

The Effect of Environmental Administrative Punishment on Water Pollution: An Analysis from the Perspective of Game Theory

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Abstract: The water resource pollution in China is very serious, and as a kind of public goods, water resource is easy to cause "free riding" behavior in the process of consumption. How to eliminate the interest conflict between different economic subjects? Environmental administrative punishment is one of the answers. This measure based on the Pigou theory is the foundation of China's environmental governance. From the perspective of game theory, this paper analyzes the effect of administrative punishment means of the water resources environment by constructing and analyzing the game theory model and concludes: that the unreasonable setting of the administrative punishment system for the water resources environment and the incomplete implementation process make its effect poor. Finally, the paper puts forward improvement suggestions from three aspects: strengthening supervision, system innovation and the application of Coase theory.

Keywords: environmental administrative punishment, water pollution, game theory, economics of environment

1. Introduction

China's economy and society develop rapidly, the people's living standard is constantly improving, however, the efficiency of China's economic development is low, the development mode still needs to be improved. Rivers spread over every area on land (except the dry and run-off areas), reasoning that they are the most easily used water bodies by human beings and the most easily affected ones by human activities. Nowadays, many rivers and lakes are polluted by industrial wastewater. More than 47% of the total surface water in China has water quality of class iii or below [1]. A large number of untreated sewage directly into the water body, which is an important reason for the pollution of water resources in China. At present, faced with increasingly severe resource and environmental constraints, strong government regulation has become a key measure of environmental governance, and carries strong social expectations, among which administrative punishment is the most basic means.

In China, the environmental administrative punishment is analyzed mainly from the perspectives of law and law economics. For example, Maxiang Cong's Basic Issues on Environmental Protection Law explored the concept of environmental administrative punishment system and clarified the administrative and civil liabilities of administrative punishment. The Course of Environmental Protection Law by Depei Han and the Course of Environmental Resources Law by Shouqiu Cai

mainly involve the implementing organs, administrative measures and procedures of environmental administrative punishment. As an interdisciplinary discipline, law and economics focus on studying the economic efficiency of environmental administrative punishment from the perspective of economics. For example, Fude Zhang studies environmental administrative law enforcement efficiency by using economic analysis method, and Wei Xie analyzes the "one-size-fits-all" problem in the implementation process of emission permits from the perspective of economics. Developed countries have gradually established the effective environmental administrative penalty system in line with the national conditions, which is inseparable from the comprehensive and in-depth study of the environmental administrative penalty system by many scholars. However, law and economics is still the main research perspective on environmental administrative punishment.

To sum up, from the existing research, the research field is mainly concentrated in the field of law and law economics, with few from the perspective of environmental economics, using game theory to analyze environmental administrative punishment.

From the perspective of environmental economics, this study explores and analyzes the problems of environmental administrative punishment by building a game theory model. From the perspective of theoretical research, this is conducive to the diversification of environmental administrative punishment research perspectives. From the realistic factor, it can help optimize policies, guide local policy implementation, and achieve better results in water pollution prevention and control in China.

2. Policy Analysis

Environmental administrative punishment is a kind of sanction imposed by administrative organs with state representatives on violations of environmental laws and norms for the purpose of environmental management and protection of the legitimate rights and interests of citizens, legal persons or other organizations [2]. The main body of environmental administrative punishment in China is the people's government at and above the county level, the environmental protection department at and above the county level, etc. The measures of administrative punishment mainly include oral warnings, administrative fines, and so on.

Environmental administrative punishment is a measure based on the Pigou theory.

The existence of negative externalities of environmental pollution leads to the inefficiency and inequity in the allocation of environmental resources, which prompts people to design a kind of institutional rules to correct the externalities and internalize the externalities. Pigouvian tax is a kind of economic means to control the negative externality of environmental pollution put forward by Pigou, a welfare economist. According to the Pigou theory, economists advocate the use of taxes to force firms to internalize externalities: when a firm imposes a negative external social cost, a tax should be imposed on it that is exactly equal to the marginal cost of damage. The concept of "tax" mentioned here is an academic concept [3], which can be used as both tax and charge in practical applications, such as environmental resource tax, environmental pollution tax and pollutant discharge fines.

3. Game Theory Model

From the perspective of game theory, the paper will establish a game theory model, obtain pure strategic Nash equilibrium and mixed strategic Nash equilibrium, and analyze the concrete causes of the abstract results of game theory in reality, and finally put forward suggestions for policy improvement.

3.1. Pure Strategic Nash Equilibrium

3.1.1. Hypothesis

Assume player 1 is governments which have two choices: inspect and not inspect, player 2 is enterprises which also have two choices: control the pollution and discharge the pollution.

B presents the cost of inspection by the government; C presents the cost of pollution control by the enterprise; F presents the fine imposed by the government for illegally discharging waste water.

$F > B$ is the motivation of the government charging the fines, so this inequality is always true.

3.1.2. Process

Table 1: Game theory model table-pure strategic nash equilibrium.

Governments \ Enterprises	Pollution discharge	Pollution control
	inspect	F-B, -F
Not inspect	0,0	0,-C

If the fines imposed by the government are less than the costs saved by companies when discharging pollutants, that is $C > F$ the pure strategic Nash equilibrium of this game model is (inspect, pollution discharge)

If the fines imposed by the government are large enough, that is $F > C$, $-F < -C$

There is no pure strategic Nash equilibrium in this case.

3.1.3. Conclusion & Example

The pure strategic Nash Equilibrium is (inspect, pollution discharge).

In reality, the reasonable explanation is that the enterprises will pay the fines and still discharge pollution because the fines are smaller than the cost saved by discharging pollution.

A real life example can be found in Guangxi Province, one company named Huayin Aluminum has had nine mud spills investigated by authorities in the four years since it opened in 2008. The fine for each spill is only 100,000 yuan, compared with its an annual output of 5 billion yuan is almost nothing.

3.1.4. Analysis

First of all, the disadvantages of pure strategy Nash equilibrium are caused by the low fine, which is due to the government's incomplete grasp of market information. The precondition for the implementation of Pigou theory is that the government has a comprehensive understanding of the marginal costs and benefits of each enterprise in the market, as well as the marginal costs and benefits of the whole society, which is very difficult. The result of incomplete information is likely to be lower administrative fines.

Secondly, the subject of administrative punishment is the local government and environmental protection department as mentioned above. It is worth noting that the local finance is related to the economic benefits of local enterprises, which is likely to lead to local protectionism and make the local government set a lower penalty amount. Besides, fines become an income for the government,

which means if the environment improves, there will be a lack of fine income, reasoning that the government lack motivation to control environmental pollution.

From the point of view of enterprises, fines will not prevent enterprises from polluting, but may produce compensation psychology, so that enterprises more unbridled pollution after fines.

3.2. Mixed Strategic Nash Equilibrium

3.2.1. Hypothesis

Based on the previous assumptions, assume θ presents the probability of government inspection, then $1-\theta$ presents the probability of government not inspecting; γ presents probability of enterprises discharging pollutants, then $1-\gamma$ presents probability of enterprises controlling pollutants. ($0<\theta<1$, $0<\gamma<1$)

3.2.2. Process

Table 2: Game theory model table-mixed strategic nash equilibrium.

Enterprises	Pollution discharge(γ)	Pollution control ($1-\gamma$)
Governments		
Inspect(θ)	F-B, -F	-B,-C
Not inspect($1-\theta$)	0,0	0,-C

If the government chooses inspection, the expected benefit is

$$B\gamma + (-B)(1 - \gamma) = F\gamma - B$$

If the government chooses not to inspect, the expected benefit is 0
 So when $F\gamma-B>0$, $\gamma>B/F$, the government tends to choose to inspect.
 If the enterprise chooses pollution discharge, the expected benefit is

$$(-F)\theta + 0(1 - \theta) = -F\theta$$

If the enterprise chooses to control the pollution, the expected benefit is

$$(-C)\theta + (-C)(1 - \theta) = -C$$

So when
 $\theta<C/F$, the enterprises tend to choose to discharge pollutants.
 $\theta>C/F$, the enterprises tend to choose to control the pollution.

3.2.3. Conclusion & Example

The mixed strategic Nash equilibrium of this game model is $\gamma=B/F$, $\theta = C/F$. Under hypothetical conditions, enterprises choose pollutant discharge with a probability of B/F , while the government chooses inspection with a probability of C/F .

In reality, the reasonable explanation is that the enterprises discharge at night or on holidays to escape supervision, and governments are willing to turn a blind eye to corporate pollution.

A real life example is found in Youxi county, a papermaking enterprise often in holidays, early morning, rainy day sewage discharge to avoid the punishment, and finally, be caught on the spot at 3 o'clock on March 12th.

3.2.4. Analysis

The disadvantages of mixed strategy Nash equilibrium are caused by the inadequate supervision of water pollution. Because of the large number of the Chinese water system and vast waters, the supervision cost of water pollution prevention and control is high, which needs to consume a lot of human and material resources, so there are always omissions in the water quality supervision.

In the process of administrative supervision, there are also the phenomenon of government failure and buck-passing, which comes from the unclear division of power. Although the framework of the existing legal system of environmental protection has been formed in China, the whole legal system of environmental protection contains scattered laws and regulations.

For example, the status of Chinese "Environmental Protection Law", "Administrative Punishment Law", "the People's Republic of China Water Pollution Prevention and Control Law" are the same, but in view of the same kind of illegal activities will have a cross, differences in the situation [4]. There are some illegal acts that can be handled by both the people's government and the environmental protection department, and even some authorized subjects, which can easily cause buck-passing among different departments.

4. Suggestions and Measures

4.1. Improve the Penalty System

Firstly, we need to perfect the legislation of China to improve the system of environmental administrative punishment. China needs to sort out all kinds of environmental protection and water resources protection laws, define the status of each law and determine the rights and responsibilities of each functional department.[5] In terms of administrative fines, the relationship between the charge for exceeding the standard and the charge for sewage discharge, the charge for concentration and the charge for total quantity, the charge for a single factor and the charge for multiple factors, etc., should be clarified.

In addition, we can learn from the American system. In terms of property punishment, the purpose of fines in environmental law enforcement in the United States is firstly to ensure that the punished wrongdoer or enterprise loses the competitive advantage gained by illegal behavior and to maintain the fairness of competition, and secondly to compensate for the negative social external effects caused by environmental destruction and assume social responsibility. Therefore, the environmental administrative penalties in the United States are relatively large, and there will even be the bankruptcy of enterprises due to environmental damage. China needs to pay more attention to punishment, not only to make the economic profits of the illegal activities disappear, but also to bear more social responsibility.

4.2. To Strengthen the Supervision

Due to the large scope and complex terrain of Chinese basin, many basin enterprises only depend on the function of government supervision department, which is very limited.

Mobilize the public to supervise the water environment. Economic rewards and honorary rewards can be used to motivate the people to supervise and report enterprises in the river basin.

Adopt upstream and downstream mutual supervision. Water resources have typical trans-boundary characteristics, so the downstream can be used to supervise the upstream to improve the supervision efficiency. Typical policy measures include the ecological compensation mechanism between upstream and downstream. If the upstream water pollution treatment meets the standards, the downstream government will compensate the upstream government, and if it does not meet the standards, the upstream government will compensate the downstream government, thus achieving the

Kaldor-Hicks improvement. A typical case is the "Xinan River Ecological Compensation Experimental Zone", which effectively solves the "free riding" phenomenon in public goods consumption through the ecological compensation between Anhui and Zhejiang governments.

Introduce the "river chief system". The key to the river chief system is to set the "river chief" as the main person in charge of water resources of the local Party and government organs, integrate the resources of relevant functional departments in water pollution treatment, and carry out centralized management [6]. The essence of the "river chief system" is the "guarantee system" of leading cadres. The biggest advantage of the system is to strengthen the supervision from the system, avoid mutual buck-passing, but also to solve the problem of incentive. Under this system, responsibility is not only very clear, but also fully implemented to the people, which can effectively alleviate the interest between the various functional departments of the government. Moreover, since the pay rise, promotion and evaluation of river chiefs are all linked to the effectiveness of watershed governance, work efficiency is improved and enforcement is strengthened. For example, Bijie city is aimed at the responsible person of environmental management disadvantage to implement "one vote veto" system. If Party and government leaders fail to complete their tasks in environmental governance, or if their tasks fail to meet the standards, their assessment results will be unqualified, which will directly affect their careers.

4.3. Application of the Coase Method

In addition to the Pigou method, you can also use the Coase method. According to the Coase Theorem, as long as the property right is clear and the transaction cost is zero or small, the final result of the market equilibrium will be efficient and the Pareto optimal allocation of resources will be realized no matter who is given [7]. The property right at the beginning. Therefore, the government does not need to grasp all the information of the market, but only needs to determine the right to use water resources of each subject. Through the government, enterprises, associations and other entities in the market to buy or sell pollutant discharge rights, regulation of pollution discharge volume, to achieve economic and environmental development.

Zhejiang province 2007 has gradually established an emissions trading market, as of May 2022, the province has paid for the use of sewage discharge rights and turnover reached 14.6 billion yuan, making up about half of the country. The emissions trading system, makes the price signals play a role in environmental protection, reducing management costs, and motivating the pollution emission enterprises and citizens.

5. Conclusion

Through the use of game theory analysis, the paper found that there are a series of disadvantages in the environmental administrative punishment measures based on Pigou theory. As the fine becomes revenue for the local government, the government's supervision power is insufficient, and local protectionism emerges. Because of the high cost of supervision, the supervision subject is not clear, which leads to the deniability between the power subject. Because the fines are small, enterprises have no power to control pollution; Due to the compensation psychology of fines, enterprises are more unbridled pollution.

The paper suggests that on the one hand, supervision measures can be improved, policy innovation can be carried out to improve government functions, on the other hand, the Coase method can be used to give more ecological environmental protection tasks to the market, and the effective allocation of emission rights through price signals.

There are also shortcomings in this study. For example, the game theory analysis is an abstract conceptual analysis, and no actual case data is substituted for calculation. It needs to be improved in the future research.

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