Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2020.26349

205 (2020) 208–213
November

Effects of heterogeneous environmental regulation on the control of water pollution discharge

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Received 17 January 2020; Accepted 11 July 2020

ABSTRACT

The development of ecological civilization and quality of economic development has once again highlighted the problem of environmental pollution, which has aroused extensive discussions from all walks of life. Given that command-control, market-incentive, and public-participation environment planning functions are different, command-control they cannot be replaced by each other. Therefore, this paper makes three innovations: first, this paper analyzed and compared the effects of various environmental regulations on the polluted water emissions; second, the paper examined the synergistic effects of environmental regulations; third, the paper analyzed the heterogeneity among regions. Based on the heterogeneous environmental regulations, this paper analyzed the relationship between different types of environmental regulations and the combination of environmental regulations, and the management of water pollution. The results show that the command-control type, market incentive type and public participation type environmental regulation have enhanced the quality of the water environment to varying degrees. Among the three types, the public participation type is the most effective, followed by the command-control type and market incentive type. In the eastern region, only environmental regulations from public participation have formed effective incentives. In the western region, command-control environmental regulations and market incentive environmental regulations become effective governance.

Keywords: Public participation; Environmental governance; Environmental regulation mix; Regional heterogeneity

1. Introduction

Water is the vein of human life. The water quality determines the living conditions of human beings [1]. Water is an important indicator of livelihood and can reflect the ecological civilization development level [2–4]. At present, most regions in China are short of water resources. There is an increasing demand for water resources. However, water ecology is destroyed and water pollution incidents emerge continuously. Water pollution is becoming more and more serious, and become concerns of all sectors of society [5–7]. According to the results of the surface water monitoring network, the discharge of water pollutants in the whole country and the key drainage areas decreased significantly since the outbreak of Covid-19 in China. The proportion of the quality surface water sections increased year on year, while class V decreased year on year. In February

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2020, in 1934 national surface water assessment sections, the proportion of sections with quality water (class I–III) is 79.9%, an increase of 4.9% year on year; the proportion of sections with class V poor quality water is 2.2%, a decrease of 4.4% year on year. The main pollution indexes include chemical oxygen demand, total phosphorus and permanganate index.

China is in the economic and social transition. The progress in water quality improvement cannot meet the growing demand for environmental quality, so the water quality problem has become not only an increasingly salient obstacle to economic transition but also an important drive. In order to control environmental pollution, China learns from the experience and lessons of western industrialized countries. Furthermore, the Chinese government has abandoned the strategy of "pollution first and then treatment". Instead, it came up with the idea of "prioritizing water conservation, spatial balance, systematic treatment and concerted efforts" and has introduced a series of policies. Government pollution control, enterprise pollution reduction and public supervision complement each other. The combination of the three can slow down the discharge of water pollution. As of policy guidance, environmental regulation implements the reward and punishment mechanism to reduce environmental pollution according to the emission standards and rules and regulations. In the implementation, it gradually forces or guides enterprises to carry out technological innovation.

The effect of different environmental regulations and the interaction of different environmental regulations on water pollution treatment will be different because water environment treatment in different regions varies. There is regional heterogeneity in the effect of environmental regulation. Based on provincial panel data, this paper empirically tests and analyzes the above-mentioned problems.

Environmental regulation has been studied for a long time. Based on the data on the related studies on the enterprises in the United States and Canada in the 1990s, Magat and Viscusi [8] studied how environmental governance policies would affect the emissions of environmental pollutants, such as biological oxygen demand and solid suspended solids, and found that environmental governance policies had certain influences. According to the functional subjects, environmental regulation can be divided into three types: command-control, market incentive and public participation types.

Bauman et al. [9] believed that the command-control type for environmental regulation could reduce the cost curve of edge pollution control. According to Kathuria [10], the market-based environmental policies often had poor governance effect. As public participation emerged in the 1950s, Martineau-Delisle and Nadeau [11] found that public participation could cultivate trust in environmental protection institutions by using the case study method. Zheng et al. [12] the effects of public participation in environmental protection can be divided into outcome effect, procedural effect and reflective effect. Zhang et al. [13] believed that public participation could alleviate environmental pollution problems as the public would affect how the government invests in environmental protection and adjusts the industrial structure after research. Song et al. [14] studied the impact of environmental regulation and industrial structure on haze pollution in China from the two perspectives of independence and linkage. Song et al. [14] analyzed the impact of environmental regulation on enterprise innovation. Zhang et al. [15] studied the impact of environmental regulation on haze pollution control.

At present, the academic research on the effects of environmental regulation on pollution control mainly focuses on the analysis and comparison of single environmental regulation on environmental pollution control. However, environmental pollution control cannot be solved overnight. The sole efforts from one authority cannot change to solve all the environmental pollution. Environmental pollution can only be solved by the coordination and interaction between environmental regulations, but at present, the research on the combination of environmental regulations is still relatively in the shortage. Based on the provincial panel data except for Hong Kong, Macao and Tibet from 2004 to 2017, this paper comprehensively discusses the effects of environmental regulations and their interactions on water pollution treatment, and further explores the regional heterogeneity of environmental regulations, so as to reveal the combined effect of various environmental regulations.

2. Model establishment and variable selection

The panel regression model is adopted to estimate the relationship between different environmental regulations, different regions and different environmental regulation combinations and water environmental pollution control. The model is shown as follows:

$$\begin{aligned}\mathrm{Lnpol}_{i,t} = {} & \alpha_0 + \alpha_1 \mathrm{Lnpepc}_{i,t} + \alpha_2 \mathrm{Lnpub}_{i,t} + \alpha_3 \mathrm{Lnpsc}_{i,t} + \\ & \alpha_4 \mathrm{Lnpepc}_{i,t} \times \mathrm{Lnpub}_{i,t} + \alpha_5 \mathrm{Lnpepc}_{i,t} \times \mathrm{Lnpsc}_{i,t} + \\ & \alpha_6 \mathrm{Lnpepc}_{i,t} \times \mathrm{Lnpub}_{i,t} \times \mathrm{Lnpsc}_{i,t} + \alpha_7 \mathrm{Lnpub}_{i,t} \times \\ & \mathrm{Lnpsc}_{i,t} + \alpha_j X_{i,t} + \mu_{i,t}\end{aligned} \quad (1)$$

In Eq. (1), pol refers to the emission intensity of environmental water pollution in each province and city. pepc, pub and psc mean the command-control environmental regulation, the public participation environmental regulation and the market incentive environmental regulation respectively. The command-control environmental regulation is expressed as the per capita investment in environmental pollution control [16], Deputies to the National People's Congress (NPC) and members of the Chinese People's Political Consultative Conference (CPPCC) come from all walks of life, with a wide range of knowledge and a high level. They are the authority of public participation. Therefore, the proposals of the NPC and the CPPCC per capita are used to express the public participation type, and the amount of per capita emission fee to be paid to the warehousing households is used to express the market incentive type [17]. X is the other control variables that affect the intensity of water pollution discharge, mainly including trade openness, the urbanization process, expenditure on science and technology, population size. μ is the residual term. Among them, trade openness is measured by the proportion of total import and export to GDP, urbanization is calculated by the urbanization rate, science and technology expenditure is based on the proportion of science and technology expenditure in financial expenditure, and population size is measured by population density. The data used in this paper are from the Statistical Yearbook of China

(2005–2018) and the Environmental Statistical Yearbook of China (2005–2018).

3. Empirical test results

3.1. Effects of different types of environmental regulations and combinations on the environmental treatment of water pollution

As shown in Table 1, different types of environmental regulations and different combinations of environmental regulations can improve water pollution intensity. According to Table 1, the command-control type, market incentive type and public participation type can improve the water environment to a certain extent. The command-control type restrains water pollution at a significant level of 10%. When the per capita investment in environmental management increases by one unit, the water pollution intensity will decrease by 1.694 units. Market incentive environmental regulation restrains water pollution at a significant level of 10%. When the per capita discharge increases by 1%, the environmental intensity of water pollution will decrease by 0.821%. Public participation type can significantly control water pollution at a significant level of 5%. For every 1% increase in the number of proposals put forward by local NPC and CPPCC, the intensity of water pollution will decrease by 2.404%.

Comparing the command-control type, the market incentive type and the public participation type, the public participation one has the most obvious effect in the environmental regulation, followed by the command-control, the market incentive has the least effective. Three types of environmental regulations have varied in the effects on environmental governance. It is mainly due to the fact that deputies of the National People's Congress and members of the Chinese People's Political Consultative Conference also suffer from water pollution. Therefore, they propose local government legislation demands based on reality. At the same time, these proposals can mobilize the enterprises, consumers, and the entrepreneurs who know so well about the pollution status quo and enterprise improvement, to offer their opinions and suggestions in detail. Their suggestions are more reasonable and can draw attention from the government. Local governments can make decisions based on the public's feedback on the environment, so as to make up for the shortcomings in environmental protection management.

With the continuous improvement of the market mechanism, the pollution discharge fee is paid by the enterprises according to the types and quantity of the disposal. Therefore, enterprises can be mobilized. Enterprises arrange production and business activities based on the principle of profit maximization and further carry out technological innovation. Command-control environmental regulation is mandatory. It manages environmental pollution administratively and could increase the enterprise's burden within a short time. Although enterprises can make up for the negative effect through innovation compensation, the overall effects of water environment treatment are poor.

By studying various combinations of environmental regulations, the combinations of command-control and public participation, that of market incentive and public participation, and that of command-control, market incentive and public participation pass the significance test.

Among these combinations, a combination of command-control and public participation has the optimal treatment effect, with the estimation coefficient of 0.739. The possible reason may be that with the increase in people's living standards, the public's environmental awareness is increasing generally. Also, the government encourages speech freedom. As a channel for expressing people's willingness, NPC and CPPCC proposals can guide the behaviors of local government and improve the governmental function on environmental protection from top-down.

The combination of market incentive and public participation, with the elasticity coefficient of 0.300, ranks the second in terms of the effectiveness. By combining market incentives and public participation, the consumption

Table 1
Impact estimation results of different environmental regulations and combinations on water pollution environmental treatment

Variable	Coefficient	Robust standard error	*t*	*P*	95% Conf. Interval	
lnpepc	–1.694*	0.8755	–1.94	0.063	–3.4847	0.0965
lnpub	–2.404**	1.1704	–2.05	0.049	–4.7980	–0.0105
lnpsc	–0.821*	0.4228	–1.94	0.062	–1.6854	0.0440
Lnpepc × lnpub	–0.739**	0.3546	–2.08	0.046	–1.4641	–0.0138
lnpepc × lnpsc	–0.218	0.1313	–1.66	0.108	–0.4863	0.0507
lnpub × lnpsc	–0.300*	0.1749	–1.72	0.097	–0.6578	0.0574
lnpepc × lnpub × lnpsc	–0.0996*	0.0523	–1.90	0.067	–0.2067	0.0075
lnopen	–0.212	0.1447	–1.47	0.153	–0.5082	0.0837
lnurb	–1.579*	0.8402	–1.88	0.070	–3.2971	0.1398
lntec	–0.308***	0.0636	–4.84	0.000	–0.4379	–0.1778
lnpop	–1.535***	0.4299	–3.57	0.001	–2.4148	–0.6562
_cons	0.403	3.6638	0.11	0.913	–7.0898	7.8966
Adj. R^2			0.7186			
N			420			

Note: *, **, *** were significant at 10%, 5% and 1%, respectively.

habits of the public could urge the enterprise to discharge the wastes in a better manner.

The combination of command-control and the market incentive is in third place, with the estimation coefficient of 0.218; however, it does not pass the significance test. Local governments put in funds for environmental governance to solve environmental problems, but did not use measures such as industrial upgrading for effective prevention and control. Local governments support the development of innovative and environmentally friendly enterprises. Green-tech enterprises make profits, but heavy pollution enterprises are affected by simple and crude administrative orders such as shutdown. At present, there is no effective balance between the two environmental regulations, so the effect is not significant.

The combination of command-control, market incentive and public participation is the least effective, with the estimation coefficient of only 0.0996. Theoretically, the combination of these three environmental regulations should be the most powerful in controlling environmental pollution. The reason could be that these three regulations are not well coordinated and the constraint and supervision mechanism is imperfect.

Urbanization, expenditure on science and technology and population all could improve water environmental pollution greatly. The elasticity coefficients of the three show that the intensity of water pollution emission will be reduced by 1.579%, 0.308% and 1.535% respectively when the urbanization level, the proportion of science and technology expenditure in financial expenditure and the population density are increased by 1%.

3.2. Influence of environmental regulations and combinations of different types in different areas on environmental governance of water pollution

Different environmental regulations and combinations of environmental regulations can positively improve the intensity control of water pollution and water discharge all over China; however, as China has a large territory, the intensity of water pollution discharge, investment in environmental governance and public participation vary from region to region. Therefore, regional heterogeneity research is conducted: researchers have divided China into the east, the middle and the west region. The estimation results are shown in Table 2. The adjusted R^2 are 0.7826, 0.8149 and 0.8320, respectively, with a high degree of the fitting. Through horizontal comparison, the influences of the environmental regulations of all the regions on water pollution are proven to vary greatly.

In the west, command-control environmental regulation can significantly improve the intensity of water pollution, but in the east and the middle, it has no significant effect. In the western region, investment in environmental governance is mainly used for infrastructure construction, because this kind of environmental regulation can improve environmental pollution in a very short period of time. However, investment in environmental governance in the east and the middle has long-lasting effects, which could not be seen within a short time. This differs from the results of Zhang and Chen [18] and partially conforms to the conclusions of Sun and Liu [19].

Public participation type in the east has restricted the intensity of water pollution. Though public participation in the west does harm to the water environmental pollution control, such influence is not significant, indicating that the method cannot greatly help alleviate the water pollution. This conforms to the research conclusion of Yu [20] and partially conforms to the study results of Lan and Chen [21].

Market incentive type in the west could help alleviate the intensity of water pollution, and pollution discharge fees in the east can negatively affect water pollution emissions, but there is no statistical proof.

For different environmental regulation combinations, the combination of command-control and public participation as well as environmental regulations both in the east and

Table 2
Regression results of different environmental regulations on water pollution intensity in the Eastern, Central and Western of China

Variable	Eastern China	Central China	Western China
lnpepc	–1.723 (–1.10)	0.132 (0.08)	–1.932* (–2.07)
lnpub	–4.613** (–2.24)	0.248 (0.15)	–2.217 (–1.63)
lnpsc	–1.136 (–1.43)	0.104 (0.11)	–0.905* (–1.94)
Lnpepc × lnpub	–1.115* (–1.95)	–0.0363 (–0.08)	–0.795* (–1.86)
lnpepc × lnpsc	–0.163 (–0.69)	0.00307 (0.01)	–0.273* (–2.07)
lnpub × lnpsc	–0.596* (–2.01)	0.0236 (0.08)	–0.308 (–1.54)
lnpepc × lnpub × lnpsc	–0.140 (–1.69)	–0.0135 (–0.18)	–0.112* (–1.86)
lnopen	0.183 (1.00)	0.0005 (0.00)	–0.450** (–2.54)
lnurb	–0.517 (–1.33)	–3.115*** (–5.25)	–3.985*** (–4.72)
lntec	–0.284*** (–4.24)	–0.0839 (–0.86)	–0.163* (–1.97)
lnpop	–1.584*** (–3.90)	–2.755 (–0.92)	–0.394 (–0.66)
_cons	0.462 (0.07)	14.98 (0.73)	–8.150** (–3.04)
Adj. R^2	0.7826	0.8149	0.8320
N	154	112	154

Note: *t* value in parentheses,*, ***, *** were significant at 10%, 5% and 1%, respectively.

in the west will negatively affect water pollution, but this combination has no significant impact on the central region. A combination of command-control and market incentive environmental regulations in the west has significant negative effects on water pollution, while that in the east is not significant. A combination of market incentive and public participation regulations in the east helps to reduce the intensity of water pollution but has no significant effect on the western region. A combination of command-control, market incentive and public participation environmental regulations are beneficial to control water pollution, but it is not significant in the east and the middle areas.

The estimation coefficient of market openness on the discharge of water pollution is 0.450 in the west, which is larger than that of China. The market openness on the discharge of water pollution has not so significant influence in the east and the middle of China. The regression coefficient of urbanization on the discharge of water pollution is 3.115 and 3.985 respectively in the middle and the west, but it is not significant in the east. Influences of expenditure on science and technology on the discharge of water pollution are significant in both the east and the west, but it is not significant in the west, which has proven the research conclusions from Li and Li [22]. The regression coefficient of population density on the discharge of water pollution is 1.584 in the east, but it is not significant in the middle and in the west.

4. Research conclusions and reflection

The environmental issue cannot be ignored in China despite the quality of economic development. Especially, given the shortage of water resources in China, water pollution has become a major obstacle to economic and social development and people's livelihood. Therefore, it is of theoretical and practical significance to study the influences of different environmental regulations on the discharge of water pollution. Based on the data from 30 provinces of China (excluding Hong Kong, Macao, Taiwan and Tibet) from 2004 to 2017, this paper analyzes how the different environmental regulations and combinations of environmental regulations can affect the intensity of discharge of water pollution. Research findings are as follows: Command-control, market incentive and public participation types are important driving forces to promote environmental governance of water pollution in China. Reasonable utilization of various environmental regulations is key to promoting the joint governance on water pollution; the public participation type is the most effective in alleviating discharge of water pollution, followed by command-control and market incentive types; Different types can achieve varied results in the east, the middle and the west: There are no significant interactions between different environmental regulations and different combinations of environmental regulations in the middle area; in the east, the combination of command-control and public participation and the combination of public participation and the market incentive is significantly effective. In the west, the combination of command-control and public participation, a combination of command-control and market incentive and a combination of command-control, public participation and the market incentive is significantly effective.

Given the above research findings, policy implications are proposed as follows, first, at present, it is a trend to control water pollution through environmental regulations. Local government should not only attach importance to investment in environmental governance but also strengthen public participation, especially through the public participation from the NPC and CPPCC proposals so as to promote the efficiency of public participation. Second, it is prone to form the trap of "racing at the bottom" in the command-control environmental regulation. When making the command-control environmental regulation, government authorities must rely on the market to establish more flexible emission charging standards, so that enterprises can give full play to their autonomy and perfectly control the pollution; Third, for regions with serious water pollution, local governments should change the mindset of "GDP first", establish a long-term mechanism of joint prevention and control, guide consumers to move toward green consumption, force high pollution enterprises to transform and upgrade, comprehensively promote water pollution control in China, and jointly promote ecological development. Fourth, based on the regional differences, on the prerequisite of maintaining the effect of traditional measures on the treatment of water pollution discharge, the eastern region gives full play to the advantages of public participation in politics and increases the combination of public participation, the governmental investment and market incentive. The west should maintain the government's investment in environmental governance funds, strictly follow up on the implementation of emission trading systems and policies, and supervise the emission work. In this way, government regulation and public participation, market mechanism and government regulation, market mechanism and government regulation and public participation are well coordinated. With the local government's leading role with its compulsory force, the market mechanism and the public's participation are combined to achieve the goal of reducing environmental pollution.

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