

Article

The Effect of Public Participation on Environmental Governance in China—Based on the Analysis of Pollutants Emissions Employing a Provincial Quantification

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Abstract: For a long time, governments and enterprises have been the two main subjects for environmental governance in China. With the growing complexities of environmental issues and the improvement of public environmental awareness, public participation is gradually playing an important role in the process of China’s environmental governance. This paper aims to explore the necessity, the rationale, and the specific effect of public participation on environmental governance in China. A theoretical model is first proposed to illustrate the significance of public participation. Then, an empirical model is built to investigate the impact of public participation on pollutant emissions of the four main pollutants SO₂, NO_x, COD, and NH₄, based on the panel data of 30 provinces from 2011 to 2015 in China. The results and main findings are: (1) public environmental complaints exert a noticeable and positive impact on the reductions of pollutants; (2) this impact varies according to different pollutants, among which reducing SO₂ emissions shows the most efficiency; and (3) the impact of public participation on the reduction of pollutants shows the characteristics of hysteresis and regional difference. We find that when the rate of public participation of lagging one period increases by 1%, the reduction of SO₂ is 5.03 tons per capita, 1.54 tons per capita, and 0.94 tons per capita in the region of middle, east, and west China, respectively. Therefore, the status of public participation should be strengthened and effective public participation is urgently needed in environmental governance. A systematic cooperative governance among the public, governments, and enterprises needs to be established in the long run.

Keywords: public participation; environmental governance; pollutants reduction

1. Introduction

High-speed economic growth and social development have brought serious environmental problems to China. Air pollution represented by fog and haze and water pollution in rivers and lakes have drawn great public attention in recent years. According to the latest “Bulletin of China’s Environmental Conditions 2016”, about 75% of the cities in China were below the standard of air quality; about 40% of the water bodies in China suffered from pollution of different degrees; and about 33% of the counties in China were in bad condition in terms of the ecological environmental quality [1]. PM_{2.5}, in particular, has been a hot topic discussed widely by the Chinese public. With an increasing number of episodes targeting air pollution and days of “low visibility” reported by the media, much attention has been paid to reducing pollutant emissions and improving environmental quality [2].

In order to save the deteriorating ecological environment in China, environmental governance is urgently needed.

Environmental governance advocates sustainable development as the supreme consideration for managing all human activities—political, social, and economic [3]. With the growing complexities of environmental issues, environmental governance requires participation from multiple subjects. For a long time, governments and enterprises have been the two main subjects for environmental governance in China. However, both governments and enterprises could fail to be effective sometimes. In the current Chinese context, fiscal decentralization of the economy and the promotion incentive of politics bring about fierce competition among local governments. On one hand, traditional environmental federalism believes that the environmental regulations under the fiscal decentralization shall lead to the phenomenon of “race to the bottom” (which is a socio-economic phrase that is used to describe government deregulation of the business environment, or a reduction in tax rates, in order to attract or retain economic activity in their jurisdictions. As outcome of globalization and free trade, the phenomenon may occur when competition increases between geographic areas over a particular sector of trade and production) [4]. Local governments would rather make a less strict standard of environmental regulations than consider the long-term benefits and caring for the environment, which is a public good with outstanding externalities. Some local governments prefer loosening environmental standards in order to attract more investments, therefore generating more job opportunities and tax revenues. This leads to a decrease of environment quality [5]. On the other hand, the Chinese political promotional gaming inevitably leads to an overemphasis on economic growth and ignorance on public utilities such as the environment, education, and health care. Under these particular circumstances, public participation shall play an important role in local and national environmental governance.

Over the past thirty years, public participation has been in a dominant position of determining how society manages or protects the environment in many countries [6]. The general public ought to have the right to live in a healthy environment, and more often than not, they have a better understanding of their surroundings. They could offer crucial information and suggestions for environmental governance [7]. Public participation could reduce the costs of monitoring violation and take responsibility for prosecuting violators [8]. Citizen involvement is intended to produce better decisions, and thus generate more efficiency benefits for the rest of society [9]. Public participation has not only improved environmental policies, but also played an important educational role and helped resolve the conflict and mistrust that often plague environmental issues [10].

Disclosure of environmental information is a key issue that influences the chance of public participation. With the rapid development and wide use of the Internet and mobile internet in China, information disclosure has made tremendous progress in the last decade. A series of environmental policies have been implemented to guarantee public participation, such as “Environmental Information Disclosure Measures” in 2008, “Environmental Impact Assessment Public Participation Interim Measures” in 2009, “Implementation Plan for Energy Conservation and Emission Reduction” in 2012, and “Environmental Protection Law—Public Participation” newly revised in 2015.

Considering a retrospect of the environmental information disclosure in China, there was no air quality forecasting system to provide an early warning to the public and allow authorities to take appropriate actions to reduce the impact, for example, on human health, before the year of 2013. Moreover, air quality information was only published through a daily API (Air pollution index) before the year 2012, and a new Air Quality Index (AQI) including a limit value for PM_{2.5} and an 8-h limit value for O₃ was only released after the year 2012. In addition, the link between the AQI, pollutants concentration levels, and health impact is not widely understood by the public. The turning point was in the year of 2012, when the US embassies published air quality data in Beijing and Guangzhou. After that, the Chinese public developed a strong interest in acquiring and understanding air quality information. Currently, the status of the public participation in environmental governance in China is very active and promising. The rights for the public to

know, to participate, and to supervise have been greatly promoted in China. Especially with the fast development of information technology and environmental disclosure, more and more Chinese members of the public participate in environmental issues. Chen Jining, the former Minister of Environmental Protection, pointed out in 2017 that “Environmental protection involves thousands of families, each of whom is both a victim and a protector. Each citizen should not be a bystander or accuser of environmental problems, but a participant and contributor to solve environmental problems”. It is worth noticing that the theme of the World Environment Day of 2018 is “Everybody participates in environmental protection”. Moreover, there are many different levels and types of public participation in environmental governance. For instance, public complaints by letters and visits, environmental non-profit organizations, assembly and group events, environmental impact assessment, environmental policy formulation, and environmental prosecution, etc.

Figure 1 shows the number of public complaints provided by the environmental protection administration at all levels through the channels of letters, telephones, and the internet from 2011 to 2015. The total number of complaints has been increasing annually and a major proportion of the complaints were conducted through the telephone and Internet. Figure 1 indicates that the frequency of public participation in environmental governance is growing, and the channels for complaints have been transferring from traditional letters and petitions to the telephone and networks. The origin of the data comes from the Annual Statistic Report on Environment in China and China Statistical Yearbook on Environment from 2011 to 2015 [11,12].

Figure 2 further shows the public complaints through the telephone and network at a provincial level per capita from 2011 to 2015 in China (In order to maintain the integrity of the map of China, although there is no statistical data on Tibet, Taiwan, Hong Kong, Macao and South China Sea Islands, we still draw them on the map). It can be seen from the figure that there are obvious regional differences among provinces. The level of public participation in the southeast coastal provinces is the highest, whereas that in some northwest and central provinces is the lowest.

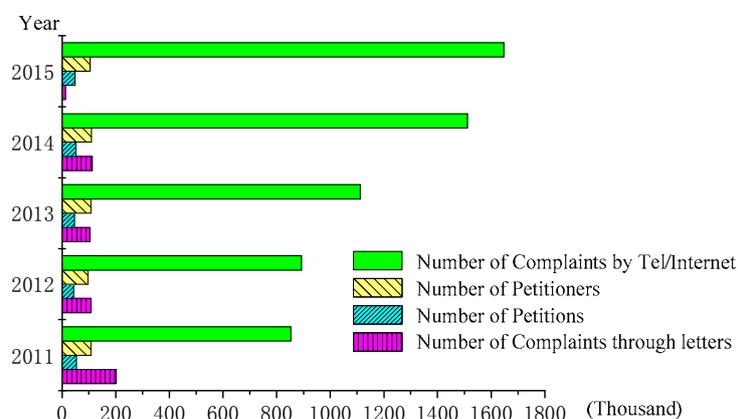


Figure 1. Number of public complaints through letters, telephones, and networks in environmental protection systems at all levels from 2011 to 2015 in China.

between collaborative governance and watershed quality, and found that a group engaging in management activities would be beneficial to greater environmental gains [23]. Newig et al. identified five clusters of causal mechanisms describing the relationship between participation and environmental outcomes [24].

How and to what extent can public participation affect environmental governance? Does public participation improve the environmental governance? Studies have been carried out, and relevant conclusions could be generally summarized into the following two categories.

Some researchers believe that public participation has a positive impact on environmental governance. Lo et al. affirmed that the environmental community in Guangzhou played an important role, and that the public was indirectly incorporated into the policy making process [25]. Wang and Di carried out an empirical analysis of 85 local towns in China and found that residents' complaints on environmental pollution increased the level of local environmental governance [26]. As environmental non-governmental organizations (ENGOS) became increasingly effective in public participation, Yang suggested that environmental ENGOS can serve as both "sites" and "agents" of democratic social change in China. Notably, the "site" refers to a new field constituted by ENGOS where citizens may practice political skills, organize and participate in civic action, and test political limits [27]. Zhang et al. identified the main factors that shape corporates' environmental management performance, and found that public participation in the form of community pressure was a major and effective one [28]. Bryan examined the processes and consequences of pollution enforcement and found that citizen complaints and media exposures regarding polluting factories show a significant positive influence [29]. Zhang and Lu pointed out that public complaints through letters and petitions had a positive effect on reducing China's carbon intensity and per capita carbon emissions [30]. Yan's empirical study showed that public participation in nationwide samples was positively correlated with environmental fairness, that is, the higher the environmental volume of the previous issue, the better the environment would be in the next phase [31]. Zheng performed an empirical study and found that public environmental attentions could urge local governments to pay more attention to environmental governance, to improve environmental quality in cities by means of relevant investments, and to upgrade the industrial structures [32]. The study by Guo showed that public participation was an important factor in promoting environmental improvement. The participation of the increase of 1 person-time per 10,000 people in water pollution could promote a 6.3% increase in industrial emissions reduction in polluted water [33]. Zhang et al. pointed out that the number of environmental petition letters had a positive impact on the investment efficiency of environmental governance [34].

Some researchers, on the contrary, have proposed opposite opinions. Folz and Hazlett carried out a study of solid waste recycling and found that the "participation" factor did not effectively affect the recycling [35]. Dasgupta and Wheeler suggested that the influence of public participation in environmental performance was not of significance because the average number of environmental complaints in major cities and provinces in one year is small, ranging from 55.0 per 100,000 inhabitants for Shanghai to 1.7 per 100,000 inhabitants for the northwestern province Gansu [36]. Benjamin investigated the obstacles that citizens meet when attempting to protect the environment and found that citizen activism became an isolated affair [37]. Liu et al. evaluated the environment awareness of residents in the Haihe river basin by questionnaires and found that the impact of public participation activities was limited [38]. Wang combined environmental regulations and public participation in the same framework and pointed out that environmental complaints had no significant impact on industrial polluted water, polluted air, or waste solid [39]. Dong et al. did an empirical study using China's environmental statistical data and found that environmental complaints from the public can provide valuable information for regulators to efficiently allocate inspection resources; however, the information may be noisy since complaints are more likely to arise from wealthier and better-educated regions [40]. Liu found that the importance of public participation on environmental regulation had not yet been revealed [41]. Song did a similar study and found that public participation in the industrial gathering area showed significant negative effects [42].

The above studies illustrate the growing attention on the influence of public participation in environmental governance. However, current researches are still insufficient to reach a general conclusion. It is worth noting that previous studies either defined public participation as one of the many factors

that influence the environment, or classified public participation as one of the environmental regulations. Rarely did researchers treat the “public” as a main subject. In fact, environmental governance emphasizes participation and interactive cooperation among various subjects. The “public”, in the same way as governments and enterprises, is a main subject in environmental governance. In China, it is sometimes revealed that an enterprise exceeding the emission limit is able to cope with pressure from the government, but unable to bear the pressure from the public and the government together [43]. Combining theoretical analysis with empirical analysis, this article attempts to explore the effect that public participation exerts on environmental governance. During the process, a theoretical model is first proposed to illustrate the importance of public participation. Then, a regression model is built to investigate the effect of public participation on environmental governance from the perspective of pollutant emissions based on panel data of 30 provinces from 2011 to 2015 in China. This paper tries to answer the question “does public participation promote environmental governance in China?”

3. Theoretical Model

Assume there are three subjects in the economic operation: the local government, enterprises, and S homogeneous individuals [44]. In the Chinese political context, the local government has strong control of local key economic and social resources, but it tends to maximize profits under the inspirations of political promotion. Assume that the central government mainly evaluates the local governments by indicators of economic and environmental performances. However, in the short term, it is difficult to measure the local government’s effort of improving environmental quality. Consequently, the central government sets GDP as the main assessing index for local officials, which inevitably causes a promotion tournament among different local governments.

In the meantime, enterprise K pursues profit maximization and decides its own production through the game between market and government regulations. The individuals yearn for good environment qualities. Their utilities depend on their own economic interests and the satisfaction from participating in environmental governance. The total amount of pollution-reducing emissions in the whole society is set as $D = D_{o+p} + D_z$, in which the government and the enterprise are responsible for reducing the emission amount by pollution control D_{o+p} , and public participation reduces the amount of pollution emission D_z .

3.1. Considerations of Local Government and Enterprises in Environmental Governance

First, the behavior of local governments is investigated. Assume that the total disposable investment of the local government is 1, and each local government has only two goals, economic growth and environmental governance. Share $1 - \lambda$ is used for economic growth and share λ is used for environmental governance. Since environmental governance is a long term and unrecognized work, it is difficult to realize good benefits in the local government’s tenure, thus a revenue function of the local government is built, as in Equation (1).

$$\pi_g = \alpha(1 - \lambda)(1 + \omega_1) + (\lambda/\beta)(1 + \omega_2) \quad (1)$$

where π_g represents the total yield of the local government; α , β are yield coefficients (greater than 1); ω_1 , ω_2 are random disturbance terms that correspond to $N(0, \delta_1^2)$, $N(0, \delta_2^2)$, respectively; δ_1^2 and δ_2^2 reflect the uncertainty of expected investment income; $\alpha(1 - \lambda)(1 + \omega_1)$ is the benefit of local governments’ investments in economic growth; and $(\lambda/\beta)(1 + \omega_2)$ is the investment income of environmental governance. Further assume that local governments are risk-averse, and the risk aversion coefficient is $\kappa > 1$. The total risk of local governments’ investment is defined in Equation (2), and the expression of maximized net yield obtained by the local government investment is defined in Equation (3), where Π represents the net yield of the local government.

$$C = \frac{\kappa}{2}(\text{var}\pi) = \frac{\kappa}{2} \left[\alpha^2(1 - \lambda)^2\delta_1^2 + \frac{\lambda^2\delta_2^2}{\beta^2} \right] \quad (2)$$

$$\text{MAX } \Pi = \alpha - \left(\frac{\alpha\beta - 1 - \kappa\beta\alpha^2\delta_1^2}{\beta} \right) \lambda - \left(\frac{\kappa\alpha^2\delta_1^2\beta^2 + \kappa\delta_2^2}{\beta^2} \right) \frac{\lambda^2}{2} - \frac{\kappa\alpha^2\delta_1^2}{2} \quad (3)$$

Furthermore, the first-order condition of maximized net profit and the optimal solution are expressed in Equations (4) and (5), respectively.

$$\frac{\partial \Pi}{\partial \lambda} = \left(\alpha - \frac{1}{\beta} - \kappa\alpha^2\delta_1^2 \right) + \left(\kappa\lambda\alpha^2\delta_1^2 + \frac{\kappa\lambda\delta_2^2}{\beta^2} \right) = 0 \quad (4)$$

$$\lambda = \frac{(\kappa\alpha^2\beta^2\delta_1^2 + \beta - \alpha\beta^2)}{\kappa(\alpha^2\beta^2\delta_1^2 + \delta_2^2)} \quad (5)$$

Equation (6) indicates that the environmental investment of local governments and the uncertainty of economic growth are positively correlated. In other words, the greater the local governments' confidence in the growth of the local economy, the more likely the government will govern the environment. According to Equation (7), for the local governments, the investment in environmental governance is negatively correlated with the uncertainty of the expected return of the investment. This means that the more uncertain the local governments' investment in environmental governance is, the less likely it is to invest in environmental governance.

$$\frac{\partial \lambda}{\partial \delta_1^2} = \frac{\alpha^2\beta^2[\kappa\beta(\alpha\beta - 1) + \kappa^2\delta_2^2]}{\kappa^2(\alpha^2\beta^2\delta_1^2 + \delta_2^2)^2} > 0 \quad (6)$$

$$\frac{\partial \lambda}{\partial \delta_2^2} = \frac{\alpha\beta^2\left[1 - \alpha\kappa\delta_1^2 - \frac{1}{\alpha\beta}\right]}{\kappa(\alpha^2\beta^2\delta_1^2 + \delta_2^2)^2} < 0 \quad (7)$$

In the promotion incentive mode of fiscal decentralization, the local governments believe that the return of investments δ_1^2 for economic growth can be expected, while the return of investments δ_2^2 for environmental governance can be unpredictable. Under extreme conditions, the uncertainty of investment in environmental governance may reach infinity, that is $\delta_2^2 \rightarrow \infty$. Under these circumstances, the local government will put all their investment in economic growth, while the investment in the governance environment will be nearly zero, as indicated by Equation (8). On one hand, local governments usually have to participate in fierce competition games; on the other hand, the uncertainty of environmental investment is obvious. Therefore, it is the dominant choice for local governments to ensure the maximization of economic returns and to give up environmental governance. That is, the local governments will put all kinds of resources into economic development and care less or even abandon the environmental governance.

$$\lambda = \lim_{\delta_2^2 \rightarrow \infty} \frac{(\kappa\alpha^2\beta^2\delta_1^2 + \beta - \alpha\beta^2)}{\kappa(\alpha^2\beta^2\delta_1^2 + \delta_2^2)} \rightarrow 0 \quad (8)$$

Secondly, we consider the behavior of the enterprise. In a perfectly competitive product market or factor market, enterprise K conducts production activities and becomes a direct source of pollution emission, thus becoming an object of the local government's environmental control. Assume that the income function of the enterprise is $P \times A(K_A)f(K_P)$, where P represents the price; and K_A and K_P represent the technical capital investment and capital investment of the enterprise, respectively; $A(K_A)$ represents the technical level; and $f(K_P)$ represents the level of output under the established technological level. The output function of the enterprise can be expressed as $F = Af = A(K_A)f(K_P)$. In the meantime, the pollution discharge function of enterprise K in the production process is set as $W = (F, E)$. According to the descriptions of the nature of pollution functions, $W' = (F, \bullet) > 0$, $W' = (\bullet, E) < 0$, which means that the pollutant emitted by the enterprise increases with the increase of production F and decreases with the increase of investment E in environmental governance. Assume

that the investment income of environmental governance which is to be obtained by local governments is transferred to the enterprise in the form of environmental regulation, that is to say, local governments require enterprise K to achieve the goal of environmental governance by environmental regulations. We set environmental regulations as $ER = ER(\lambda/\beta)$ and $ER' > 0$. That is, the higher benefits of environmental governance the local government anticipates, the stronger the government sets regulations on enterprise K . We use η to represent the share of pollution control in the total production, where $E = \eta F = \eta A(K_A)f(K_P)$ and $0 < \eta < 1$. Thus, the choice made in order to maximize the enterprise's profit is shown in Equation (9), and the first-order condition for the optimization of Equation (9) is solved by constructing the Lagrangian function, as shown in Equation (10).

$$\text{MAX} \pi_p = \bar{P}[A(K_A)f(K_P) - \eta A(K_A)f(K_P)] \quad (9)$$

$$\text{s.t.} \quad ER = W[A(K_A)f(K_P), \eta A(K_A)f(K_P)] \quad P(1 - \eta)A(K_A)f'(K_P) + \psi A(K_A)f'(K_P)[W_F + \eta W_E] = 0 \quad (10)$$

By collating, we further get $P = \psi \times \partial W / \partial E$, $\partial W / \partial E = -\partial W / \partial F$, $\partial W / \partial K_A > 0$, and $\partial W / \partial \eta < 0$. It shows that when facing the government's environmental regulations, the optimal choice for the enterprise is to let the increase of marginal pollutants in production be equal to the reduction of marginal pollution through pollution control. When the enterprises face stringent environmental regulations from local governments, the investment of environmental governance shall increase and the pollutants shall reduce, indicating that the share of environmental governance investment is an increasing function of government environmental regulations. However, due to the soft restriction of fiscal decentralization, the investment amount of environmental governance λ keeps declining. Since $ER = ER(\lambda/\beta)$ and $ER' > 0$, ER decreases.

The following is a comprehensive analysis: local governments loosen environmental regulations for the development of the local enterprise, in order to achieve economic benefits by increasing productions and expanding the scale of the enterprise. The aim of the enterprises is always to achieve maximized profits, and the loosened environmental regulations will increase the production and profits for enterprises. Therefore, enterprises are not willing to take responsibility for reducing pollutant discharge. This has led to the effect of "race to the bottom". Based on the above analysis, Hypothesis 1 is proposed.

Hypothesis 1. *In the system of Chinese fiscal decentralization, strong local governments shall carry out fierce promotion championships, which may lead to an insufficient supply for environmental governance within the local governments and an improvement of economic benefits by loosening environment regulations to improve the enterprise's production. Therefore, pollutant emissions of the enterprise shall increase, and the positive impact of the government and the enterprise on environmental governance may be limited or uncertain.*

3.2. The Impact of Public Participation on Environmental Governance

Lastly, we analyze the impact of public participation on environmental governance. It is assumed that the labor supply and income level of the public are exogenous variables, so the utility function of homogeneous individuals shall be in the form of Equation (11).

$$u_i = U(M_i, Q_i, D_z, S_i) \quad U'' > 0, U'' < 0 \quad (11)$$

where M_i represents the utility of public consumption for private goods, Q_i represents the utility of public leisure consumption, D_z represents the reducing amount of pollution emissions by public participation, and S_i represents the satisfaction of the public by participating in environmental governance. The total time of individuals is assumed to be divided by $T = Q_i + t_i$, that is, the public will allocate the time balance after labor supply into leisure time Q_i and the time of participating in environmental governance t_i . t_i represents the public's effort to deal with environmental governance in terms of time. The pollutants reduced by the public are represented by $d_i = d(t_i, \chi)$ and $d_i' > 0$, $d_i'' < 0$. The public's satisfaction by participating in environmental governance as a function of the public's best

effort time t_i^* is represented by $S_i = f(t_i^* - t_i)$. It can be seen that S_i reaches its peak when $f_{\max}(0) = k$, and at this moment, $t_i^* = t_i$. It is further assumed that the social welfare function is the sum of public utility functions, as Equation (12). Then, t_i^* is the key for maximizing social welfare, and it should satisfy the conditions as listed in Equation (13).

$$H = u_1 + u_2 + u_3 + \dots + u_N \quad (12)$$

$$\partial H / \partial t_i = -U'_Q + U'_D(d'_i N) + U'_S f'_i = 0 \quad (13)$$

When $t_i^* = t_i$ and $t_i = t_j$, it is found that the best efforts of the public for environmental governance locate where the marginal utility of leisure is equal to the social marginal benefit of reducing pollution emissions by the public, namely $U'_Q = d'_i \times U'_D \times N$. But the extent to which the public works on environmental governance in reality depends on Equation (14), where $U'_Q = d'_i \times U'_D + U'_S \times f'_i$. This means that the maximization of public personal utility cannot achieve the social ideal distribution of pollution emission reduction, and $U'_Q > d'_i \times U'_D$.

$$\partial u_i / \partial t_i = -U'_Q + U'_D d'_i + U'_S f'_i = 0 \quad (14)$$

However, if the public have a strong sense of identity for environmental governance, they will be willing to spend more time in the participation of environmental governance. That is when $t_i \rightarrow t_i^*$, $f'_i \rightarrow 0$ and $U'_Q \rightarrow d'_i \times U'_D$. It reflects that when the growing public effort of environmental governance approaches the social required optimal level, the pollutant emissions shall reach their minimum value. In the meantime, as discussed above, the investment for environmental governance by local governments and enterprises can be limited and the performance of environmental governance can be uncertain. Since $D = D_{o+p} + D_z$, it can be seen that public participation can make up for the lack of governmental measures to a certain extent and reduce pollution emissions, thus improving the level of environmental governance. Based on the above analysis, Hypothesis 2 is proposed as follows:

Hypothesis 2. *The higher the acceptance of the public to environmental governance, the greater the public participation is in environmental governance. That is, public participation is beneficial for reducing pollution emissions. To some extent, public participation could compensate for the inadequate supply of environmental governance from local governments and enterprises in the current Chinese political system.*

4. The Effect of Public Participation on Environmental Governance

4.1. Model and Variables

To explore the impact of public participation on environmental governance, the study designs the models as follows.

$$SO_2 = \alpha_0 + \alpha_1 PP + \alpha_2 GOV + \alpha_3 ENT + \alpha_4 FDI + \alpha_5 TEC + \mu_{SO_2} \quad (15)$$

$$NO_X = \beta_0 + \beta_1 PP + \beta_2 GOV + \beta_3 ENT + \beta_4 FDI + \beta_5 TEC + \mu_{NO_X} \quad (16)$$

$$COD = \gamma_0 + \gamma_1 PP + \gamma_2 GOV + \gamma_3 ENT + \gamma_4 FDI + \gamma_5 TEC + \mu_{COD} \quad (17)$$

$$NH_4 = \lambda_0 + \lambda_1 PP + \lambda_2 GOV + \lambda_3 ENT + \lambda_4 FDI + \lambda_5 TEC + \mu_{NH_4} \quad (18)$$

where α , β , γ , λ are the coefficients, and μ is the random error. The dependent variables are the polluted air emission of sulfur dioxide (SO_2) and nitric oxide (NO_X) and the polluted water emission of the chemical oxygen demand (COD) and ammonia nitrogen (NH_4). Environmental governance refers to the set of regulatory processes, mechanisms, and organizations through which political actors influence environmental actions and outcomes [16,45]. The environmental governance is often measured by the amount of local pollutant emissions or the investment of the local government by

previous researchers [46–49], and the former one is used more often, because the amount of pollutant emissions is the result of joint actions of both the amount of pollutant produced and the environment policies [50]. From the performance of environmental governance, we use the per capita value of these pollutants to represent the environmental governance. In terms of current situations, public complaints on air and water pollution account for more than 80% of the total complaints [51]. Therefore, the selection of dependent variables is of more pertinence. Furthermore, SO₂, NO_x, COD, and NH₄ are the four main “monitoring pollutants” by the Chinese government during the research period from the year 2011 to 2015. The amount of these four “monitoring pollutants”, to some extent, manifests the situation of environmental governance. Due to the data availability and importance, we chose these four pollutants as the proxy variables of environmental governance.

The core variables are the three main subjects for environmental governance: public participation (PP), governmental behaviors (GOV), and enterprises’ behaviors (ENT).

The first core variable is public participation (PP). There are many ways for the public to participate in environmental governance, such as complaints by letters or visits, prosecution of environmental nonprofit litigation, environmental decision making, assessment of environmental impact, etc. Considering the data availability, researchers preferred to use the number of public environmental complaints by letters or visits to represent the degree of public participation [25,29]. Referring to Li’s method, this article measures public participation by the number of public environmental complaints through the channel of telephones and networks [52]. To get rid of the influence on population size, we calculate the participation rate by means of dividing the participation number by the number of local population.

The second core variable is government environmental behavior (GOV). The government uses comprehensive ways to achieve environment goals, such as planning, organizing, controlling etc. Previous studies chose the investment volume of pollutants governance to represent the degree of government management. This study calculates the environmental investment proportion of GDP to measure the governments’ environmental behavior.

The third core variable is enterprises’ behavior (ENT) in environmental governance. The paper chooses the index of investment in the construction project of industrial pollution prevention and the investment shall be completed the current year. The investment is mainly used to deal with old source of pollution and the integrated utilization of polluted air, waste water, and polluted solid.

The control variables are the foreign direct investment (FDI) and the technology (TEC). Previous studies pointed out that the degree of economic openness and technology would exert a direct influence on pollutant emissions in a region [53,54]. To enhance the interpretation strength of the model, we add foreign direct investment and technology (TEC) as control variables. The respective index is the proportion of FDI in GDP, and the technical market turnover in GDP.

4.2. Descriptive Statistics and Test

Table 1 shows the statistical description of variables. According to the availability of original data, the study collects data from 30 provinces (except Tibet, Hong Kong, Macau, and Taiwan) in China’s mainland during the year 2011 to 2015 (which is defined as the twelfth five year period of China). The total number of the sample is 150. Data are obtained from the China Statistical Yearbook on Environment [11], Annual Report of China Environmental Statistics [12], China Statistical Yearbook [55], and China Statistical Yearbook for Regional Economy [56]. Descriptive statistics are as follows. Please see the original data in the Supplementary: Table S1.

Before conducting the regression using the models and data, unit root tests of all the variables have been carried out in order to insure the data stationarity. For convenience, two ways of the panel unit root test are used. One is the Levin-Lin-Chu (LLC) test, assuming the common unit root process. The other is the Fisher-ADF test, assuming the individual unit root process. If both of the unit root tests refuse the null hypothesis, this sequence is of stationarity. Otherwise, this sequence is not stationary. According to the test results in Table 2, the *P* values of all the sequences show a high significance at the 1% level. Therefore, the data in this manuscript is stationary and could be used in the model analysis.

Table 1. Variable Statistical Description.

Variable Types	Variable	Variable Meaning and Calculation Method	Observation Number	Mean	Standard Deviation	Minimum	Maximum
Dependent Variable	SO ₂	sulfur dioxide per capita (ton/person)	150	0.0191	0.0129	0.0026	0.0645
	NO _x	nitrogen oxide per capita (ton/person)	150	0.0184	0.0125	0.0054	0.0720
	COD	chemical oxygen demand per capita (ton/person)	150	0.0156	0.0078	0.0050	0.0411
	NH ₄	ammonia nitrogen per capita (ton/person)	150	0.0015	0.0006	0.0004	0.0028
Core Variables	PP	number of public environmental complaint/number of local population	150	0.0009	0.0008	0.0001	0.0036
	GOV	Investment of environmental pollution control/GDP	150	1.5020	0.6559	0.4559	3.8121
	ENT	Investment in the construction project of industrial pollution prevention and control investment shall be completed this year. (ten thousand yuan)	150	53.7167	47.0757	5.5810	347.7379
Control Variables	FDI	FDI/GDP	150	0.0001	0.0002	0.0000	0.0013
	TEC	Technical market turnover/GDP	150	0.0095	0.0222	0.0002	0.1462

Data illustration: (1) All the original data comes from official statistical yearbooks in China, instead of experimental data or questionnaire data; (2) The statistical description in the table is totally based on the objective data samples, without the process of standardization or logarithm.; (3) The session unit of the panel data is each province of China. To get rid of the possible influences caused by the population and GDP difference among provinces, most proxy variables are defined as the original data divided by the population or GDP. Thus, the numerical value becomes relatively small, and the overall data is relatively concentrated with small deviation coefficients. See more relevant tests of the data and models in the following.

Table 2. Panel Unit Root Test.

Variables	Assumes Common Unit Root Process	Assumes Individual Unit Root Process
	LLC Test	Fisher-ADF Test
SO ₂	−17.475 *** (0.000)	141.606 *** (0.000)
NO _x	−9.686 *** (0.000)	131.764 *** (0.000)
COD	−11.919 *** (0.000)	140.760 *** (0.000)
NH ₄	−9.415 *** (0.000)	132.732 *** (0.000)
PP	−9.096 *** (0.000)	129.227 *** (0.000)
GOV	−16.827 *** (0.000)	183.209 *** (0.000)
ENT	−10.605 *** (0.000)	152.931 *** (0.000)
FDI	−60.172 *** (0.000)	540.689 *** (0.000)
TEC	−9.059 *** (0.000)	166.411 *** (0.000)

*** represent statistical significance at the 1% level.

Meanwhile, to deal with the potential heteroscedastic problem of the established panel data model, the White Heteroskedasticity Test is carried out. In Table 3, the test results show that the concomitant probability of the P value of the Chi-square statistic is larger than 0.05, so the null hypothesis is accepted, i.e., there is no heteroscedastic problem in the panel data model. Of course, a possible endogenous problem may exist in the model. If all the variables are exogenous variables, a fixed effect (FE) or random effect (RE) could be used to estimate the panel model. If there is an endogenous problem in the model, that is, there is a correlation between the random disturbance and independent variables, either the method of FE or RE would lead to nonuniformity. Based on this, the Davidson-MacKinnon test and Hausman-Wu test are carried out. Table 3 shows that test results of two methods accept the null hypothesis. Therefore, there is no endogenous problem in the model.

Table 3. Panel Heteroscedasticity Test and Endogenous Test.

	White Test	Davidson-MacKinnon Test	Hausman-Wu Test
Dependent Variable SO ₂	[24.05] (0.240)	[3.576] (0.064)	[0.262] (0.609)
Dependent Variable NO _x	[25.89] (0.169)	[0.049] (0.825)	[0.622] (0.432)
Dependent Variable COD	[11.62] (0.929)	[0.846] (0.360)	[0.081] (0.775)
Dependent Variable NH ₄	[29.55] (0.078)	[0.792] (0.376)	[0.105] (0.746)

In the White Test, the Chi-square statistic is in the [], and the p -value is in the (); In the Davidson-MacKinnon Test, the D-M statistic is in the [], and the p -value is in the (); In the Hausman-Wu Test, the H-W statistic is in the [], and the p -value is in the ().

Tables 4 and 5 show the overall regression results of SO₂ (model 1–model 4), NO_x (model 5–model 8), COD (model 9–model 12), and NH₄ (model 13–model 16), respectively. Among them, core variables and control variables are all the same. They are: public participation currently (PP), public participation with lagging one year (L1.PP), public participation with lagging two years (L2.PP), governmental behaviors (GOV), enterprise behaviors (ENT), foreign direct investment (FDI), and technology (TEC).

Table 4. Overall Regression Results (1).

Variables	SO ₂				NO _x			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
C	0.0174 (12.46) ***	0.0170 (12.44) ***	0.0188 (33.8) ***	0.0189 (23.29) ***	0.0113 (7.69) ***	0.0145 (10.99) ***	0.0197 (25.65) ***	0.0203 (18.76) ***
PP	−1.7418 (−2.21) **				0.1360 (−0.18)			
L1.PP		−1.2894 (−2.46) **				−0.3876 (−0.68)		
L2.PP			−1.2200 (−3.03) ***	−0.9958 (−2.67) ***			−1.8291 (−3.35) ***	−1.2735 (−2.90) ***
GOV	0.0011 (1.82) *	0.0012 (2.33) **	0.0001 (−0.29)	−0.0003 (0.73)	0.0019 (2.18) *	0.0020 (2.64) **	0.0007 (1.31)	0.0009 (1.71) *
ENT	3.11×10^{-5} (2.05) **	2.13×10^{-5} (1.84) *	1.5×10^{-5} (4.42) ***	1.54×10^{-5} (4.66) ***	7.87×10^{-5} (3.77) ***	3.73×10^{-5} (4.80) ***	1.35×10^{-5} (4.00) ***	1.39×10^{-5} (4.20) ***
FDI				2.4751 (−0.13)				−22.5072 (−0.83)
TEC				−0.0661 (−1.88) *				−0.0621 (−2.23) **
R-sq	0.6069	0.6688	0.5852	0.3275	0.8327	0.8413	0.5478	0.3387
F Test	2.7400	4.4000	10.5100	7.9400	10.7000	10.5600	13.9400	10.6700
FE/RE	FE	FE	FE	FE	FE	FE	FE	FE

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Overall Regression Results (2).

Variables	COD				NH ₄			
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
C	0.0044 (−1.65)	0.0076 (3.07) **	0.0196 (47.06) ***	0.0198 (36.72) ***	0.0008 (3.70) ***	0.0012 (5.92) ***	0.0020 (46.67) ***	0.0020 (29.46) ***
PP	1.5859 (2.18) **				0.3405 (3.31) ***			
L1.PP		1.1324 (−1.48)				0.1358 (2.14) **		
L2.PP			−0.9630 (−3.21) ***	−0.7780 (−2.50) **			−0.1189 (−3.61) ***	−0.0914 (−2.60) **
GOV	0.0033 (1.91) *	0.0023 (−1.29)	−0.0001 (−0.48)	1.27×10^{-5} (−0.05)	0.0001 (−0.85)	6.02×10^{-5} (−0.41)	$−1.68 \times 10^{-5}$ (−0.74)	$−6.88 \times 10^{-6}$ (−0.03)
ENT	8.94×10^{-5} (4.07) ***	8.32×10^{-5} (3.91) ***	6.69×10^{-6} (3.34) ***	6.94×10^{-6} (3.51) ***	5.57×10^{-6} (3.29) ***	4.74×10^{-6} (2.83) ***	4.32×10^{-7} (2.00) *	4.54×10^{-7} (2.13) **
FDI				−1.2083 (−0.09)				−1.0075 (−0.52)
TEC				−0.0430 (−2.53) **				−0.0034 (−1.71) *
R-sq	0.3229	0.2794	0.2193	0.2526	0.2620	0.1313	0.2899	0.3254
F test	10.5400	10.1600	12.8700	7.1500	8.0800	5.3800	9.9900	5.1900
FE/RE	FE	FE	FE	FE	FE	FE	FE	FE

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

4.3. Results and Discussions

Data processing is conducted by software Stata 13.0. Empirical results are presented in Tables 4–6.

The east region is the richest region in China, which includes 11 provinces: Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, and Liaoning. The middle region includes eight provinces: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. The west region is the poorest region in China, which includes 11 provinces: Inner-Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shanxi, Gansu, Ningxia, Qinghai, and Xinjiang.

Table 6. Regional Regression Results—Eastern, Central, and Western.

Variables	Eastern Region		Central Region		West Region	
	Model 17: SO ₂	Model 18: NO _x	Model 19: SO ₂	Model 20: NO _x	Model 21: SO ₂	Model 22: NO _x
C	0.0146 (24.73) ***	0.0191 (11.65) ***	0.0149 (34.86) ***	0.0088 (6.47) ***	0.0223 (−5.11)	0.0132 (3.82) ***
L1.PP	−1.5462 (−3.20) ***	−1.1978 (−3.28) ***	−5.0328 (−6.12) ***	2.5331 (0.76)	−0.9474 (−1.82) *	0.2480 (−0.44)
GOV	0.0008 (4.48) ***	0.0008 (1.32)	−0.0002 (−0.9)	0.0035 (3.00) **	0.0022 (2.58) **	0.0026 (2.40) **
ENT	5.0×10^{-7} (0.04)	3.0×10^{-5} (1.43)	4.0×10^{-5} (5.28) ***	0.0001 (4.29) ***	2.51×10^{-5} (−1.47)	3.99×10^{-5} (3.89) ***
FDI	−31.7799 (−2.52) **	−92.7694 (−2.51) **	83.1095 (3.29) **	−173.1999 (−1.33)	52.5372 (−0.27)	224.5841 (−1.38)
TEC	0.0309 (1.17)	0.0277 (0.70)	−0.0177 (−0.49)	0.1842 (3.29) **	0.0500 (−0.72)	0.1455 (−1.28)
R-sq	0.4574	0.3018	0.6783	0.7010	0.8335	0.6495
F test	19.52	93.31	39.17	86.13	2.74	3.87
FE/RE	FE	FE	FE	FE	FE	FE

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

4.3.1. Public Participation Promotes Environmental Governance

According to model 1, 2, and 3, the coefficient of public participation is negative, which illustrates that the higher the public participation, the lower the pollutant emissions. That is, public participation exerts a significant positive impact on pollutant emissions. Additionally, the degree and period of the impact are different.

To be specific, current public participation has a significant effect on SO₂ emission reductions, and public participation of lagging one period and lagging two periods have more significant impacts which pass the test of 1% significance. In comparison, the impact of public participation on the reductions of NO_x, COD, and NH₄ is not so immediate. Public participation of lagging two periods makes a significant and positive impact on the reduction of NO_x, COD, and NH₄, according to model 7, 8, 11, 12, 15, and 16. It can be seen that public participation exerts a larger influence on the reduction of SO₂ (model 3) and NO_x (model 7) than COD (model 11) or NH₄ (model 15). That is to say, public participation promotes more reductions in polluted air than polluted water. Previous researchers proposed similar conclusions, as Wu pointed out that environmental complaints have a more obvious effect on the reduction of polluted air than polluted water [57]. This is probably because the air is everywhere and its quality influences everyone's daily life more directly. In comparison with the waste water, the emission of polluted air is much easier for the public to reveal, and the achievement of governance is clearer for public supervisions. Thus, hypothesis 2 has been confirmed.

Table 6 shows the regional heterogeneity of public participation in environmental governance. In the eastern region of China, public participation exerts a significant and positive impact on the reduction of SO₂ (model 17) and NO_x (model 18). Meanwhile, in the middle and west region of China, public participation only exerts a significant and positive impact on the reduction of SO₂ (model 19 and model 20). As for the degree of the impact, when the rate of public participation of lagging one period increases by 1%, the reduction of SO₂ is 5.03 tons per capita, 1.54 tons per capita, and 0.94 tons per capita in the region of middle, east, and west China, respectively. On the whole, public participation in eastern and central areas is better than that in the western area.

For the causes of the regional heterogeneity, we infer that it is the level of economic and social development that determines the effect of public participation on environmental governance. The public in the eastern and central regions of China is more concerned about the quality of the environment, and has a stronger awareness of their environmental rights since the eastern and central regions are richer compared with the western areas in China: "Current environmental complaints from the public in China are as follows: the highest is the north and eastern coastal area, the second is the central and south, the lowest is the northwest and southwest", according to "Work Report on Environmental Reporting of 12369 in the First Half of 2017" [51]. As we know, regional development in China is unbalanced. The average income and educational level can be significantly different in the east, the middle, and the west [58]. Therefore, the public appeal for improving environmental quality also possesses regional characteristics. The latest research demonstrates that the performance of environmental governance lags behind the public environmental appeal in richer regions in China [59]. Public appeal improves the green development efficiency in China, and this effect in the eastern region is higher than in the western region [60].

Local governments play a crucial role in dealing with public environmental complaints. The governments' attention to public complaints and the intensity of the supervision on enterprises affect the reduction of pollutant emissions directly. Local governments in the region of the east and middle of China attach greater importance to public satisfaction. They take stronger actions to deal with public environmental complaints by urging relevant enterprises to reduce pollutions. By comparison, the level of public participation is lower in the western region; and the governments' attention to public participation is insufficient, thus the supervision of enterprises is weaker. It can be seen that economic and social development is an important basis for public participation in the realization of environmental governance.

4.3.2. Limits of Governments and Enterprises

Most of the models show that the investment of environmental pollution control by local governments exerts a slightly negative impact on pollutant emissions. Similarly, enterprises' behaviors do not exert a positive influence on the pollutants. Although the governments and the enterprises made some efforts in environmental governance, the impact is not significant. The possible reasons are as follows. First, the investment of industrial pollution control by the government only accounts for about 10% of the total investment of environmental governance from 2011 to 2015, which is inadequate. Only when the growth speed of environmental investment keeps up with the growth speed of GDP, will the pollutant emission be reduced. In the Chinese fiscal decentralization system, although local governments pay attention to the environmental governance under the pressure of assessment from the central government, the promotion game still exists and plays a role. Therefore, local leaders had strong incentives to pursue local economic growth even if the environment was sacrificed. Second, the investment in environmental pollution control of enterprises, to some extent, reflects the scale of production and pollution. The increase of investment in governance does not reduce pollutant emissions, which reveals that the current production of enterprises is still a crude production model. However, enterprises do not have adequate motivations to transform the current model into an elaborate model since changing requires a relatively high cost. Meanwhile, local governments tend to loosen environmental regulations of enterprises which directly promote the increase of GDP rather than the reductions of pollutants. Third, the impact of environmental investment on pollutant emission reduction may be sluggish. It takes time for the effect to be manifested. To conclude, current behaviors of local governments and enterprises can hardly exert a positive influence on pollutant emissions. Thus, hypothesis 1 has been confirmed.

4.3.3. Contributions of FDI and Technology

According to the result, in the eastern region of China, FDI exerts a significant positive influence on the reduction of SO₂, NO_x, and COD. In the central region, FDI exerts positive influences on the reduction of NO_x, COD, and NH₄. In the western region, pollutant reduction is negatively affected. To sum up, FDI exerts a positive ecological effect in the eastern developed region, but leads to "pollution heaven" in the western underdeveloped region of China. Data indicates that technology has a significant positive impact on the reduction of pollutant emissions (model 4, 8, 12, 16). That is, the greater the technical input, the lower the reductions of pollutant emission. By adopting new technology and new materials and reforming the original products, the efficiency of the resources and energy will be improved. Environmental technologies offer a new substantive orientation and management process for minimizing the ecological impacts of economic production while enhancing the competitiveness of firms [60]. Table 6 shows that technology exerts a positive effect on NH₄ emission reduction in the eastern region. Whereas the effect on NO_x and NH₄ emission in the central region is negative. The emission reduction of all pollutants in the west is negative. The adoption of technology is relatively weak in the central and western regions of China. Therefore, the result manifests the unbalanced development of technology among various regions. In the long run, the contribution of technology application to the reduction of pollution is greater than the contribution of industrial structure adjustment, and the widespread application of cleaner technology needs to be pushed through more restricted environmental regulations [61].

4.3.4. The Sensitivity Analysis

Sensitivity analysis assumes the model is $y = f(x_1, x_2, \dots, x_n)$ (x_i represents the i -th attribute value). Each attribute value varies in terms of the possible data range. Sensitivity analysis is a method used to study and predict the influences which attribute variations exert on the model output. In this process, the sensitivity coefficient shows the degree of influence. The larger the sensitivity coefficient, the greater the influence will be. Many methods could be used to conduct the sensitivity analysis.

This paper adopted the Non-parametric statistics which were put forward by Saltelli and Marivoet in 1990. A multiple linear regression model needs to be built first, and the sensitivity coefficient of each attribute needs to be worked out by Equation (19).

$$SRC(x_i) = \frac{b_i \sigma_i}{\sigma_y} \quad (19)$$

where b_i represents the regression coefficient of x_i ; and σ_i and σ_y represent the standard deviation of x_i and y , respectively.

Based on the regression result of model 4, model 8, model 12, and model 16, we calculate the sensitivity coefficient of the core variables according to Equation (19). The results are presented in Table 7

Table 7. Result of Sensitivity Analysis.

		Public Participation	Governmental Behaviors	Enterprises' Behaviors
SO ₂	regression coefficient	−0.9958	−0.0003	1.54×10^{-5}
	standard deviation	0.0008	0.6559	47.0757
	sensitivity coefficient	−0.0618	−0.0153	0.0562
NO _x	regression coefficient	−1.2735	0.0009	1.39×10^{-5}
	standard deviation	0.0008	0.6559	47.0757
	sensitivity coefficient	−0.0815	0.0472	0.0523
COD	regression coefficient	−0.7780	1.27×10^{-5}	6.94×10^{-6}
	standard deviation	0.0008	0.6559	47.0757
	sensitivity coefficient	−0.0798	0.0011	0.0419
NH ₄	regression coefficient	−0.0914	$−6.88 \times 10^{-6}$	4.54×10^{-7}
	standard deviation	0.0008	0.6559	47.0757
	sensitivity coefficient	−0.1219	−0.0075	0.0356

The result shows that under the conditions of different pollutant emissions, the sensitivity coefficients of the public participation, the government behavior, and the enterprise behavior are different. The absolute value of the sensitivity coefficient of public participation (PP) ranks first, the enterprise behavior (ENT) ranks second, and the government behavior (GOV) ranks last. For instance, as for the emission of SO₂, the ranking of the absolute value of the sensitivity coefficient is: the PP (0.0618), ENT (0.0562), and GOV (0.0153). This means that, all else being equal, when the standard deviation of each core variable varies by a unit, the public participation exerts the largest, the enterprise behavior exerts the middle, and the government behavior exerts the smallest influence on the emission of SO₂. Therefore, the conclusion of the sensitivity analysis verifies and supplements the conclusion of the regression model. It further illustrates that public participation in multiple governance is of great significance. This will become a further direction in the future.

5. Conclusions

This paper aims to explore the significance and impact of public participation in environmental governance in China, using both a theoretical and an empirical approach. The theoretical model is first built to analyze the necessities of public participation. Then, panel data of the main pollutants of 30 provinces during the 12th five-year plan period from 2011 to 2015 is applied to explore the effect of public participation on environmental governance. Conclusions and suggestions are as follows.

First, public participation promotes environmental governance in China. Public environmental complaints exert significant and positive impacts on the reductions of pollutant emissions. As an effective supplement for market failure and government failure, public participation is an important power for environmental supervision. Effective public participation is strongly encouraged for environmental supervision. To promote public participation, environmental education among the public is essential, since public awareness can facilitate positive public participation [62]. In the meantime, channels of public participation need to be widened in this Internet epoch. Not only telephones and the Internet, but also new

media tools such as Weibo (The Chinese Twitter) and WeChat (The Chinese Whatsapp), are encouraged to be used for public participation.

Second, public participation has relatively lagging characteristics in promoting environmental governance. Public environmental complaints form a powerful pressure which forces enterprises and governments to take actions to reduce pollutant emissions. Local governments also play a crucial role in this system. The governments' responses to public complaints and the intensity of supervisions to enterprises will affect the reductions of pollutant emissions directly. Therefore, it is important for local governments to set up an ecological concept, and change the traditional political view of GDP priority. Local governments need to attach great importance and make full use of supervisions by public participation in different ways. In addition, shortening the lags of the impact that public participation exerts on pollutants emissions by improving the efficiency of environmental regulations is needed.

Third, the effect of public participation on environmental governance varies among different pollutants and different regions. Public participation promotes more reductions of polluted air than polluted water. In comparison with polluted water, the emission of polluted air is much easier and closer for the public to reveal, and the achievement of governance is clearer for public supervisions. Therefore, the role of public participation in environmental supervision should be emphasized more in the areas where pollutions could be easily exposed, such as garbage sites, communities, rivers, and other dominant pollution sources. From a regional point of view, the public participation in eastern and central regions performs better in reducing pollutants than in western regions of China. The level of economic and social development is an important basis for the realization of public participation in environmental governance. Thus, developed regions should give full play to the role of public participation in environmental governance. Western regions need to attach attention to promoting public environmental literacy and the consciousness of environmental rights by environmental education.

Finally, environmental governance requires participation from multiple subjects. Besides public participation, governments should promote the disclosure of environmental information to allow easier and wider access for public supervision. Enterprises should take the initiative to consider environmental social responsibilities while pursuing profits. To achieve environmental governance fundamentally, systematic cooperative governance among the public, governments, and enterprises needs to be established in the long run.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2071-1050/10/7/2302/s1>, Table S1: Data for Empirical Analysis of Public Participation on Environmental Governance in China.

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