

Governance Mechanisms of Confucian Culture on Sewage Discharge of Industrial Enterprises: Considering the Mediating Role of Public Environmental Concerns

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Abstract. Based on the data consisting of 3743 city-year observations in China from 2011 to 2022, this study utilizes the multi-dimensional fixed-effects panel regression models and the Bootstrap test method to analyze the impact of Confucian culture on the sewage discharge of industrial enterprises as well as the mediating role of public environmental concerns in the relationship between the two. The empirical results show that Confucian culture, as a representative of environmentally friendly social culture, can significantly improve the situation of sewage discharge of industrial enterprises. The mechanism analysis suggests that Confucian culture greatly improves public environmental concerns by effectively shaping and guiding public attitudes and behaviors, which in turn strengthens informal environmental monitoring and inhibits sewage discharge of industrial enterprises. In addition, this study further confirms that the informal environmental monitoring mechanisms (Confucian culture, public environmental concerns) and formal environmental monitoring mechanisms (government environmental regulations) can play a synergistic and strengthening role in the governance of sewage discharge.

Keywords: Confucian culture; public environmental concerns; sewage discharge; government environmental regulations; mediating effect.

1. Introduction

In recent years, China's rapid industrialization has strongly supported economic development and improved people's living standards. However, the accompanying problem is that environmental pollution, especially the issue of sewage discharge, has become increasingly severe along with economic development and cannot be ignored. In fact, the extensive economic development pattern led to the discharge of nearly 65 billion tons of sewage in 2022. The fundamental and trend-based pressures on the supervision and protection of China's water ecological environment have not been fundamentally alleviated. Faced with this significant pressure of water pollution, the Chinese government has issued a number of formal environmental regulatory measures in the form of government decrees. Many existing studies have explored the governance effect of government environmental regulations (GERs) on sewage discharge from the perspective of formal environmental monitoring mechanisms [1, 2]. However, there is a lack of research on the impact of informal environmental monitoring mechanisms. This study argues that GERs require close cooperation with informal environmental monitoring mechanisms, such as the public environmental concerns (PECs), and the prerequisite for this cooperation is an environmentally friendly social culture. In China, Confucian culture has the characteristics of being environmentally friendly. There is no doubt that Confucian culture, which represents the mainstream values of Chinese social culture, plays an important role in shaping and guiding the public's attitudes and behaviors, and has potential supervisory and governance effectiveness for sewage treatment.

Therefore, in view of the fact that limited literature has explored the sewage treatment effect of the informal environmental supervision mechanism of PECs from the perspective of social culture, this study attempts to explore whether Confucian culture, being used to represent the environmentally friendly social culture, can reduce sewage discharge and achieve sewage treatment by promoting PECs, based on the city-level data of China from 2011 to 2022.

2. Methodology

2.1 Hypothesis

Regarding the impact of Confucian culture on PECs, the analysis can be carried out from the following two perspectives. First, from the perspective of ethical norms, the concepts of "Harmony between man and nature" and "Loving the people and cherishing all things" in Confucian culture are helpful for shaping the public's awareness of ecological responsibility through ethical norms. For example, YANG Zhonghai and LIU Jinqi(2024) [3] found in their research that the public in Confucian cultural circles is more likely to accept the ethical positioning of "Humans as trustees of nature", and their environmental concern level is significantly higher than that in non-Confucian regions. Second, from the perspective of the restraining effect of social norms, the social network constructed by the Confucian ideology of "Balance between the individual and the group" has a unique environmental governance effect. The collectivist tendency influenced by Confucian culture makes individuals pay more attention to the positive externality of environmental behaviors [4]. For example, based on the theory of public resource governance, Ostrom (2009) [5] confirmed that in communities with Confucian institutional carriers such as ancestral halls and village compacts, the probability of residents spontaneously maintaining the ecological environment is increased.

Regarding the impact of PECs on the sewage discharge of industrial enterprises, the analysis can be carried out from at least the following two perspectives. First, from the perspective of the reputation restraint mechanism, PECs forms a real-time public opinion supervision network through new media platforms, forcing enterprises to strengthen environmental compliance. For example, when the public exposes the sewage discharge behavior of enterprises through environmental complaint platforms or the Internet, the stock price of the enterprises will immediately decline, reflecting the sensitivity of the capital market to negative environmental events. This "Reputation-Market Value" linkage mechanism prompts enterprises to take the initiative to optimize sewage treatment facilities to avoid the increase in financing costs and operational risks caused by public opinion crises. Second, from the perspective of the synergistic strengthening effect of government supervision, informal environmental regulation is frequently regarded as a potent complement to formal environmental regulation implemented by governments [6], public environmental demands will be transformed into institutional pressure through policy advocacy channels such as proposals from environmental protection organizations and suggestions from the People's Congress and the Chinese People's Political Consultative Conference. This transmission path of "Public Demands-Strengthened Supervision" increases the cost of illegal sewage discharge by enterprises.

Based on the above analysis, the following hypothesis can be proposed:

H1: The intensity of Confucian culture can restrain the sewage discharge of industrial enterprises in the region by promoting PECs.

2.2 Benchmark Model

Given that the recursive model of the mediating effect integrated with the Bootstrap test is a commonly used method for testing mediating mechanisms, this study follows the method and constructs the following three empirical models:

$$Sd_{it} = \varphi_0 + \varphi_1 Cc_{it} + \varphi_2 CV_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (1)$$

Where i represents the city; t represents the year; Sd_{it} is the sewage discharge of industrial enterprises in the city; CV_{it} is the vector matrix of control variables; Cc_{it} is the intensity of Confucian culture in the region; μ_i and θ_t are the fixed effects of the city and the year respectively; ε_{it} is the random disturbance term. The core parameter examined in this model is φ_1 . If φ_1 is significantly negative, it can be inferred that Confucian culture can decrease sewage discharge.

$$Pea_{it} = \varphi_0 + \varphi_1 Cc_{it} + \varphi_2 CV_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (2)$$

In Model(2), Pea_{it} is the logarithm of PECs, and other parameters are the same as in Model(1).

The core parameter examined in this model is φ_1 . If φ_1 is significantly positive, it can be inferred that Confucian culture can promote PECs.

$$Sd_{it} = \varphi_0 + \varphi_1 Cc_{it} + \varphi_2 Pea_{it} + \varphi_3 CV_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (3)$$

The core parameters examined in Model(3) are φ_1 and φ_2 . If the absolute value of φ_1 in this model is smaller than that in Model (1), and φ_2 is significantly negative, it can be inferred that Confucian culture can reduce urban sewage discharge through the mediating effect of PECs.

2.3 Variable Design

Dependent variable: City sewage discharge intensity (Sd). Drawing on the ideas of Lai Yongjian and He Xiangmin (2025) [7], Sd is measured by the ratio of the actual sewage water discharge volume of the city to the industrial added value of that year. This variable is logarithmized.

Independent variable: Intensity of Confucian culture (Cc). The dense distribution of Confucius Temples within a given area not only reflects the depth of the influence of Confucian culture in the history of this region but also reveals the important role of Confucian culture in aspects such as the development of ideology and culture, economic development, and the cultivation of residents' personalities [8]. Drawing on the approach of Ning Zhang et al.(2021) [9], the latitude and longitude coordinates of each Confucius Temple and each city are manually searched on Baidu Maps. Then, according to the latitude and longitude coordinates, the number of Confucius Temples within a radius of 200 kilometers from the city center of each city is counted, and after adding 1, the natural logarithm is taken to obtain the intensity of Confucian culture(Cc).

Mediating variable: PECs (Pec). Drawing on the research of Chuandong Li et al.(2024) [10], the average annual value of Baidu search index of 25 specific environmental keywords is used to measure PECs. The reason for choosing this index is that the public has a high perception of environmental pollution, and as a Chinese search engine, Baidu has a wide search coverage.

Control variables: Drawing on the research of Yang et al (2024) , and Wang et al (2024) and Lai Yongjian(2025) [1, 2, 7], five control variables are selected. Economic development level (LnGDP) is measured by taking the logarithm of the per capita GDP of the city; Industrial structure (Is) is represented by the sum of the percentages of the secondary and tertiary industries in the regional gross domestic product; Fiscal intervention (Fg) is measured by the percentage of fiscal expenditure to GDP; Foreign direct investment (Fi) is measured by taking the logarithm of the value obtained by adding 1 to the percentage of the actual utilized foreign capital to GDP; Minimum wage level (lp) is measured by taking the logarithm of the local minimum monthly wage.

2.4 Data Sources

Considering the consistency and availability of data for some cities over time, this study ultimately selects 213 prefecture-level cities as the research objects. Among them, the proportions of cities in the eastern, central, and western regions are 51%, 27%, and 22% respectively. In addition, considering the update of the latest data, the sample period from 2011 to 2022 is chosen, and the sample consists of 3743 city-year observations.

The data mainly come from China Regional Economic Statistical Yearbook, China City Statistical Yearbook, China Environmental Statistical Yearbook, and the China Economics Net Database. The data on PECs are obtained from the Baidu Search Index. Individual data are sourced from the China Stock Market & Accounting Research Database(CSMAR).

3. Empirical Results

3.1 Main Results

The regression results of Model (1)-(3) are presented in panel A of Table 1. In column (1), the regression coefficient of Confucian culture (Cc) with respect to sewage discharge intensity (Sd) is significantly negative, reaching significance at the 1% level ($B = -0.365$). This indicates that

Confucian culture can restrain sewage discharge. Column (2) shows that the regression coefficient of Confucian culture (Cc) relative to PECs (Pec) is significantly positive, also significant at the 1% level ($B = 0.053$), suggesting that Confucian culture can promote PECs. In column (3), the regression coefficient of Confucian culture (Cc) relative to sewage discharge intensity (Sd) remains significantly negative, yet with a weaker impact ($B = -0.302$). Meanwhile, the regression coefficient of PECs (Pec) relative to sewage discharge intensity (Sd) is also significantly negative ($B = -0.992$). This implies that Confucian culture can reduce sewage discharge by promoting PECs. The results of the Bootstrap test are shown in panel B of Table 1. These results confirm the validity of the mediating mechanism of PECs, with the mediating effect accounting for 14.5%. Thus, H1 holds.

Table 1. Test results on the Mediating Mechanism of PECs

Panel A						
Columns	(1)		(2)		(3)	
Variables	Sd		Pec		Sd	
LnGDP	-0.768**(-11.247)		0.274** (16.164)		-0.495**(-6.979)	
Is	4.484** (15.372)		-0.451**(-6.225)		4.037** (14.116)	
Fg	-0.772**(-11.593)		-0.072**(-4.339)		-0.844**(-12.992)	
Fi	0.149** (9.038)		0.006(1.411)		0.155** (9.677)	
lp	0.358** (3.264)		0.565** (20.700)		0.919** (7.724)	
Cc	-0.365**(-28.007)		0.053** (16.395)		-0.302**(-21.989)	
Pec					-0.992**(-10.551)	
(Constants)	-7.731**(-4.559)		1.723** (4.087)		-6.022**(-3.645)	
City/Year Fixed Effects	Yes		Yes		Yes	
Adj R ²	0.460		0.620		0.492	
Panel B						
Path	Meaning	Effect	95% CI Lower Limit	95% CI Upper Limit	z/t	P
Cc=>Pec=>Sd	indirect effect	-0.053	-0.102	-0.056	-4.584	0.000
Cc=>Sd	Direct effect	-0.312	-0.339	-0.285	-22.989	0.000

Note: * $p < 0.05$ ** $p < 0.01$, with t - values in parentheses; The type of bootstrap is the percentile bootstrap method; The F - values of all models are far beyond the significant critical value. The same below.

3.2 Robustness Tests

This study conducts the following multiple robustness tests.

(1) Variable substitution. Firstly, the change in city sewage discharge intensity (ΔSd) is used to replace Sd. The mediating effect still holds, indicating that Confucian culture can slow down the growth of urban sewage discharge intensity by strengthening PECs. Secondly, drawing on the research of Weijie Jiang and Hui Yu (2024) [11], the logarithm of the number of Jinshi in each city during the Ming and Qing Dynasties plus 1 is used as a measurement indicator (Cc_Jinshi) to replace Cc. The regression is carried out again according to Model (1)-(3), and the results remain unchanged. Thirdly, the logarithm of the frequency of negative media reports on the environmental issues of each city plus 1 (Mea) is used to replace Pec. The regression is carried out again according to Model (1)-(3), and the results remain unchanged.

(2) Excluding city samples without Jinshi. Generally speaking, regions without Jinshi are less influenced by Confucian culture, but it does not rule out the situation of being strongly influenced by other cultures and local customs. Therefore, excluding this part of the data in this paper, the regression results still confirm H1.

(3) Introducing the interaction effect of province and year. To further eliminate the interfering factors in the benchmark regression results, the interaction effect of province and year is introduced into Model (1)-(3) for robustness testing. The results still hold.

3.3 Endogeneity Test

Drawing on the approach of Wang Wenkai (2021) [12], we use the shortest distances from different cities to the five origins, namely Qufu Confucius Temple, Beijing Confucius Temple (Guozijian), Nanjing Confucius Temple, Hangzhou Confucian Temple, and Chaoyang Confucian Temple, as the instrumental variable for Confucian culture (CC_Instrument).

Equation (4) represents the first-stage equation for the instrumental variable test. Here, Confucian culture (Cc) is the explained variable, CC_Instrument is the instrumental variable for Confucian culture, and the meanings of the remaining variables are the same as those in Model (1). The fitted value of Confucian culture obtained from the regression of Model(4) is substituted into Model(5) for the second-stage regression. The coefficient of the instrumental variable in the first stage is significantly negative, as expected, and the F-value is much larger than the critical value of 10, indicating no weak-instrument variable problem. From the second-stage regression results, it can be seen that they are consistent with the benchmark regression results. Confucian culture has a significant inhibitory effect on sewage discharge. After considering the endogeneity problem, the empirical results remain unchanged. It should be noted that the endogeneity test is only applicable to Model (1) and does not take into account the mediating effect test.

3.4 Further exploration

We attempt to further examine whether Confucian culture can restrain sewage discharge at the city level by promoting GERs. Drawing on the research of Shen Chen et al. (2024) [13], the study measures the intensity of government environmental regulation (Ger) by the ratio of "the logarithm of the frequency of words related to GERs in the government work report" to "the logarithm of the number of words in the government work report", where the text analysis method is adopted. Using Ger as the mediating variable to replace Pec in Model (2) and Model (3), we conduct regression analysis again. The results in Table 2 confirm the existence of the mediating effect of GERs, and the intensity of the mediating effect is 10.3%. Evidently, Confucian culture, as an informal environmental monitoring mechanism, and GERs, as a formal environmental monitoring mechanism, can play a synergistic and strengthening role in the governance of sewage discharge.

Table 2. Test results on the Mediating Mechanism of Governmental Environmental Regulations

Panel A						
Columns	(1)		(2)		(3)	
Variables	Sd		Ger		Sd	
Cc	-0.365**(-28.007)		0.026**(9.248)		-0.327**(-25.800)	
Ger					-1.454**(-13.617)	
(Constants)	-7.731**(-4.559)		-0.470(-1.293)		-8.416**(-5.219)	
CV	Yes		Yes		Yes	
City/Year Fixed Effects	Yes		Yes		Yes	
Adj R ²	0.460		0.131		0.512	
Panel B						
Path	Meaning	Effect	95% CI Lower Limit	95% CI Upper Limit	Z/t	P
Cc=>Ger=>Sd	indirect effect	-0.053	-0.102	-0.056	-4.584	0.000
Cc=>Sd	Direct effect	-0.312	-0.339	-0.285	-22.989	0.000

In addition, to further examine the synergistic effect between Confucian culture and specific environmental regulation policies, we divided all sample cities into carbon pilot cities and non-carbon pilot cities. We applied Model (1) to fit the samples of the two types of cities respectively and compared the results. In carbon pilot cities, the inhibitory effect of Confucian culture on sewage discharge is significantly stronger. This result indicates that the carbon pilot

policy promotes the effectiveness of Confucian culture in sewage treatment, and there is a synergistic effect between the two. Due to space constraints, results are available upon request.

4. Conclusions

Based on the city-level data of sewage discharge and Confucian culture from 2011 to 2022, this study explores the promoting effect of Confucian culture on PECs and its governance. The results show that: (1) Confucian culture has a positive impact on PECs, which helps to enhance the intensity of informal environmental monitoring; (2) PECs can restrain sewage discharge, indicating the necessity of emphasizing the informal environmental monitoring mechanism in environmental governance; (3) Confucian culture can improve the governance effectiveness of sewage discharge through the mediating mechanisms of PECs and GERS.

The above research conclusions provide valuable practical implications for public policies. On the one hand, when formulating environmental regulation policies, public policy-makers such as the government should fully consider regional cultural factors, especially the influence of Confucian culture. In regions deeply influenced by Confucian culture, Confucian culture can be combined with environmental regulation policies to formulate more targeted and effective policy measures. On the other hand, recognizing the role of Confucian culture in enhancing the effectiveness of sewage discharge governance through the mediating mechanisms of PECs and GERS, the government should actively promote the coordinated development of formal environmental regulations and informal environmental monitoring mechanisms.

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