



# Research on the Public Behaviour Under the Impact of Enterprises Pollution Based on the Game Theory

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**Abstract.** With the rapid progress of science and technology, environmental problems are becoming increasingly prominent of human. Environmental issues have become a common challenge facing the international community. It is also one of key topics of current research. The author establishes a game model to analyse the public's behaviour decision-making when they face the environmental pollution caused by enterprises. Then, it is found that litigation cost is an important reason affecting public behaviour. Under the condition of low litigation costs, the dominant strategy for the public is to file a lawsuit against the illegal pollutant discharge enterprises. And then, according to the number of environmental litigation cases in recent five years, the data analysis shows that the Chinese government and the public have paid increasing attention to environmental issues in the past five years. The settlement rate environmental protection has remained at a relatively stable state. In conclusion, this paper suggests that the government should reduce the cost of public litigation, improve the trial efficiency of relevant cases and increase the publicity of environmental protection. Allowing the public to participate in the environmental protection system is conducive to the government's better governance of the illegal discharge of pollutants by enterprises.

**Keywords:** public · enterprises · environmental · pollution · litigation

## 1 Introduction

The standard of people's living has developed because of the technology advances and economic growth. Some enterprises and factors adopt to the excessive model of economic growth to achieve the maximization of their benefits. Economic growth under this model must be at the cost of environmental degradation and ecological damage [1]. According to the estimation, 70% environmental pollution comes from industrial enterprises in China in 2009 [2]. Air pollution and water contamination have imposed a threat to people's health. It is necessary for everyone to pay attention to environmental issues, especially industry. However, some polluting enterprises still illegally discharge pollutants in the production process to the environment in order to reduce their production costs. The ecological environment of the surrounding areas has been damaged, which has caused

trouble to the life of local residents. How to effectively control environmental pollution is a problem which is worth exploring. This is conducive to the restoration of the ecological environment.

In academic circles, scholars have made many studies on environmental pollution based on game theory. Taking environmental pollution control as an example, Zhou analysed the mechanism of policy implementation retardation and put forward some suggestions on Institutional Innovation [3]. Wang and Li qualified the decision-making behaviour among manufacturers, residents and the government by combining static game of perfect information and complete information dynamic game. They think that it is possible to form a Nash equilibrium conducive to environmental protection by changing the benefits of both sides of the game [4]. Xiang's research showed that there was a mutual reinforcing relationship between the attitude of residents and governments towards environmental pollution by building the incomplete static information game model [1]. Xiong and Xu considered that increasing the punishment for enterprise pollution was conducive to promoting environmental protection in the short term, and increasing the punishment for the ineffective governments supervision can achieve a better result for a long term [5]. Shang applied the basic principles of game theory to analyse the economic causes of environmental pollution. Through the matrix game model, it intuitively explained the plight of the victim's collective action [6]. Ma and Ren believed that strengthening cooperation between enterprises and strengthening government supervision can reduce treatment costs and pollutant emissions [7]. However, there is a little analysis of public behaviours under the environmental pollution based on the game theory. In fact, the public is the direct victim of environmental pollution. Such as air pollution can increase the incidence rate of respiratory related diseases. Some research suggested that urban air pollution was the direct or induce reason for chronic bronchitis, emphysema, bronchial asthma and other respiratory diseases [8]. Therefore, it is necessary to establish a game model to study the public behaviour strategies in the face of environmental pollution problems. It also has an important reference significance for the government to control polluting enterprises.

In the game model, the author supposes that both sides of the game are defined as rational people. Rational people want to maximize their interests and make decision after weight advantages and disadvantages. Faced with the serious environmental pollution by enterprises, public can choose to take steps, such as litigation, to seek compensation for losses. Public litigation can impose restriction to emission behaviours of enterprises at a certain extent. It can also better help the government to regulate the compliance of sewage enterprises. If public do not take actions to claim compensation for the loss, the public should not only bear their own losses, but also connive at the intention of illegal acts of enterprises, which is not benefit to environmental government.

This article will establish a simple game model and analyse it based on certain assumptions. Two different situations can be formed by changing a variable in the model. The author will focus on exploring how the public behaviour strategies change in these two different situations and what factors determine public behaviour decision. In the results and discussion part, the author combines the statistical data of the Ministry of justice of China to draw two figures to show the situation of environmental protection cases in China in the past five years. According to the conclusion, some suggestions can be put

forward. These may provide a new ideal for the government to control environmental pollution in the future and help society achieve sustainable development.

## 2 Methodology

The public can seek compensation from enterprises for the losses caused by the illegal pollutant discharge acts through many ways. Legal litigation is the most commonly used way at the present stage [9]. The game model in this article explores the behaviour decision-making of both sides of the game in the short term. It is necessary to divide the public into two parts as the two sides of the game. Both of them have two choices when they face the illegal discharge of pollution by enterprises. When an enterprise illegally discharges pollutants and causes environmental pollution, making the public feel uncomfortable, the public can freely choose whether to sue the enterprise. According to the two behaviour strategies of public, a game model can be established. Table 1 shows the indicators involved in the game model.

From Table 1, the total cost of public litigation is the  $L$ .  $L_1$  means low litigation costs and  $L_2$  means high litigation costs. The amount of compensation for public damage caused by illegal discharge of pollution by enterprises is the  $C$ . In the case of low litigation costs, the relationship between the amount of enterprises compensation and the cost of public litigation can be expressed  $C > L_1$ . When the litigation costs are high, then  $C < L_2$ , the relationship among the compensation amount and public litigation costs in both cases can be expressed as  $L_1 < C < L_2$ .

If both sides of the game take the lawsuit, the total costs of delivery and the compensation amount of the enterprise will be equally distributed by both sides of the game. Once an enterprise illegally discharging pollutants is sued by the public, enterprises must rectify their pollution discharge facilities and production processes and invest funds to improve the areas of environmental pollution caused by them. Under pressure from all parties, enterprises must restore the environment to the state before it was polluted. The public benefit from environmental improvement is represented by the  $A$  in Table 1. Environment is regarded as a public good. Therefore, as long as one party choose to litigate and the environment is improved, the public all can get the benefit of the  $A$ . When both sides of the game do not choose to sue, the final payoff of both sides is 0. Because the game model studies the behaviour decisions of both sides of the game in short term.

**Table 1.** Description of model indicators

Primary index	Handle	Secondary index
Total cost index of public litigation	$L_2$	High litigation cost (dollar)
	$L_1$	Low litigation cost (dollar)
Public benefit index	$C$	Enterprises compensation amount (dollar)
	$A$	Environmental improvement benefit (dollar)

The environmental pollution problems caused by excessive discharge pollutants in short term may cause public discomfort, but will not bring substantial economic losses to the public.

By analysing the model indicators in Table 1, it is easy to get the benefits of different public behaviour decisions. If both sides of the game choose to sue, their respective profits are  $(C-L_2)/2 + A$  or  $(C-L_1)/2 + A$ . One party chooses to sue and the other party does not choose to sue, then the income of the litigant party is  $C-L_2 + A$  or  $C-L_1 + A$  and the income of the non-litigation party is the  $A$ . Both parties do not choose litigation and the benefits of both parties are 0. Based on the above settings, the game relationship between the public can be described two payoff matrixes.

### 3 Results and Discussion

By constructing a game model, this paper explores the behaviour strategy choices of the public under different litigation costs when facing the illegal emission of pollutants by enterprises. Through the analysis of the indicators, the results can be shown in Tables 2 and 3.

Table 2 shows the payoff of different decisions made by the public under the high-litigation costs. In the case of high litigation cost, the amount of compensation is less than the litigation costs of the public. The benefits corresponding to different strategies have the following relationship.

$$A > (C - L_2)/2 + A > C - L_2 + A \tag{1}$$

Because it is impossible to determine the accurate difference between the litigation costs and the enterprise compensation amount, it cannot judge the size relationship between  $C-L_2 + A$  and 0. If both sides of the game choose litigation, then their benefits are the same. Suppose that one party choose to sue and the other party chooses not to

**Table 2.** Game relationship between the public under high litigation cost

		Public	
		Litigation	Non-litigation
Public	Litigation	$((C-L_2)/2 + A, (C-L_2)/2 + A)$	$(C-L_2 + A, A)$
	Non-litigation	$(A, C-L_2 + A)$	$(0, 0)$

**Table 3.** Game relationship between the public under low litigation cost

		Public	
		Litigation	Non-litigation
Public	Litigation	$((C-L_1)/2 + A, (C-L_1)/2 + A)$	$(C-L_1 + A, A)$
	Non-litigation	$(A, C-L_1 + A)$	$(0, 0)$

litigation, the party who does not litigate will get higher payoff than the litigate due to “Free riding”. Litigant spends litigation costs to improve environmental pollution caused by enterprises. As the environment is a public good (non-competitive and nonexclusive), the benefits from environmental improvement will be shared by the public. Therefore, the party who does not choose to sue can obtain the income of A at zero cost. The behaviour strategy is not be known by the both sides of the game, so public always choose non litigation can get A or 0 benefits. If players choose to sue, it can get the income of A or  $(C-L_2)/2 + A$ . because there is a risk of negative surplus in choosing litigation. No matter what decision the other party makes, choosing not to sue is the best choice for both sides of the game. The dominant strategy is not to sue for public at high litigation costs. If both parties choose dominant strategy, then the total social income is 0 which can be expressed by mathematical equation as  $T_2 = 0$ .

Under the low litigation costs, the game relationship between the public and environmental pollution is shown in Table 3.

When the litigation costs less than the compensation amount, the relationship between different benefits can be expresses as

$$A < (C - L_1)/2 + A < C - L_2 + A \tag{2}$$

Based on the above inequality  $A < (C-L_1)/2 + A$ , one party chooses litigation, the other party’s best option is litigation too. If one player chooses not to sue and the other player elects to litigate, then the income of litigant party  $(C-L_1 + A)$  can be greater than that of non-litigation party(A). The public all choose not to file a lawsuit against illegal pollutant discharge enterprises, then both sides of the game will gain 0. The public all hope that they can get the maximum benefit in any case, no matter how the other party chooses. The public tend to select litigation enterprises which cause environmental pollution due to excessive emission pollution to conduct prosecution. Combining with the above analysis, summarize that non litigation is the dominant strategy for public, when the litigation costs are low and the enterprise’s compensation can cover the total litigation costs. Suppose that the public all choose the best strategy, the total social benefits can be expressed as

$$T_1 = (C - L_1) + 2A \tag{3}$$

By changing the variable of public litigation cost in the game model, the conclusions are shown in the following Table 4.

**Table 4.** Public and social benefits under different dominant strategies

Dominant strategy	litigation	Non litigation
Public benefit (one side)	$(C-L_1)/2 + A$	0
Social benefits	$(C-L_1) + 2A$	0

In the short term, the total litigation cost is the decisive factor for the public to weather choose to file a lawsuit in the face of enterprises' excessive emission pollution. In other words, whether the enterprise's compensation can compensate the total costs of public litigation determines the final strategic choice of the public.

In the case of low litigation costs, public can get positive surplus by choosing to sue. It is suitable for public to litigate. The litigation can play a restrictive role in the discharge behaviour of enterprises or factors to a certain extent. When leaders of enterprises make decisions on pollutant discharge, it is necessary for enterprises to carefully consider the relationship between the benefits they get from exceeding the standard and the costs they have to pay. At the same time, public litigation is also a kind of disguised supervision of enterprises, it can also provide a reference for the government to evaluate pollutant discharge enterprise.

From the perspective of total social benefits, the total benefits of the public's dominant strategy in the case of low litigation costs are better than that in the case of high litigation costs. It is possible to realize the maximization of social and economic benefits under the low litigation.

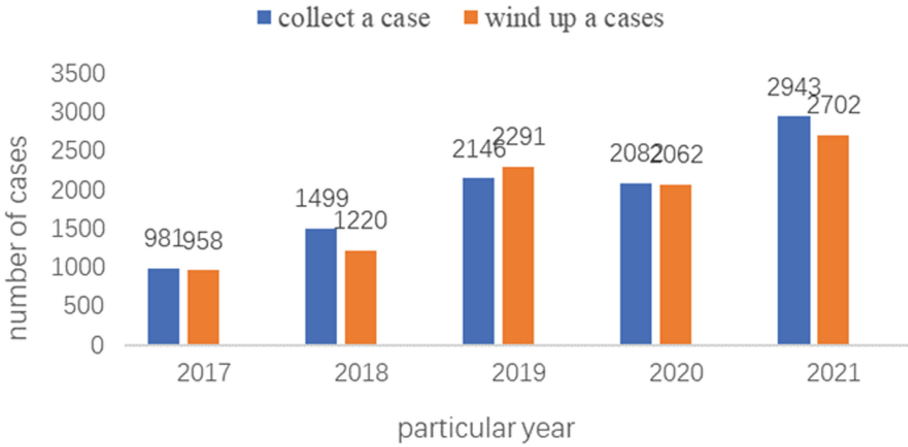
The analysis based on the choice of public behaviour strategies in two cases can help provide some ideas for the government to control the pollution emission behaviour of enterprises. First of all, it is necessary to simplify the procedures of civil litigation and improve the trial efficiency of environmental pollution and other related litigation cases. Reduce the litigation costs of public as much as possible. Encourage the public to participate in the environmental supervision system which can help governments reduce the costs of supervision of enterprises' pollution discharge behaviour.

Secondly, the government can increase penalties for enterprises illegal discharge pollutants. This includes increasing the amount of compensation that enterprises pay to citizens who have suffered damage. The relevant departments may include the litigation costs of public into the consideration of determining the amount of compensation.

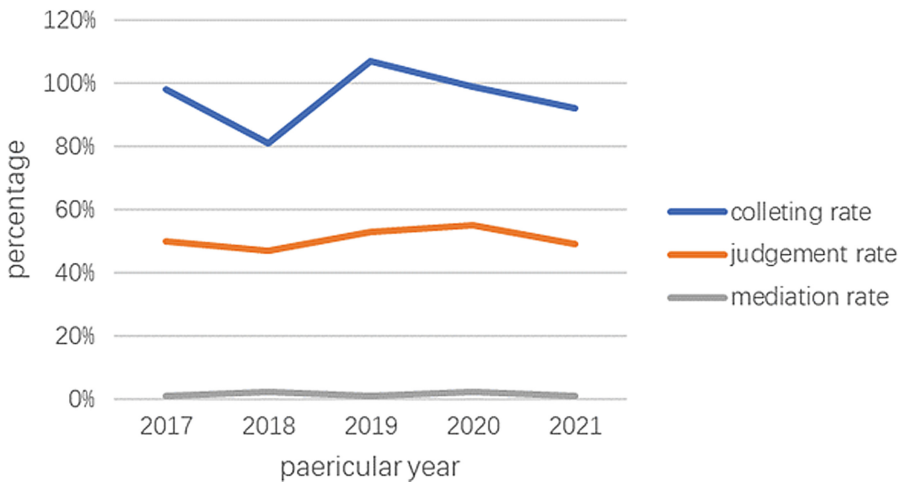
Thirdly, the government should enhance the citizens' awareness of environmental rights protection. The society should increase the promotion and publicity of the environmental act. Reduce information barriers and enhance the transparency of information in the field of environmental litigation. In the face of environmental pollution caused by enterprises and damage to public' interests, public should have law to follow and a way to go. Environmental problems come from economic development, so the solution of environmental problems ultimately depends on economic theory. The social should develop the economy while solving the environmental pollution.

In recent years, the Chinese government and the public have paid more and more attention to environmental issues indeed. The overall number of environmental litigation cases are on the rise. The Fig. 1 and Fig. 2 show the statistics of the number of cases closed and closing rate in the first instance of environmental protection administration in China in the past five years. These data are from the statistical bulletin of China's judicial department in the past five years.

Figure 1 is obviously showing that China's environmental protection litigation cases are on the rise. From 981 cases in 2017 to 2943 cases in 2021, the total number of litigation cases about environmental protection has increased by 1962 for five years. It is indicating that public environmental awareness has been continuously enhanced.



**Fig. 1.** Statistics on the number of environmental protection cases



**Fig. 2.** Analysis of the efficiency of accepting cases

This shows that the government attaches great importance to environmental issues and the trial efficiency of environmental litigation cases is considerable. Figure 1 shows that the closing rate has remained above 80% in the past five years and reached 99% in 2020. Compared the two methods of judgement and mediation, as shown in Fig. 2, judgment is a more common way to close environmental protection cases. The solution of environmental problems depends more on the function of the government.

Nevertheless, environmental pollution is still a big challenge for China in the future. The government and the public need to work together to better control and manage environmental pollution. Realize the harmonious coexistence between human and environment.

## 4 Conclusion

The author analyses the behaviour strategies of public facing the excessive emission of pollutants from enterprises under high litigation cost and low litigation cost. The public is free to choose whether to file a lawsuit or not. According to the game model, it shows that under the high cost, the public dominant strategy is not to sue. Because this choice can ensure public basic rights and interests. Under the low litigation costs, choosing litigation is the best behaviour strategy of public. Litigation is also the dominant strategy for public. The public can get higher benefits by suing. If the government can control the litigation costs at a low level, the public choice of litigation will help government better supervise the enterprises' pollution discharge behaviour. It is also conducive to the social environmental protection work.

The paper establishes a game model based on certain assumptions. By changing the variable of litigation costs in the model, two payoff matrixes under different litigation cost levels are obtained. Based on the game theory, the public' dominant strategy can be shown. Then calculate the total social income under the corresponding circumstances through the payoff to the public dominated behaviour strategy. Through the study of the model, three suggestions can be put forward for the government to manage the illegal pollution discharge of enterprises. First, simplify litigation procedures and reduce litigation costs. The second is to increase the punishment for enterprises' environmental pollution activities. The third is to deepen the public' awareness of environmental rights protection. Actively fight against environmental pollution. Finally, the author summarizes the number of environmental litigation cases in China in recent years. In the past five years the number of environmental litigation cases has increased significantly. Before 2017, the judicial department did not count environmental protection litigation cases as a type of case alone. Since 2017, environmental protection cases have appeared separately in the judicial statistical bulletin. This shows that with the economic development, environmental problems have become increasingly prominent. The public and the government also pay more and more attention to environmental protection.

In order to make the analysis more concise, the above game model impose some restrictions on the objective conditions of the model. Some situations in reality are not included in the analysis system. It makes the game model analysis of article have some shortcomings. Firstly, the article only considers the public's behaviour decisions when facing the illegal sewage discharge of enterprises in a short term. In fact, the damage of environmental pollution to the public is mainly reflected in the long-term impact. In the long term, if the public does not choose to sue, the public will suffer less than zero loss of interests under pollution infringement. The game relationship between the public is more complicated in a long term. Secondly, the total litigation costs  $L_1$  and  $L_2$  in the article only includes the direct cost of litigation and does not include the indirect cost into the game model. In real life, time cost, opportunity cost and psychological cost are also important factors that affect the public decision-making in litigation. How to quantify these costs reasonably and apply them to the game model of public behavior decision-making in this article is an important topic for the author to conduct in-depth research in the future.



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