

Game analysis among the central government, local governments, and firms in China's environmental pollution governance

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Abstract. China's environmental pollution governance has entered the game stage centered on interests, and there are three main bodies in environmental pollution governance: the central government, local governments and firms. The research firstly reveals the relationships among the central government, local governments, and firms in the process of environmental pollution governance, and then analyzes the game among the central government, local governments and firms using game theory in Economics. Finally, the research makes a conclusion and proposes some corresponding policy proposals so as to solve the problem of environmental pollution.

1. Introduction

As the concept of green development continues to gain people's support, people have come to realize the importance of the environment for economic and social development^[1]. However, there are still the situations in which rapid economic development is sought at the expense of the environment in China, and it has caused serious environmental pollution problems, especially, air pollution, soil pollution and water pollution^[2].

China has put environmental pollution governance in a high position, as one of the most important tasks of governments at all levels^[3]. Because of continuous exertion, China's environmental pollution governance has ameliorated by degrees. Even so, environmental pollution in many places of China has intensified, and the environmental pollution problem is still not optimistic. The situation is associated to the collusion between local governments and firms, which are the main bodies in charge of the environmental pollution. Hence, studying the interactive relationships among the main subjects in environmental pollution governance has very important significance.

2. The Interactive Relationships among the Subjects in Environmental Governance

Over the past few years, the holistic environment quality has not enhanced obviously, notwithstanding China has intensified its pollution governance investment and environmental legal system. Superficially, it appears that China's difficult position of environmental pollution governance is due mainly to the unreasonable industrial structure and extensive mode of economic development. Nevertheless, the underlying reason is the game played among the central government, local



governments and firms. Therefore, analyzing the relationships among these bodies is important to formulate valid pollution governance policies.

The relationships between government departments firstly are benefit relations, and then power relations, public administration relations^[4]. Because of the performance evaluation system using only GDP as the core index and China’s fiscal decentralization, local governments often concentrate on their own regions’ economic development, fiscal revenue, and personal interests^[5], tend to think their own regions’ economic development higher than environmental protection, and carry out measures based on their own benefits, causing the central government’s environmental policy distorted, which leads to the interest conflicts between the central government and local governments.

The interests between local governments and firms are highly relevant. Consequently, local governments and firms have the impulse to conspire to evade the supervision of the central government. Whether firms and local governments collude rests with the associated costs and benefits. In general, collusion is beneficial to increase the income of both sides. Without a doubt, in case the collusion is found, both sides will be penalized. While, because of the incomplete environmental policies and laws, the gains from collusion are often greater than the cost in the past experiences, and the asymmetry of information, local governments are more likely to collude with firms.

3. Game Analysis of Environmental Pollution Governance

Based on the above analysis of the relationships among the central government, local governments, and firms, a tripartite game is formed. The central government represents public interests, and doesn’t collude with local governments and firms. While, local governments and firms do collude with each other because of common interests.

3.1. Assumptions of the Model

Through the above analysis, we can find that the central government, local governments, and firms are not capable of determining other participants’ selections accurately, because of fractional information. The gigantic cost of supervision means the central government will carry out supervisory measures with a certain probability. In the same way, local governments and firms will make a choice to collude with a certain probability, too.

Assumptions: C means the central government’s regulating cost; M means the central government’s amount of penalty on local governments; N means the central government’s amount of penalty on firms; β_1 means the gain of local governments from colluding with firms; β_2 means local governments’ rent from firms; and β_3 means firms’ gain from colluding with local governments.

Then, $P(y)$ represents the probability that the central government will carry out regulatory measures; $P(s)$ represents the success probability of the central government’s regulation; $P(f)$ represents the colluding probability between local governments and firms; $B(y)$ represents the central government’s prospective income; $B(f)$ represents local governments’ prospective income; and $B(e)$ represents firms’ prospective income. Therefore, we have a tripartite game matrix of the interaction among the central government, local governments, and firms (see Table 1).

Table 1 Game Matrix Table

		Central Government		
		Probability of Regulation $P(y)$		Probability of Non-regulation $1 - P(y)$
		Probability of Success $P(s)$	Probability of Failure $1 - P(s)$	
Local governments and firms	Probability of collusion $P(f)$	$\beta_1 + \beta_2 - M$ $\beta_3 - \beta_2 - N$ $M + N - C$	$\beta_1 + \beta_2$ $\beta_3 - \beta_2$ $-C$	$\beta_1 + \beta_2$ $\beta_3 - \beta_2$ 0
	Probability of Non-collusion $1 - P(f)$	0 0 $-C$	0 0 $-C$	0 0 0

3.2. Analysis of the Model

Based on game theory and the data in Table 1, there is no pure-strategy Nash equilibrium in the game process. Thereby, we solve for a mixed-strategy Nash equilibrium.

(I) The central government's prospective income is formulated as this:

$$B(y) = P(y)P(f)[P(s)(M + N - C) + (1 - P(s))(-C)] + P(y)(1 - P(f))[P(s)(-C) + (1 - P(s))(-C)] \quad (1)$$

The central government maximizes its own benefits through:

$$\frac{\partial B(y)}{\partial P(y)} = P(f)P(s)(M + N) - C \quad (2)$$

When the central government's income has nothing to do with its regulation probability, firms and local governments' best colluding probability is as follows: $P(f)_y^* = \frac{C}{P(s)(M+N)}$.

Under these circumstances, if the colluding probability is $P(f) = P(f)_y^*$, the central government's income will not vary, in despite of any regulation. The outcome of the central government's regulation or non-regulation is not different. In principle, the central government's most favorable selection is non-regulation. If the colluding probability is $P(f) < P(f)_y^*$, the central government should not to regulate. If the colluding probability is $P(f) > P(f)_y^*$, the central government will select to regulate, stopping the environmental pollution.

(II) Local governments' prospective income is formulated as this:

$$B(f) = P(y)P(f)[P(s)(\beta_1 + \beta_2 - M) + (1 - P(s))(\beta_1 + \beta_2)] + P(f)(1 - P(y))(\beta_1 + \beta_2) \quad (3)$$

Local governments maximize their own benefits through:

$$\frac{\partial B(f)}{\partial P(f)} = P(y)[P(s)(\beta_1 + \beta_2 - M) + (1 - P(s))(\beta_1 + \beta_2)] + (1 - P(y))(\beta_1 + \beta_2) \quad (4)$$

When local governments' income has nothing to do with the probability of collusion between local governments and firms, we have $\frac{\partial B(f)}{\partial P(f)} = 0$. And then, we can get the central government's best probability being found.

st regulation probability as follows: $P(y)_f^* = \frac{(\beta_1 + \beta_2)}{P(s)M}$.

Under these circumstances, if the central government selects to regulate with probability $P(y) = P(y)_f^*$, local governments' benefits are not different, in despite of colluding with firms or not. If the central government selects to regulate with probability $P(y) < P(y)_f^*$, then local governments will be prone to collude with firms, because the latent cost is low. If the central government selects to regulate with probability $P(y) > P(y)_f^*$, local governments won't collude with firms because of the high

(III) Firms' prospective income is formulated as this:

$$B(e) = P(y)P(f)[P(s)(\beta_3 - \beta_2 - N) + (1 - P(s))(\beta_3 - \beta_2)] + P(f)(1 - P(y))(\beta_3 - \beta_2) \quad (5)$$

Thus, firms maximize their own benefits through:

$$\frac{\partial B(e)}{\partial P(f)} = P(y)[P(s)(\beta_3 - \beta_2 - N) + (1 - P(s))(\beta_3 - \beta_2)] + (1 - P(y))(\beta_3 - \beta_2) \quad (6)$$

When firms' income has nothing to do with the probability of collusion between local governments and firms, we have $\frac{\partial B(e)}{\partial P(f)} = 0$. And then, we can get the central government's best regulation probability as follows: $P(y)_e^* = \frac{(\beta_3 - \beta_2)}{P(s)N}$.

Under these circumstances, if the central government chooses to regulate with probability $P(y) = P(y)_e^*$, then firms' benefits are not different, in despite of colluding with local governments or not. If the central government selects to regulate with probability $P(y) < P(y)_e^*$, firms are prone to collude with local governments because of the lower probability of being found. In this case, firms' most favorable selection is to collude with local governments. If the central government selects to regulate with probability $P(y) > P(y)_e^*$, firms are not prone to collude with local governments for the purpose of maximizing their own benefits.

4. Conclusions

In general, we can find that environmental pollution governance is a game process among the central

government, local governments and firms. Different target orientation affects their respective behaviors, leading to the difficult position of environmental pollution governance. Thereby, the conclusions of the research are drawn forth. ① Analyzing from $P(f)_y^*$, the collusion probability $P(f)_y^*$ is proportional to the central government's regulating cost, and is inversely proportional to the central government's amount of penalty on local governments, firms and the success probability of the central government's regulation. ② Analyzing from $P(y)_f^*$, the regulation probability of the central government is proportional to the gain of local governments from colluding with firms and local governments' rent from firms, and is inversely proportional to the success probability of the central government's regulation and the central government's amount of penalty on local governments. ③ Analyzing from $P(y)_e^*$, the regulation probability of the central government is proportional to the firms' gain from colluding with local governments, and is inversely proportional to local governments' rent from firms, the success probability of the central government's regulation, and the central government's amount of penalty on firms.

5. Policy Proposals

Based on the above analysis and conclusions, related policy proposals are proposed for the purpose of improving the pollution governance.

5.1. *Enhancing the Enforcement of Related Laws and Regulations*

It is difficult to solve the problem of pollution in China, mainly because of the failure of the government. The lack of conformity can't resolve the environmental pollution problem. Some local governments are prone to set the national environmental protection policies in disregard, without strict implementation of the law. Thence, we must enhance the implementation of environmental policies, regularly perfect the law implementation system, and enhance the level of law implementation to better the performance of environmental pollution governance.

5.2. *Perfecting the Regulatory System*

Environmental regulatory system is the basis of environmental governance^[6]. Currently, local environmental protection departments should accept the dual leadership of the relevant departments of the higher governments and local governments. Thence, it is considered that they should be stripped out of local governments to maintain their independence. In addition, research has shown the public and social groups' supervision plays an important role in encouraging firms to respect environmental laws and reducing collusion^[7]. Therefore, we should build an information disclosure mechanism, and build a third-party regulatory mechanism, consisting of the media, non-governmental organizations, and the public, etc.

5.3. *Perfecting the Incentive and Restraint Mechanisms*

For local governments, we can change the performance evaluation system with GDP at the core, and add in the indicators of resources and the environment, thus making green elements a key consideration in administrative decision making. These means will greatly add to the cost of collusion between local governments and firms, and lessen the probabilities of collusion. Meanwhile, the relevant departments and personnel should be penalized or awarded based on their governance performance. For firms, they should be penalized or awarded according to their performance of pollution control. In this way, a policy of positive incentives and reverse penalties can bring about a clear picture of award and penalty, which will help to better the environment^[8].

5.4. *Intensifying the Technological Innovation*

Technological innovation plays an important role in environmental pollution governance^[9]. Firstly, it can improve the production efficiency and resource utilization, and lower the environmental pollution. Secondly, it can reduce the cost and enhance the efficiency of pollution governance, and bring profits

to firms. And thirdly, it can lower the governments' cost of environmental regulating.

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