local officials may neglect environmental protection to develop the economy, China has gradually shifted from an extensive economic development model to an intensive one in recent years, and regards the effect of environmental governance as an important factor in assessing local officials. This motivates local governments to attach importance to environmental protection while developing the economy. Therefore, the economic development reduces the environmental pollution. Meanwhile, the relative number of regional population and the degree of regional industrialization are significantly positive at the statistical level of at least 10%, indicating that the increase in population and the degree of industrialization aggravate environmental pollution.

7.2 Robustness Test

Two main methods are used for measuring FD. In addition to the expenditure method used in the above regression analysis, another method to measure the degree of FD is the income method. Thus, revenue decentralization is used in the robustness test to measure FD. The degree of decentralization is the degree of income decentralization (*Dec_inco*) = per capita fiscal revenue at the prefecture-level city/(per capita fiscal revenue at the prefecture-level + per capita fiscal revenue at the provincial-level + per capita fiscal revenue at the central-level). The empirical results in **Table 4** show that FD is significantly positively correlated with industrial SO_2 emissions and $PM_{2.5}$ concentration at the 1 and 5% statistical levels, respectively. That is, China's FD has exacerbated regional environmental pollution. This result is consistent with the previous analysis results, indicating that the analysis results in this study are robust.

7.3 Endogenous Analysis

To overcome the endogenous problem, we use the panel instrumental variable method to estimate. Specifically, we use the average value of the FD degree of other prefecture-level cities in the province where a prefecture-level city is located as the instrumental variable of the FD degree of this prefecture-level city. This instrumental variable satisfies the two assumptions of correlation and exogeneity. On the one hand, the degree of FD of a prefecture-level city within a province in China is affected by the province where it is located, and prefecture-level cities have regional competition within that province. Thus, the FD of a city is affected by the FD of other cities. On the other hand, the level of environmental pollution in a region is unaffected by the degree of financial decentralization of other prefecture-level cities. The reason is that the environmental pollution of a prefecture-level city is governed by the financial funds of the prefecture-level city and has nothing to do with those of other prefecture-level cities.

Table 5 shows the results of the panel instrumental variable method. From the regression results, the degree of FD is significantly positively correlated with industrial SO_2 emissions and $PM_{2.5}$ concentration. In addition, the F values of the weak instrumental variable test are all significantly larger than the critical value of 16.38 set by Stock and Yogo (2005), indicating no weak instrumental variable problem. Although the values of the regression coefficients have changed slightly, the signs and significance levels are the same as the previous ones, which further supports the conclusion of the main regression.

7.4 Heterogeneity Analysis

7.4.1 Regions With Different Levels of Economic Development

Different regions in China have gaps in economic development levels. We divide the sample into eastern, central, and western regions and conduct regression based on Model one to analyze the impact of FD on environmental pollution in different regions. The results in **Table 6** show that the degree of FD in the eastern region has no significant effect on industrial SO_2 emissions and $PM_{2.5}$ concentrations. However, the FD is significantly positively related with industrial SO_2 emissions at the 1% statistical level in the central region and the FD is significantly positively correlated with $PM_{2.5}$ concentration at the 1% statistical level in the western region, indicating that the FD in the central and western regions has worsened local environmental pollution. Specifically, each unit of FD in the central region increases industrial SO_2 emissions by 2.28%. For every percentage point increase in FD in the western region, $PM_{2.5}$ concentration increases by 0.75%.

The results of regional heterogeneity show that China's FD system has different incentives and constraints on government behavior in different regions. First, the economically developed eastern region has formulated stricter standards for the entry of enterprises with high pollution in attracting investment. Thus, the regional pollution level is less affected by FD. Second, although under China's FD system, the eastern part of China needs to hand over part of the local tax revenue to the central government. However, given the large tax revenue base and relatively strong financial resources in the eastern region, sufficient funds are available to invest in environmental governance. Third, the highly developed economic level of the eastern region has brought about a change in its economic growth model. The eastern region has changed from an extensive economic growth model with high

TABLE 5 | Endogenous analysis.

Independent variable	$lnSO_2$		$lnPM_{2.5}$	
	The first stage	The second stage	The first stage	The second stage
Dec_ren_IV	1.204*** (0.340)		0.178*** (0.054)	
Dec_ren		1.702*** (0.430)		0.216*** (0.071)
Controls	Yes	Yes	Yes	Yes
Prefecture-level city FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
F statistic		74.58		95.49
Observations	1149	1149	1149	1149

same as ***Table 3***.

TABLE 6 | Results of the eastern, central, and western regions.

Independent variable	$lnSO_2$			$lnPM_{2.5}$		
	East	Central	West	East	Central	West
Dec_exp	0.581 (0.637)	2.279*** (0.845)	0.622 (1.188)	0.115 (0.140)	0.055 (0.210)	0.746*** (0.235)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture-level city FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.4423	0.2969	0.2964	0.4472	0.2874	0.4683
Observations	426	413	310	426	413	310

same as ***Table 3***.

TABLE 7 | Results of the regions affected and not affected by Confucian culture.

	$lnSO_2$		$lnPM_{2.5}$	
	Influenced by confucian culture	Not influenced by confucian culture	Influenced by confucian culture	Influenced by confucian culture
Dec_exp	0.266 (0.767)	1.823*** (0.618)	0.163 (0.189)	2.708*** (0.603)
Controls	Yes	Yes	Yes	Yes
Prefecture-level city FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	0.4575	0.2970	0.4300	0.3087
Observations	265	884	265	884

same as ***Table 3***.

pollution to a clean and intensive economic model, thus effectively alleviating the degree of correlation between FD and environmental pollution.

7.4.2 Regions With Different Cultural Penetration

In addition to economic differences, cultural differences are also an important factor affecting the relationship between FD and environmental pollution. As an important part of Chinese traditional culture, Confucianism has profoundly impacted Chinese society. Confucian culture pays attention to the harmonious coexistence of human beings and nature and the sustainable development of the environment. Thus, we divide the whole sample into areas affected by Confucian culture and areas not affected by Confucian culture and conduct regressions respectively to explore the differences in the impact of FD on environmental pollution under different cultural backgrounds. We regard the areas with existing Confucian temples as the areas affected by Confucian culture and those without Confucian temples in the jurisdiction as areas not affected by Confucian culture. The distribution data of Confucian temples comes from China Confucius Temple Network and China Confucian Temple Distribution Report.

Table 7 reports the regression results. Regardless of whether environmental pollution is measured by SO_2 emission or $PM_{2.5}$ concentration, FD in areas affected by Confucian culture has no significant impact on environmental pollution, but FD in areas not affected by Confucian culture has a considerable impact on environmental pollution. For each unit of FD, industrial SO_2 emissions and $PM_{2.5}$ concentrations increased by 1.82 and 2.71%, respectively. The areas affected by Confucian culture have accumulated strong environmental protection culture and political opinions, which weakens the influence of local officials' behavior distortions on environmental pollution.

8 CONCLUSION AND IMPLICATIONS

On the basis of principal–agent theory, this study analyzes how Chinese-style FD affects environmental pollution from the assumptions of "political man" and "economic man" of local governments and their incentive and restraint mechanisms. This study also constructs a multi-task principal-agent model to analyze the distortion of local government behavior under FD. In addition, this study uses panel data of prefecture-level cities from 2014 to 2018 to empirically estimate the impact of the Chinese-style FD system on environmental pollution. Results show that Chinese-style FD worsens environmental pollution, whether measured by SO_2 or $PM_{2.5}$. Specifically, each unit of FD increases the industrial SO_2 emissions and $PM_{2.5}$ concentrations by 1.46 and 0.20%, respectively. This result is supported by a robustness test of alternative measures of FD. The average FD degree of other prefecture-level cities in the province where a prefecture-level city is located is also taken as the instrumental variable of the FD degree of this prefecture-level city, and the instrumental variable method is applied to analyze the endogeneity problem. Endogeneity analysis results also support the main conclusion of this study.

This study estimates the differences in the impacts of FD on environmental pollution across different regions based on their levels of economic development and cultural penetration. Results show that FD has no impact on environmental pollution in eastern China but aggravates industrial SO_2 pollution in central China and $PM_{2.5}$ pollution in western China. Meanwhile, by using the number of Confucian temples in the region as a proxy for Confucian culture, results show that Chinese-style FD does not affect environmental pollution in areas influenced by Confucian culture yet aggravates environmental pollution in those areas that are not influenced by the Confucian culture.

On the basis of these findings, this study offers some recommendations for policymakers and regulators. First, the administrative powers and expenditure responsibilities between the central government and local governments can be clarified in the form of laws or regulations. Environmental governance has a significantly positive externality, and central and local governments should undertake their respective fiscal expenditure responsibilities and determine their expenditure proportions according to the nature and responsibilities of such expenditure. Second, policymakers should establish an environmental governance system that is compatible with local economic development incentives. Although the central government has assumed some responsibilities of environmental governance, local governments, as the main implementers of regional environmental governance, need to perform most of these responsibilities. Therefore, such an incentive-compatible environmental governance system can reverse the spending preferences of local officials in the field of economic development, thereby stimulating their enthusiasm in environmental governance. Third, a public budget system for environmental finance should be established. As a financial method that can change the behavioral choices of economic subjects, environmental finance can urge governments to actively pursue environmental governance. Fourth, China can establish a financial transfer payment compensation mechanism for environmental protection, especially a horizontal financial fund transfer system between regions, to solve the problems associated with cross-regional environmental governance.

This study also has its limitations. First, this study uses SO_2 and $PM_{2.5}$ data to offer a more comprehensive measure of environmental pollution compared with previous research. However, using longer-term micro data for measuring environmental pollution can provide additional empirical evidence to support the relationship between FD and environmental pollution. Additional evidence may also be collected through interviews and fieldwork with government officials and the public. In addition, this study links fiscal decentralization and environmental pollution through local government actions, and additional mechanisms can be studied in future works. Future studies may also focus on the impact of other institutional arrangements on public health, such as China's household registration, social security, and corporate taxation systems, to further enrich research in this field.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

HC: conceptualization, writing (review and editing), supervision. ZT: writing (original draft), methodology, software. SX: writing (review and editing). SC: methodology, visualization. PZ: data curation, software. WL: data curation.

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