ISSN: 2710-0723

The Impact of Fiscal Decentralization on Environmental Pollution Index: Theoretical Analysis and Empirical Examination

Xiaowen Guo*

The Department of Economics in Harpur College, State University of New York at Binghamton, Vestal, 13850, The United States

*xguo2@binghamton.edu

Abstract

As sustainable development gains momentum, many Chinese cities are increasingly focused on balancing economic growth with environmental pollution control. This study develops a theoretical model to assess the impact of fiscal decentralization on environmental pollution, examining both the direct and indirect pathways of influence. Fiscal decentralization is regarded as a mechanism that empowers local governments with economic incentives, allowing them to gain from economic growth by granting them control over revenue generation and expenditure. The analysis reveals that the effect of fiscal decentralization on environmental quality depends on the interplay between the "growth effect" and the "regulation effect," with the growth effect typically prevailing. Fiscal decentralization tends to increase pollution directly by prioritizing economic expansion over environmental protection and indirectly by affecting factors such as economic development and urbanization. Utilizing panel data from 279 cities in China, this paper empirically examines both the direct impact of fiscal decentralization on pollution levels and the indirect channels through economic growth and urbanization. The findings indicate that the growth effect often overshadows the regulation effect, leading to higher pollution levels through both direct and indirect mechanisms. This research concludes by proposing policy measures to address the environmental challenges posed by fiscal decentralization, emphasizing the importance of balanced local governance and stronger environmental regulations.

Keywords

Fiscal Decentralization; Environmental Pollution Index; Growth Effect; Utilizing Panel Data.

1. Introduction

In recent years, sustainable development has emerged as a cornerstone of policy discussions worldwide, reflecting the growing need to balance economic growth with environmental stewardship. This challenge is particularly pronounced in China, a country that has witnessed unparalleled economic expansion over the past few decades[1]. Rapid industrialization and urbanization have propelled China into the ranks of global economic powerhouses, lifting millions out of poverty and transforming the nation's infrastructure. However, these achievements have come at a significant environmental cost, with widespread air and water pollution, deforestation, and soil degradation threatening public health, biodiversity, and long-term economic stability. Addressing these environmental challenges while maintaining economic momentum remains a top priority for policymakers in China.

Refer to the expression used Liu's paper, among the tools employed to manage these competing priorities, fiscal decentralization has emerged as a double-edged sword[2]. By transferring fiscal responsibilities and decision-making power from the central government to local

ISSN: 2710-0723

governments, fiscal decentralization has encouraged local authorities to design and implement economic strategies tailored to regional needs. This autonomy has fueled economic growth by enabling local governments to foster investment, develop infrastructure, and create jobs. However, the decentralization of fiscal power has also introduced significant challenges, particularly in the realm of environmental governance. Local governments, often evaluated based on their economic performance, may prioritize growth over environmental protection, leading to increased pollution and resource depletion. This creates a complex and nuanced relationship between fiscal decentralization and environmental sustainability that warrants further investigation.

The impact of fiscal decentralization on environmental outcomes can be understood through two competing forces: the growth effect and the regulation effect. The growth effect reflects the tendency of local governments to prioritize economic expansion, often by attracting pollution-intensive industries or promoting rapid urbanization without sufficient environmental safeguards. This approach, while effective in driving short-term economic gains, tends to exacerbate environmental degradation. Conversely, the regulation effect posits that fiscal decentralization could improve environmental outcomes by allowing local governments to design targeted policies and enforce region-specific regulations. In practice, however, the regulation effect is often weakened by limited financial resources, lax enforcement mechanisms, and the emphasis on economic growth metrics in local government evaluations. The interplay of these two effects forms the foundation of the complex relationship between fiscal decentralization and environmental pollution.

This study aims to shed light on how fiscal decentralization affects environmental pollution in China, using panel data from 279 cities in 2007-2021. By constructing a theoretical framework and conducting empirical analysis, the research examines both the direct and indirect pathways through which fiscal decentralization influences pollution. Specifically, it investigates the direct effect of fiscal decentralization on pollution levels and its indirect effects mediated by economic development and urbanization. The findings reveal that fiscal decentralization predominantly increases pollution, with the growth effect often overshadowing the regulation effect. This highlights the need for a balanced governance framework that aligns fiscal autonomy with environmental responsibility, ensuring that local governments can pursue economic growth without compromising environmental sustainability.

The relationship between fiscal decentralization and environmental pollution has been widely debated, with scholars exploring how decentralization impacts local governance and ecological outcomes. Traditional perspectives often highlight the "race to the bottom" phenomenon, where decentralization incentivizes local governments to prioritize economic growth over environmental protection, exacerbating pollution due to inter-regional competition[3]. Conversely, the "race to the top" argument suggests that decentralization empowers local governments to address environmental concerns more effectively by responding to public demand for improved quality of life. Studies like Chen and Liu's analysis of 31 Chinese provinces from 2003 to 2017 emphasize the spatial spillover effects of fiscal policies and environmental regulations, noting that decentralization may either intensify pollution under weak regulatory frameworks or foster inter-regional cooperation with robust policies[3]. He provides further evidence using Chinese panel data from 1995 to 2010, showing that fiscal decentralization does not directly reduce pollution but positively correlates with pollution abatement spending and pollutant discharge fees, reflecting its complex and context-dependent effects[4]. Similarly, Guo et al. explore the impact of fiscal decentralization on local pollution, identifying that fiscal revenue decentralization exacerbates pollution more than expenditure decentralization, though higher local environmental preferences can mitigate these negative effects[5]. These studies collectively underscore the multifaceted dynamics of fiscal decentralization,

ISSN: 2710-0723

emphasizing the importance of institutional frameworks, regulatory stringency, and local governance priorities in shaping its environmental outcomes.

The research advances the existing literature on fiscal decentralization and environmental pollution by offering a comprehensive theoretical and empirical analysis. Unlike previous studies, such as He and Guo et al., which primarily focus on the direct effects of fiscal decentralization, my paper integrates both the "growth effect" and "regulation effect" to highlight the competing mechanisms influencing environmental quality[4,5]. Additionally, my inclusion of urbanization and economic development as mediating factors provides a nuanced understanding of indirect pathways, a dimension overlooked in studies like Chen and Liu[3]. By analyzing panel data from 279 cities, the study offers broader empirical coverage and deeper insights into localized impacts compared to prior works focusing on provincial data. Methodologically, my two-stage regression model separates direct and indirect effects, enhancing precision and clarity in understanding fiscal decentralization's multifaceted impacts. Furthermore, the paper stands out with its policy-oriented recommendations, emphasizing reforming incentive structures and strengthening environmental regulations, providing actionable strategies for balancing economic growth and environmental sustainability. These contributions make the study a significant progression in this field.

The research contributes to the growing literature on environmental economics and governance by offering insights into the environmental trade-offs of fiscal decentralization. It emphasizes the importance of integrating environmental considerations into fiscal policy and governance frameworks, particularly in rapidly developing economies like China. The study concludes by offering policy recommendations to strengthen local environmental governance, promote green investments, and balance the dual goals of economic development and environmental protection. Through these efforts, China can advance its sustainable development agenda and serve as a model for other countries facing similar challenges.

2. Theoretical Analysis

2.1. Basic Assumptions

Assumption 1: The utility function of a local government is defined as $U = U(E, G)$, where E represents economic growth and G represents environmental quality. Given that fiscal decentralization often incentivizes local governments to prioritize economic growth, it is assumed that local governments allocate resources in a way that balances these objectives. Following the insights of Wei Xiang, we assume that $U_E > 0$ and $U_{EE} < 0$ for economic growth, and $U_G < 0$ and $U_{GG} < 0$ for environmental quality, reflecting diminishing marginal returns to both[6].

Assumption 2: Fiscal decentralization impacts environmental quality in two main ways. First, through direct allocation, where local governments' priorities shape environmental spending, which could positively impact environmental quality (i.e., better fiscal capacity could lead to more resources for pollution control). Second, fiscal decentralization affects local economic growth, indirectly impacting environmental quality. Specifically:

- Direct Effect: Increased autonomy allows local governments to make environmentally relevant spending decisions, which may positively or negatively affect environmental quality depending on local priorities and the strength of environmental regulations.
- Indirect Effect: Fiscal decentralization fosters economic development, which could lead to pollution. The relationship between economic growth and environmental quality is complex; growth can increase pollution due to higher industrial output (substitution effect) or decrease pollution as regions invest in cleaner technology (income effect)[7].

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2.2. Utility Maximization and Optimal

Given the assumptions above, based on the perspectives of Xu Hongxiang[7], the local government's utility maximization function can be expressed as:

$$\max U(E,G) = \chi(G) \cdot B \cdot E - \int U_G(x,G)dx \quad (1)$$

where:

- $\chi(G)$ represents the marginal effect of environmental quality on utility along the government's optimal economic path.
- B represents the fiscal budget available to local governments.
- $\int U_G(x,G)dx$ represents the negative externalities associated with environmental degradation due to economic growth.

The budget constraint is given by $B = E + G$. This constraint reflects that fiscal resources are finite, and choices favoring economic growth may reduce resources for environmental quality.

2.3. Balancing Effects of Fiscal Decentralization

Two key factors determine how fiscal decentralization impacts environmental quality:

(1) Growth Effect: Fiscal decentralization incentivizes local governments to increase economic growth to boost tax revenues and achieve local objectives. This can lead to higher pollution if growth is achieved through industrial expansion, especially in regions where environmental regulations are weak.

(2) Regulation Effect: Local governments may also allocate resources to environmental protection if the public demand for a clean environment is high. This effect is stronger in wealthier regions where citizens are more likely to prioritize environmental quality over further economic growth.

2.4. The Role of Substitution and Income Effects

The effects of fiscal decentralization on pollution can be interpreted through two economic concepts:

- Substitution Effect: Local governments may favor immediate economic growth, substituting resources that could be allocated for environmental protection with investments aimed at boosting output. This effect generally leads to increased pollution.
- Income Effect: As regions become wealthier due to fiscal decentralization, they may invest in cleaner technologies and implement stricter regulations, which could reduce pollution.

Thus, the impact of fiscal decentralization on pollution depends on the balance between the substitution and income effects, with the former typically dominating in lower-income regions and the latter potentially prevailing in more developed regions.

2.5. Indirect Effects through Economic Growth

A hidden assumption in this model is that economic growth indirectly affects environmental quality through pollution. Literature shows mixed findings: while some studies indicate that pollution initially increases with economic growth but decreases beyond a certain point (an inverted U-shape), others suggest that regions with higher environmental regulations tend to experience a more sustainable growth path. In this model, fiscal decentralization can impact pollution levels both directly (by influencing spending priorities) and indirectly (through economic growth), with varying effects depending on local government strategies and regional economic conditions[7].

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3. Regression Model Construction

3.1. Construction of Fiscal Decentralization and Environmental Pollution Indices

3.1.1. Fiscal Decentralization Index Equation

The Fiscal Decentralization index measures the degree of financial autonomy at the local level and is calculated as the ratio of fixed asset investment to general government expenditure. This reflects how much financial control local governments have over resources relative to central oversight. The formula is as follows[2]:

$$Fiscal\ Decentralization_{it} = \frac{Fixed\ Asset\ Investment_{it}}{General\ Government\ Expenditure_{it}} \tag{2}$$

where:

- i represents the region or province.
- t represents the year.

This formula divides local investment by government expenditure, reflecting the financial resource allocation at the regional level.

3.1.2. Environmental Pollution Index Calculation Steps

Building on the work of Deng Rongrong and Liu Feiyu, the Environmental Pollution Index is created using a multi-step process to combine various pollution-related variables ($x1, x2, x3, etc.$) into a single index[8,9].

(1) Min-Max Normalization: Each pollution-related variable x is normalized between 0 and 1 to standardize the data across different scales.

$$sx_{it} = \frac{x_{it} - \min(x)}{\max(x) - \min(x)} \tag{3}$$

If $sx_{it} = 0$, it is replaced with 0.0001 to avoid issues with logarithmic transformations.

(2) Proportion Calculation: The normalized values are converted into proportions:

$$p_{it} = \frac{sx_{it}}{\sum sx} \tag{4}$$

(3) Entropy Calculation: Entropy is calculated to assess the variability of each variable:

$$e_{it} = -\frac{\sum p_{it} \cdot \ln(p_{it})}{\ln(N)} \tag{5}$$

where N is the number of observations.

(1) Dissimilarity Index and Weighting: The dissimilarity index $d_{it} = 1 - e_{it}$ and the weight $w_{it} = \frac{d_{it}}{\sum d}$ are calculated to assign importance to each variable.

(2) Environmental Pollution Score: The weighted sum of normalized variables provides the final Environmental Pollution Index:

$$Score_{it} = \sum w_{it} \times sx_{it} \tag{6}$$

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where:

- w_{it} represents the weight for each variable.
- sx_{it} represents the normalized value of each variable.

3.2. Regression Model Framework

To explore the relationship between fiscal decentralization and environmental pollution, considering from Halkos and Paizanos and Feng Haibo, Fang Yuanzi, this study employs a two-stage regression model that captures both direct and indirect effects[10,11]. The original data for this study is derived from the China Statistical Yearbook, China Environmental Yearbook, China Labor Statistical Yearbook, and China Fiscal Yearbook spanning the years 2007 to 2021, consisting of panel data from 279 prefecture-level cities.

3.2.1. Direct Effect Regression Equation

The direct effect regression tests the impact of fiscal decentralization on the environmental pollution index while controlling for other influencing factors, such as economic development and urbanization levels:

$$log\_pollution_{it} = \beta_0 + \beta_1 \cdot log\_fiscal\_decentralization_{it} + \beta_2 \cdot log\_economic\_development_{it} + \beta_3 \cdot log\_urbanizatio_{it} + \epsilon_{it} \quad (7)$$

where:

- $log\_pollution_{it}$ represents the logarithm of the environmental pollution index for city i at time t.
- $log\_fiscal\_decentralization_{it}$ represents the logarithm of fiscal decentralization.
- $log\_economic\_development_{it}$ represents logarithm of economic development level.
- $log\_urbanizatio_{it}$ represents logarithm of urbanization level.
- β_1 represents the coefficient measuring the direct effect of fiscal decentralization on environmental pollution. A positive value indicates that greater fiscal decentralization is associated with higher pollution, while a negative value would indicate the opposite.
- β_2 captures the effect of economic development level on environmental pollution. Economic development can reduce pollution if cleaner technologies or stricter regulations accompany growth ($\beta_2 < 0$), or increase pollution if growth is industrially intensive ($\beta_2 > 0$).
- β_3 Reflects the relationship between urbanization level and environmental pollution. Urbanization can improve environmental quality through better infrastructure and governance ($\beta_3 < 0$) or worsen it through increased consumption and industrialization ($\beta_3 > 0$).

3.2.2. Indirect Effect Regression Equation (through Economic Development Level)

The indirect effect regression examines how fiscal decentralization influences economic development, which in turn affects environmental pollution. This captures an indirect pathway where fiscal policies impact growth and subsequently environmental quality.

$$log\_economic\_development_{it} = \alpha_0 + \theta_1 \cdot log\_fiscal\_decentralization_{it} + \theta_2 \cdot log\_urbanizatio_{it} + \eta_{it} \quad (8)$$

where:

- $log\_economic\_development_{it}$ represents logarithm of economic development level for city i at time t.
- θ_1 represents the coefficient measuring the indirect effect of fiscal decentralization on economic development. A positive value of θ_1 would indicate that fiscal decentralization

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promotes economic development, suggesting that greater local financial autonomy allows regions to make more tailored economic decisions, allocate resources more efficiently, and attract investments that drive growth. A negative value of θ_1 would imply that fiscal decentralization hinders economic development, potentially because local governments may lack the capacity or experience to manage financial resources effectively, which could lead to inefficiencies or suboptimal economic outcomes.

- θ_2 represents the impact of urbanization level on economic development. A positive value of θ_2 indicates that an increase in urbanization contributes positively to economic development. This aligns with the idea that urbanized regions often have better infrastructure, access to markets, and a concentration of skilled labor, which can drive economic growth. A negative value of θ_2 would suggest that urbanization negatively impacts economic development. This could occur if rapid or unplanned urbanization leads to issues like congestion, inefficiency, or overburdened infrastructure, which might hinder economic progress.

3.2.3. Total Effect Regression

Using the coefficients from the direct and indirect effect models, we compute the total effect of fiscal decentralization on environmental pollution as follows:

$$Total\ Effect = \beta_1 + \theta_1 \tag{9}$$

where:

- $Direct\ Effect$: β_1, the immediate impact of fiscal decentralization on the environmental pollution index.
- $Indirect\ Effect$: θ_1, the indirect effect through economic development.
- $Total\ Effect$, the combined impact of direct and indirect effects.

4. Empirical Analysis

4.1. Analysis of Regression Results (Table 1)

4.1.1. The Result of Direct Effect Regression

- $\beta_1 = 1.3757$: Fiscal decentralization has a significant and positive direct effect on the environmental pollution index. A 1% increase in fiscal decentralization is associated with approximately a 1.38% increase in the pollution index. This suggests that local financial autonomy may prioritize economic growth over environmental protection, leading to increased pollution.
- $\beta_2 = -2.7701$: Economic development significantly reduces pollution. A 1% increase in economic development leads to a 2.77% reduction in the pollution index, potentially due to cleaner technology or stricter regulations in more developed regions.
- $\beta_3 = -0.4060$: Urbanization has a negative relationship with pollution, indicating that urban areas may adopt more efficient infrastructure and policies to mitigate environmental degradation.
- Model Fit: $R^2 = 0.3464$: Approximately 34.6% of the variation in the environmental pollution index is explained by the model.

4.1.2. The Result of Indirect Effect Regression

- $\theta_1 = 0.0310$: Fiscal decentralization positively impacts economic development. A 1% increase in fiscal decentralization leads to a 0.031% increase in economic development, likely due to greater local control over resources that stimulate growth.

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- $\theta_2 = 0.1321$: Urbanization has a significant and positive effect on economic development. A 1% increase in urbanization correlates with a 0.132% increase in economic development, highlighting the economic benefits of urban infrastructure and agglomeration.
- Model Fit: $R^2 = 0.6532$: The model explains 65.3% of the variation in economic development, indicating a strong fit.

4.1.3. Effect Calculations

- Direct Effect:

The direct effect of fiscal decentralization on the environmental pollution index is $\beta_1 = 1.3757$, which shows a significant positive relationship between fiscal decentralization and environmental pollution. This suggests that fiscal decentralization, by itself, tends to exacerbate pollution. The economic reasoning behind this finding lies in the incentives created by fiscal autonomy. Local governments, empowered with greater fiscal control, often prioritize economic growth to enhance local revenue and meet performance evaluation criteria tied to GDP growth. This prioritization typically encourages the expansion of industries and infrastructure that boost local economies but are often pollution-intensive. Additionally, local governments may engage in a "race to the bottom" by relaxing environmental regulations or offering tax breaks to attract investments, further compounding pollution. This finding highlights a trade-off inherent in fiscal decentralization: while it fosters economic activity, it may do so at the cost of environmental sustainability. This substantial positive coefficient implies that fiscal decentralization alone significantly increases pollution, likely due to prioritization of local economic growth without sufficient environmental safeguards.

- Indirect Effect:

The indirect effect of fiscal decentralization on pollution, mediated through economic development, is $\theta_1 = 0.0310$. It reveals that fiscal decentralization has a smaller but statistically significant impact on pollution through its influence on economic development. Fiscal decentralization can stimulate economic growth by allowing local governments to allocate resources more efficiently, respond to regional economic conditions, and attract investments. While economic development is generally associated with advancements in technology and improvements in environmental management, in this case, the indirect effect on pollution is positive but small. This suggests that the environmental benefits of economic growth—such as cleaner technology and stricter regulatory frameworks—are insufficient to counteract the environmental costs of increased industrialization and urbanization. This underscores the need for stronger policies to channel economic growth toward sustainable development under a decentralized fiscal framework. This indicates a small but significant pathway where fiscal decentralization indirectly influences pollution via its positive impact on economic growth.

- Total Effect:

The total effect of fiscal decentralization on the pollution index is the sum of the direct ($\beta_1 = 1.3757$) and indirect ($\theta_1 = 0.0310$) effects:

$$Total\ Effect = 1.3757 + 0.0310 = 1.4066 \quad (10)$$

This demonstrates that fiscal decentralization has an overall pollution-increasing impact, with the direct effect far outweighing the indirect effect. This result suggests that the current implementation of fiscal decentralization prioritizes economic growth without adequately addressing its environmental externalities. From an economic perspective, this reflects a misalignment of incentives: local governments, motivated by short-term revenue gains and GDP growth, may neglect long-term environmental sustainability. The findings emphasize the need to balance fiscal autonomy with robust environmental governance to mitigate these negative externalities.

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Table 1. Regression Result

	(1)	(2)
	Direct Effect	Indirect Effect
$log\_fiscal\_decentralization_{it}$	1.376***	0.031***
	(0.030)	(0.001)
$log\_economic\_development_{it}$	-2.770***	
	(0.334)	
$log\_urbanizatio_{it}$	-0.406**	0.132**
	(0.065)	(0.002)
Constant Term	3.477***	2.471***
	(0.065)	(0.002)
N	4185	4185

Standard errors in parentheses.
* p < 0.05, ** p < 0.01, *** p < 0.001.

5. Conclusion and Policy Recommendations

The analysis highlights the dual effects of fiscal decentralization on environmental pollution in China. On one hand, fiscal decentralization provides local governments with financial autonomy, enabling them to drive economic growth tailored to regional needs. However, this autonomy often leads to prioritizing short-term economic gains over environmental protection, especially in economically underdeveloped regions[12]. Our findings suggest that fiscal decentralization contributes to environmental pollution primarily due to two factors: (1) local governments' competition for economic performance incentives, which are tied to GDP growth, and (2) inadequate enforcement of environmental regulations due to limited financial resources and the pressure to attract investments. The empirical results align with the notion that local officials prioritize rapid economic gains at the expense of environmental quality, especially in regions with high fiscal dependence on economic growth metrics.

To mitigate the environmental impact of fiscal decentralization, it is recommended to reform local government incentive structures by prioritizing environmental performance alongside economic growth, strengthening environmental regulation and enforcement, and providing fiscal incentives for sustainable business practices. Encouraging transparency and public participation in environmental monitoring can increase accountability, while supporting technological innovation for pollution control will enable sustainable management of environmental resources. These measures aim to balance economic development with environmental sustainability, promoting a long-term, high-quality growth path for China.

References

[1] Sahoo, S., & Goswami, S. (2024). Theoretical framework for assessing the economic and environmental impact of water pollution: A detailed study on sustainable development of India. Journal of Future Sustainability, 4(1): 23-34.

[2] Liu, Z., & Zeng, J. (2023). Local government competition, fiscal decentralization, and high-quality industrial development. Economic Issues Exploration, (7):18-42.

ISSN: 2710-0723

[3] Chen, X., & Liu, J. (2020). Fiscal decentralization and environmental pollution: a spatial analysis. Discrete Dynamics in Nature and Society, 1, 9254150.

[4] He, Q. (2015). Fiscal decentralization and environmental pollution: Evidence from Chinese panel data. China Economic Review, 36, 86-100.

[5] Guo, S., Wen, L., & Wu, Y., et al. (2020). Fiscal decentralization and local environmental pollution in China. International Journal of Environmental Research and Public Health, 17(22), 8661.

[6] Wei X. (2006). Research on Resident Consumption Based on Leisure Time Utility Function: Empirical Test of Chinese. Economic Science, (4): 104-113

[7] Xu, H., & Zhang, W. (2017). The effect of air pollution on labor supply: Theoretical analysis and empirical examination. Soft Science, 31(3): 99-102.

[8] Deng, R., & Zhang, A. (2022). The impact and mechanism of digital economy development in Chinese cities on environmental pollution. South China Journal of Economics, (2): 18-37.

[9] Liu, F., & Zhao, A. (2016). Effect of foreign direct investment on urban environmental pollution: An empirical study based on panel data of 285 cities in China. Journal of International Trade Issues, (5): 130-141.

[10] Halkos, G. E., Paizanos, E.A. (2013). The Effect of Government Expenditure on the Environment: An Empirical Investigation. Ecological Economics, 91(3): 48-56.

[11] Feng, H., Fang, Y. (2014). Analysis of environmental effects of local fiscal expenditure. Finance and Trade Economics, (2): 30-43.

[12] Zhao L, Shao K, Ye J. (2022). The impact of fiscal decentralization on environmental pollution and the transmission mechanism based on promotion incentive perspective. Environ Sci Pollut Res Int., 29(57):86634-86650.