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IMPACT MECHANISMS OF ENVIRONMENTAL RULES ON HAZE POLLUTION: AN EXAMINATION WITH THE MEDIATION EFFECT

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Abstract

This paper selects 216 China cities data from 2003 to 2016 to examine the impact of environmental regulations on environmental quality, and further analyze the intermediary effects of industrial structure, green construction and technological level on the relationship between the two. The test results show: (1) Across the country, environmental regulations have an inverted U-shaped relationship with the PM2.5 index, that is, environmental regulations at a relatively low level cannot control environmental pollution and require higher-strength environmental regulations to regulate them. (2) Across the country, industrial institutions, green construction and technological levels will indirectly affect the impact of environmental regulations on smog. There is a partial intermediary effect, that is, environmental regulations can not only directly affect smog density, but also through industrial organizations, Green construction and technological level affect the inverted U-shaped relationship. (3) The impact of environmental regulations on the smog in eastern, central and western China is heterogeneous.

Key words: environmental regulation, haze pollution, mediation effect, regional heterogeneity

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1. Introduction

With the rapid advancement of industrialization and urbanization, China's economy has achieved rapid development. But it also inevitably leads to the intensification of pollution discharge and ecological damage. Environmental problems have become a major obstacle to China's sustainable development. In particular, the frequent outbreak of large-scale haze pollution in recent years not only seriously affects residents' daily work and life, but also poses a great threat to residents' physical and mental health (Du et al., 2018; Lelieveld et al., 2015; Zhang et al., 2018; Hao et al., 2018 a, b). According to the bulletin of China's ecological environment in 2018, the ambient air quality of up to 217 cities in China exceeded the standard, accounting for 64.2% of the total number of 338 prefecture level and above cities in China, and the average proportion of days exceeding the standard was as high as 20.7%. PM2.5, PM10 and O3 were the primary pollutants in the days exceeding the standard, with a total of 1899 days of severe pollution and 822 days of severe pollution. It can be seen from the above examples and data that in recent years, the problem of urban air pollution in China has become increasingly serious, the coverage of extreme haze pollution weather is expanding, and the haze pollutants are mainly PM2.5. Because haze pollution has the characteristics of negative externality, unclear property rights and public goods, it is difficult to effectively regulate by market mechanism alone, and the government also needs to intervene to make up for the defect of market failure by means of mandatory environmental regulation (Zhang et al., 2018). However, from the current overall situation, due to insufficient policy implementation and lack of pertinence, there is still a certain deviation between the effectiveness of haze

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control and public perception. In this context, in the face of the increasingly severe Urban Haze pollution situation, China revised the law of the China on the prevention and control of air pollution in 2016. Compared with 2015, the total emissions of SO_2 and NOx in China will be reduced by at least 15% in 2020. It can be seen that regulations and measures provide a rigid institutional guarantee for Urban Haze control.

Therefore, it is of great significance to explore the impact and mechanism of environmental regulation on haze pollution from the perspective of Chinese cities (Tang et al., 2018; Zhang et al., 2021). So what is the mechanism and path of the effect of environmental regulation on haze pollution control in the process of vigorously promoting industrialization and urbanization in China? Are these mechanisms and paths consistent in different regions? How effective is environmental regulation? In order to answer the above questions, this paper uses the annual PM2.5 concentration data of 216 cities (except Hong Kong, Macao, Taiwan and Lhasa) from 2003 to 2016, uses the intermediary effect method to empirically analyze the impact mechanism and path of environmental regulation on haze governance in China, and investigates the heterogeneity of the impact mechanism and path of environmental regulation on haze governance in different regions.

At present, environmental regulation has become an important means to control the negative externality of haze pollution. Starting from the relationship between environmental regulation and haze pollution, this paper discusses the action mechanism of environmental regulation on haze in order to alleviate the problem of Urban Haze pollution, which has important theoretical and practical significance.

(1) The relationship between environmental regulation and haze pollution is an important topic entrusted to economics by the times. In view of the extensive growth model in China's current economic development at the expense of environment and resources, this paper analyzes the impact mechanism of urban environmental regulation on haze pollution from the urban level and taking haze pollution as the research object. To a certain extent, this paper expands the connotation and extension of environmental regulation and haze pollution, and provides a new idea for the theoretical research on the impact of urban environmental regulation on haze pollution in China.

(2) In the face of increasingly severe haze pollution, the Chinese government has formulated and implemented a series of control measures, but from the current results, the results are very little, far from meeting the public's demand for a better life. Through the combination of theory and demonstration, this paper analyzes the impact mechanism of China's urban environmental regulation on Urban Haze pollution, in order to answer the question of how to improve the effectiveness of environmental regulation in order to achieve collaborative governance of Urban Haze pollution. It provides a new reference for alleviating haze pollution in China's cities.

The previous literature has conducted research on the effect and path of environmental regulation based on different samples and perspectives, laying an important prerequisite and foundation for the research of this article, but there are still areas that can be improved and perfected. First, on the basis of previous studies, this article not only considers the direct effects of environmental regulations on smog pollution control, but also uses the mediation effect method to comprehensively study whether environmental regulations have indirect effects on smog control; secondly. Most of the researches focus on technological innovation and industrial structure about predecessors' influence on the path.

This paper considers that urban green space can absorb haze, and innovatively incorporates urban green area into an intermediary variable (Table 1). Thirdly, the impact path of environmental regulation on haze governance has a certain regional heterogeneity. Therefore, this paper discusses the impact of environmental regulation on haze governance in three regions: East, Middle and West. Finally, previous studies mostly selected provincial-level data, and the provincial spatial scale was larger and the intra-regional differences were greater. In addition, the data statistics of China's haze concentration are based on urban samples, taking into account the availability and matching of the data. Therefore, this article uses the main 216 cities in China as a sample to study the problem of haze pollution control.

2. Material and methods

2.1. Mechanism analysis and research hypothesis

In recent years, the research on haze pollution has gradually increased, which can be summarized into three categories: the first is the research related to the essential attributes of haze pollution (Hao et al., 2018a; Fu and Chen., 2018; Yang et al., 2018); the second is the research related to the formation process of haze pollution (Chang et al., 2018); the third is the research related to the prevention and control of haze pollution (Man et al., 2018).

It can be seen from the research content that few scholars systematically introduce environmental regulation tools into the air pollution subdivision field of haze. Therefore, combined with the existing research on haze, this paper explores the mechanism and path from the direct and indirect impact of environmental regulation.

The environmental regulation can directly affect environmental pollution through administrative measures, economic means and consumption regulation. Appropriate environmental regulation is indeed conducive to reducing pollution emissions in China (Cheng et al., 2017; Gao et al., 2016). However, based on the existing research, we cannot confirm whether excessive environmental regulation is conducive to environmental improvement.

Table 1. Variables interpretation

Classification	***Name***	***Interpretation***	***Symbol***	***References***
Explained variable	Smog	PM2.5 concentration data is based on the grid data of global PM2.5 concentration from 2003 to 2016 provided by the social and economic data and application center of Columbia University	PM2.5	Donkelaar et al. (2015)
Explanatory variable	Environmental regulation intensity	The intensity of environmental regulation is calculated by entropy weight method through the five single indexes of industrial SO_2 removal rate, smoke and dust removal rate, comprehensive utilization rate of industrial solid waste, domestic sewage treatment rate and harmless treatment rate of domestic garbage.	GER	Cole et al. (2005)
Mediating variable	Industrial structure	Added value of tertiary industry/added value of secondary industry	IS	Chen (2021)
	Urban green construction	This paper selects the per capita green space area (HA / person) of each city to measure the level of urban green construction	GREEN	Choudhary and Gokhale (2016)
	Technical progress level	Sum of practical patent authorization in each city	RD	Schettino et al. (2013)
Control variable	Level of urban development	Expressed in terms of GDP of urban areas	GDP	Song et al. (2020)
	Informatization	Annual electricity consumption/Year-end total population (10,000 KW/person)	TEL	Kula et al. (2012)
	Population size	Urban population at the end of the year	PEO	Cheney (2000)
	Government behavior	The ratio of education expenditure and science and technology expenditure to regional GDP in regional fiscal expenditure	GOV	Andersson et al. (2009)
	City appearance and environment	The ratio of city appearance and environmental sanitation investment to regional GDP	WS	Ran et al. (2020)
	Urban maintenance	The proportion of urban maintenance and construction funds and regional GDP is expressed	WJ	Tam (1999)

This is mainly based on the interaction between "green paradox" theory and "forced emission reduction" theory (Hubert, 2021). "Forced emission reduction effect" holds that the government and environmental protection departments urge enterprises to improve their production and pollution control technology by setting higher emission standards or forcibly banning high polluting enterprises, so as to avoid high emission punishment and realize pollution emission reduction.

Hamamoto (2006) found that stricter environmental regulations in some industries can improve their research and development level, which is conducive to curbing haze pollution. James and Amil (2003) used the relevant data of the paper industry, and the empirical results showed that high-intensity environmental regulation would reduce the productivity of the paper industry, which was conducive to the prevention and control of haze pollution. Lorente et al. (2016) showed that due to the existence of spatial spillover effect, the implementation of cross regional environmental regulation measures had achieved remarkable results in solving the problem of haze pollution. On the contrary, "Follow the cost effect" holds that simply increasing the intensity of environmental regulation will not reduce the emission of pollutants, but hinder the improvement of production and emission technology because it improves the environmental governance cost and extrusion technology innovation cost of enterprises,

This leads to more serious pollutant emissions (Lucas., 2008; Reynaud, 2012; Ramiah et al., 2015; Rubashkina., 2015), resulting in increased haze pollution. Sinn (2008) pointed out that the enhancement of environmental regulation has accelerated the exploitation and consumption of fossil energy, resulting in the rapid expansion of air pollution emissions and the aggravation of haze pollution. Smulders et al. (2012) confirmed this view and found that strict environmental regulation significantly exacerbated environmental pollution, which is also known as the "green paradox". Based on the above analysis, this paper proposes hypothesis 1:

Hypothesis 1: The impact of environmental regulations on haze pollution control is non-linear.

Environmental regulations not only have a direct effect on haze control, but also can play a role in haze control through industrial structure, urban greening, and technological level.

(1) Industrial structure: At the national level, economies with developed industrial structures tend to outsource their high-polluting manufacturing to obtain cheap labor from the host country, which exacerbates the spatial spillover of smog (Li et al., 2019). At the enterprise level, for high-pollution and high-energy-consuming enterprises, environmental regulations will increase the burden of production costs, reduce their original profits, and ultimately eliminate outdated production capacity. Therefore, countries or cities with developed industrial structures will have a positive effect on the impact of environmental regulations on smog.

(2) Technical level: The impact of technology on smog is mainly based on the theory of "following costs" and "innovation compensation" (Ambec et al., 2013). The "cost compliance" effect believes that enterprises can obtain higher profits and make up for the cost of environmental governance by expanding production scale and production capacity and discharging pollutants. Therefore, the theory of "following costs" believes that strict environmental standards may increase corporate pollution emissions (Yuan and Xiang, 2018). However, the school represented by Porter and Linde (1995) believes that a reasonable setting of environmental regulations can promote enterprises to improve their technological level, and the resulting "compensation effect" can not only recover part of the cost of compliance with environmental regulations, but also the effect of pollution control. Therefore, it is impossible to determine whether the impact of environmental regulations on smog through technological innovation is positive or negative.

(3) Green construction: The level of urban greening is closely related to smog pollution. Cities are the main frontiers of smog pollution (Lin and Zhu, 2018). Studies have shown that more than 90% of environmental pollution in fast-growing cities comes from exhaust emissions (Choudhary, 2016), so the construction of green belts is very important to reduce environmental pollution. Under the influence of relevant policies of environmental regulation, cities with economic foundations have joined greening construction one after another, which is conducive to the positive effect of environmental regulation on smog. Therefore, this paper proposes hypothesis 2:

Based on the above analysis, this paper proposes hypothesis 2:

Hypothesis 2: Environmental regulations can indirectly affect haze pollution control through three paths: industrial structure adjustment, urban green construction, and technological advancement.

2.2. Model construction

The specific regression equation is as Eq. (1). Among them, $SMOG_{i,t}$ represents the haze level, $GER_{i,t}$ is the intensity of environmental regulations, $CONTROLS_{i,t}$ is the control variable, $\varepsilon_{i,t}$ is a random disturbance term. $\sum Year$ indicates that the time effect is controlled. The impact of environmental regulations on smog is very likely to be non-linear. In order to further verify whether the impact of environmental regulations on smog is non-linear, we take the square term of $GER_{i,t}$ ($GER2_{i,t}$) into the regression Equation (2).

$$SMOG_{i,t} = \alpha_0 + \alpha_1 GER_{i,t} + \alpha_n CONTROLS_{i,t} + \sum Year + \varepsilon_{i,t} \tag{1}$$

$$SMOG_{i,t} = \alpha_0 + \alpha_1 GER_{i,t} + \alpha_2 GER2_{i,t} + \alpha_n CONTROLS_{i,t} + \sum Year + \varepsilon_{i,t} \tag{2}$$

According to the intermediary utility test principle of Baron and Kenny (Baron and Kenny, 1986), when analyzing the impact of environmental regulation on haze, if environmental regulation affects haze through industrial structure, it is said that industrial structure is an intermediary variable, and the two intermediary variables of urban green construction and technological progress are the same. Based on the above theories, the test steps of mediating effect constructed in this paper are as follows: first, remove the mediating variables, and the core explanatory variables should have a significant impact on the explained variables. Second, the core explanatory variables should have a significant impact on the intermediary variables. Third, after adding all variables, it is necessary to meet that the influence of intermediary variables on the explained variables is significant, and the influence of core explanatory variables on the explained variables is reduced or not significant (Mackinnon et al., 2007). The specific model is shown in equation (3) (Eq. 3):

$$M_{i,t} = \alpha_0 + \beta_1 GER_{i,t} + \beta_2 GER2_{i,t} + \beta_n CONTROLS_{i,t} + \sum Year + \varepsilon_{i,t} \tag{3}$$

Among them, *M* is the intermediary variable. If the coefficients of β_1 and β_2 are significant, it indicates that the core explanatory variable has a significant influence on the mediating variable. On this basis, this paper further constructs the mediation effect of model (4), and the specific model is shown in Eq. (4). Among them, if and are not significant, and the coefficient passes the significance test, it is a complete mediation effect, and if both and are significant, and the coefficient passes the significance test, it is a partial mediation effect.

$$SMOG_{i,t} = \alpha_0 + \delta_1 GER_{i,t} + \delta_2 GER2_{i,t} + \delta_3 M_{i,t} + \\ + \delta_n CONTROLS_{i,t} + \sum Year + \varepsilon_{i,t} \tag{4}$$

2.3. Variable description

Explained variable: Haze pollution degree (PM25). As the name suggests, haze is fog and smog, which is a general expression of suspended particulate matter with excessive content in the atmosphere. Haze weather describes an air pollution state, which is mainly composed of gaseous pollutants such as SO2 and NOx and inhalable particles, which is an important cause of haze pollution. PM10 and PM2.5 are the main inhalable particles.

Compared with PM10, PM2.5 has smaller particles, stronger activity and greater toxicity. At the same time, it has the characteristics of wide distribution range and long residence time. Therefore, PM2.5 is considered to be the culprit of haze weather. PM2.5 is the most critical component of haze pollution and can be used to approximately measure the degree of haze pollution, so it is used in this paper. Explanatory variable: environmental regulation intensity (GER). At present, the measurement methods of environmental regulation are not unified, mainly including the following two kinds: one is to express environmental regulation with different pollutant emission density (Cole and Elliott, 2003; Hao et al., 2018b; Hou et al., 2019). Second, environmental regulation policy to quantify the intensity of environmental regulation (Sun et al., 2019). Because the above indicators are relatively single and not enough to represent environmental regulation, this paper uses the comprehensive index method to build a comprehensive measurement system of urban environmental regulation. This paper selects five single indicators: Industrial SO_2 removal rate, dust removal rate, comprehensive utilization rate of industrial solid waste, domestic sewage treatment rate and domestic waste harmless treatment rate to measure environmental regulation:

- The first step was to standardize the raw data (Eq. 5):

$$P''_{ij} = \frac{X_{ij} - \min\left(X_{ij}\right)}{\max\left(X_{ij}\right) - \min\left(X_{ij}\right)} \tag{5}$$

where: X_{ij} represents the value of the *j* environmental pollution index of the *I* city.

- The second step was to perform a coordinate translation on the standardized data (Eq. 6):

$$P'_{ij} = 1 + P''_{ij} \tag{6}$$

- The third step was to calculate the proportion of the *j* environmental pollution index in the *i* city:

$$P_{ij} = P'_{ij} / \sum_{i=1}^{m} P'_{ij} \tag{7}$$

- The fourth step was to calculate the entropy and coefficient of variation of the *j* environmental pollution index:

$$e_j = \left(\frac{1}{\ln m}\right) \sum_{i=1}^{m} P_{ij} \ln\left(P_{ij}\right) \tag{8}$$

$$g_j = 1 - e_j \tag{9}$$

- The fifth step was to calculate the weight of the *j* environmental pollution index in the comprehensive evaluation (Eq. 10):

$$W_j = g_j / \sum_{j=1}^{n} g_j \tag{10}$$

- The sixth step was to calculate the comprehensive environmental pollution index:

$$GER_i = \sum_{j=1}^{n} W_j P_{ij} \tag{11}$$

Here, GER_i represents the comprehensive environmental pollution index of city *i*. The larger the value of GER_i, the higher the degree of environmental pollution in city *i*.

The control variables selected in this paper are as follows:

(1) Urban economic level (GDP), expressed by the gross product of urban areas;

(2) Population size (PEO), expressed by the number of urban population;

(3) Informationization (TEL), it is expressed by per capita power consumption (10000 kW/person);

(4) Government support (GOV), This paper is expressed by the proportion of government science and education support in GDP;

(5) Urban maintenance (WJ), expressed by the ratio of urban maintenance and construction funds to the regional GDP;

(6) City appearance and environment (WS), measured by the ratio of city appearance and environmental sanitation investment to the regional GDP.

Intermediary variables: (1) Industrial structure (IS): We choose the ratio of the added value of the tertiary industry/the added value of the secondary industry to measure the industrial structure; (2) Urban green construction (GREEN): We select the per capita green area of each city to measure the level of urban green construction and study its intermediary effect on haze pollution control; (3) The level of technological progress (RD): To measure the level of technological progress, both the difference in the overall number and the difference in the population base must be considered. The sum of the authorized amount is used to comprehensively examine the technological progress. This paper constructs the measurement model through Stata software. This paper takes 216 cities in China (excluding Hong Kong, Macao, Taiwan and Lhasa) as the research sample, and the research period is 2003-2016. The haze concentration of each city comes from the social and economic data and Application Center (SEDAC) of Columbia University. Other variables come from China Urban Statistical Yearbook and China regional economic statistical yearbook from 2003 to 2016.

3. Results and discussions

3.1. Analysis of regression results

We have taken the logarithm of PM2.5. Considering that the model may have endogeneity problems, this article uses Hausmann's endogeneity test to test the model's endogeneity. The test results accept the assumption that all variables in this article are exogenous variables, that is, the model does not have serious endogenous problems. At the same time, considering that environmental regulations may have a lag, this article incorporates the core explanatory variable environmental regulations (GER) into the model. The specific regression results are shown in Table 2 and Table 3. In the first column of Table 2, it can be seen that the influence coefficient of environmental regulations on the haze concentration is significantly positive at the 1% level, and the influence coefficient is 24.29. Environmental regulations not only fail to improve the environmental quality, but also increase the concentration of smog. In the eastern and central regions (columns 2 and 3), environmental regulations also significantly aggravated the haze concentration, with impact coefficients of 28.96 and 24.50, respectively. That is to say, the impact of environmental regulations in the eastern region on aggravating the haze concentration is much greater than that of the central region. That is, the positive effect of "forced emission reduction" is less than the effect of negative "green paradox". The environmental regulations in the western region have significantly reduced the haze concentration (columns 4), that is, the positive "reverse emission reduction" effect is less than the negative "green paradox" effect, that is, the impact of environmental regulations is heterogeneous. Regarding the control variables, the number of people (PEO) will significantly increase environmental pollution regardless of whether it is seen from the whole country or each region.

Urban GDP level (GDP) and information level (TEL) can significantly alleviate the dilemma of environmental pollution and reduce the concentration of smog. Therefore, it can be seen that the influence of the intensity of environmental regulations on the concentration of haze will be affected by the location of the region. The level of economic development in the western region is relatively weak compared to other regions, and the environmental quality has always been at a relatively good level. "Reversed Emission Reduction" theory of environmental regulation is easier to achieve in a short period of time. However, due to a large number of manufacturing industries in the central and eastern regions, air pollution is serious. If the environmental regulations are not strong enough, the expected results may not be achieved. We can't help thinking whether it is because the strength of environmental regulations is not enough for developed regions, so the positive impact cannot be obtained.

In order to test whether there is a non-linear relationship in the impact of environmental regulations on smog, we introduce the quadratic term of environmental regulation for analysis. The results of nonlinear regression are shown in Table 3. From a national perspective (column1 of Table 2), environmental regulations have shown a significant inverted "U"-shaped impact on smog density. The critical point of the quadratic form is 39.3/(2×16.52)=1.19.

Table 2. Linear regression results of environmental regulations on smog

	Nationwide	***East***	***Central***	***West***
	Model 1	***Model 2***	***Model 3***	***Model 4***
GER	24.29***	28.96***	24.50***	-4.55*
	(1.84)	(2.48)	(3.82)	(2.69)
Control	YES	YES	YES	YES
Constant	28.34***	20.91***	23.11***	24.74***
	(1.41)	(1.98)	(2.51)	(1.82)
Year	Control	Control	Control	Control
Observations	3024	1694	714	616
Numbers	216	121	51	44

*Note: The standard deviations in parentheses, *, **, *** represent the significance levels of 10%, 5%, and 1%, respectively. Control is a control variable, specifically including a series of control variables described above. And the model controls the time effect.*

Table 3. Non-linear effects of environmental regulation on haze

	Nationwide	***East***	***Central***	***West***
	Model 1	***Model 2***	***Model 3***	***Model 4***
GER2	-16.52**	-38.36***	-15.00	-2.85
	(7.53)	(10.47)	(15.06)	(11.59)
GER2	39.30***	64.98***	37.80***	-2.16
	(7.08)	(10.14)	(13.90)	(10.08)
Control	YES	YES	YES	YES
Constant	25.66***	14.56***	20.94***	24.37***
	(1.86)	(2.63)	(3.33)	(2.37)
Year	Control	Control	Control	Control
Observations	3024	1694	714	616
Numbers	216	121	51	44

*Note: The standard deviations in parentheses, *, **, *** represent the significance levels of 10%, 5%, and 1%, respectively. Control is a control variable, specifically including a series of control variables described above. And the model controls the time effect.*

When the strength of environmental regulations is weak, not only can it not alleviate the environmental dilemma, but it will also increase pollution. Only high-strength environmental regulations can effectively reduce the concentration of smog and protect the environment. In terms of different regions, the intensity of environmental regulations in the eastern region also presents an inverted U-shaped trend of haze concentration (column 2 of Table 2). The critical point is 64.98/(2×38.36)=0.85.

The impact of environmental regulations on the haze concentration in the central region is similar to that in the eastern region, except that the nonlinearity is not significant (column 3 of Table 2). However, the intensity of environmental regulations in the western region has no non-linear influence on the haze concentration. The degree of influence of other control variables on each region is basically the same as the linear situation. This also further proves that economically developed areas need high-strength environmental regulations to deal with the problem of smog management.

3.2. Mediation effect

In order to in-depth explore and verify the path of environmental regulation on haze pollution control, this paper adds three intermediary variables on the basis of the models in Table 2 and Table 3, namely, industrial organization (IS), green construction (GREEN), and technological innovation (RD) to perform regression analysis. When the industrial structure (IS) is substituted into the above linear and nonlinear models as an intermediary variable, the results are as shown in Table 4. Model 1 (linear) and model 2 (non-linear) are to verify the impact of national environmental regulations on the industrial structure (IS). It is found that under the linear model, the intensity of environmental regulation has a significant positive impact on industrial institutions.

Under the non-linear model, the impact of the intensity of environmental regulations on industrial institutions presents an inverted U-shaped trend that first decreases and then increases. Model 3 and Model 4 add industrial structure (IS) as an intermediary variable on the basis of model 1 and model 2. The explained variable was changed from industrial structure (IS) to haze concentration (SMOG).

The regression results show that the regression coefficients of the industrial structure (IS) in Model 3 (linear) and Model 4 (non-linear) are -6.66 and -6.605, respectively. That is, the greater the proportion of the tertiary industry, the lower the smog concentration. Environmental regulations (GER) will significantly increase pollution. Model 4 shows that environmental regulation (GER) can increase or reduce the haze concentration (SMOG) by influencing industrial structure (IS). In this process, the mediating effect of industrial institutions is part of the mediating effect.

In the same way, the intermediary influence process of urban green construction (GREEN) and technological level (RD) is the same and significant as the industrial structure, and both are partial intermediary effects (Tables 5 and 6). Hypothesis 2 is proved.

4. Conclusions and recommendations

This paper selects China municipal panel data from 2003 to 2016 to examine the impact of environmental regulations on environmental quality, and further analyze the intermediary effects of industrial structure, green construction, and technological level on the relationship between the two.

The test results show that: (1) Across the country, the impact of environmental regulations on haze concentration presents an inverted U-shaped change, that is, environmental regulations at a lower level cannot control environmental pollution and require higher-intensity environmental regulatory policies to regulate.

Table 4. Regression results of industrial structure as an intermediary variable

	IS		*SMOG*	
	Model 1	***Model 2***	***Model 3***	***Model 4***
IS			-6.66***	-6.61***
			(0.59)	(0.60)
GER2		0.72***		-11.77*
		(0.24)		(3.38)
GER	0.11*	-0.55**	25.01***	35.70***
	(0.06)	(0.22)	(1.80)	(6.94)
Control	YES	YES	YES	YES
Constant	0.66***	0.78***	32.73***	30.79***
	(0.04)	(0.06)	(1.43)	(1.88)
Year	Control	Control	Control	Control
Observations	3024	3024	3024	3024
Numbers	216	216	216	216

*Note: The standard deviations in parentheses, *, **, *** represent the significance levels of 10%, 5%, and 1%, respectively. Control is a control variable, specifically including a series of control variables described above. And the model controls the time effect.*

Table 5. Regression results of urban green construction as an intermediary variable

	GREEN		*SMOG*	
	Model 1	***Model 2***	***Model 3***	***Model 4***
GREEN			-0.01*	-0.01*
			(0.01)	(0.01)
GER2		72.18**		-15.94**
		(30.41)		(7.53)
GER	26.12***	-91.68***	24.07***	38.56***
	(7.43)	(28.60)	(1.84)	(7.09)
Control	YES	YES	YES	YES
Constant	24.06***	35.74***	28.54***	25.95***
	(5.70)	(7.53)	(1.41)	(1.87)
Year	Control	Control	Control	Control
Observations	3024	3024	3024	3024
Numbers	216	216	216	216

*Note: The standard deviations in parentheses, *, **, *** represent the significance levels of 10%, 5%, and 1%, respectively. Control is a control variable, specifically including a series of control variables described above. The model controls the time effect.*

Table 6. Regression results of technological innovation as an intermediary variable

	RD		*SMOG*	
	Model 1	***Model 2***	***Model 3***	***Model 4***
RD			-0.01***	-0.01***
			(0.00)	(0.00)
GER2		3.68***		-18.75**
		(1.01)		(7.52)
GER	9.80***	-2.36**	23.72***	40.73***
	(2.47)	(0.95)	(1.84)	(7.07)
Control	YES	YES	YES	YES
Constant	-768.20***	-172.10	28.78***	25.77***
	(189.40)	(249.90)	(1.41)	(1.86)
Year	Control	Control	Control	Control
Observations	3024	3024	3024	3024
Numbers	216	216	216	216

*Note: The standard deviations in parentheses, *, **, *** represent the significance levels of 10%, 5%, and 1%, respectively. Control is a control variable, specifically including a series of control variables described above. And the model controls the time effect.*

(2) Nationally, industrial structure, green construction, and technological level will indirectly affect the impact of environmental regulations on smog. There is a partial intermediary effect.

(3) In terms of regions, there are regional differences in the impact of environmental regulation on environmental pollution, that is, in areas with low pollution and low level of economic development, environmental regulation has a linear relationship with haze concentration. Improving environmental regulation can reduce haze concentration. However, for areas with high pollution and more developed economy, environmental regulation has an inverted U-shaped impact on haze concentration, that is, environmental regulation with high intensity can significantly reduce haze concentration in economically developed areas and give play to the "forced" theory. The research conclusions can provide guidance for alleviating haze pollution in Chinese cities, help improve urban air quality and drive the sustainable and healthy development of urban economy

First, environmental regulation should be formulated according to local conditions. In the eastern and central regions, the impact of environmental regulation on haze concentration shows an inverted "U" trend, while the impact of environmental regulation on haze concentration in the western region is linear and negative. In the stage of China's economy from high-speed growth to high-quality growth, it is necessary to appropriately strengthen environmental regulation, but we should not rush for success.

Second, at the national level, since environmental regulation can indirectly affect haze control through the adjustment of industrial structure, we must adjust the development ideas of high pollution and high energy consumption industries, focus on optimizing the internal structure of manufacturing industry, resolutely eliminate backward production capacity, and orderly promote haze control in areas with high pollution industries, Formulate targeted and operable haze regulation measures, strengthen regional joint prevention and control, and reduce the decline of environmental regulation effect caused by pollution spillover.

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