Multi-Evolutionary Game Research on Heavy Metal Pollution Control in Soil: Based on a Third-Party Perspective

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Abstract: The introduction of third-party governance models for the treatment of soil heavy metal pollution has promoted the marketization, professionalization, and efficiency of pollution treatment, but also can result in distortions of relevant stakeholder relationships and conflicts of interest. The game relationship among the government, soil-polluting companies, and third-party governance companies may solve the practical dilemma of comprehensive management of soil heavy metal pollution and establish a good cooperative mechanism. We constructed a three-party evolutionary game model to analyze the interaction mechanism of each agent’s strategy choice as well as the evolution of each agent’s strategy choice under different parameter trends and simulation analyses. The research showed that the amount of fines and supervision costs, rent-seeking costs and governance costs, and government subsidies and rent-seeking benefits were key factors affecting the evolution and stability strategies of government departments, soil-polluting companies, and third-party governance companies. By cooperating with third-party governance companies, the government can effectively suppress the improper behavior of soil-polluting companies. The conclusions of the study are helpful to broaden the research boundary of soil heavy metal pollution treatment and provide theoretical guidance for the treatment of soil heavy metal pollution in China.

Keywords: treatment of soil heavy metal pollution; third-party governance; evolutionary game; simulation analysis

1. Introduction

As rapid industrial development has brought about a jump in gross domestic product, it also has caused many environmental problems, among which the problem of heavy metal pollution in soil has attracted much attention [1]. According to the National Survey Report on Soil Pollution issued by the Ministry of Environmental Protection of the People’s Republic of China in 2014, China’s contaminated arable land is as much as 10 million hm², and heavy metal pollution has resulted in an annual reduction of 10 billion kg of grain. According to the report, various agricultural losses resulting from soil pollution have totaled 20 billion yuan per year. Among these losses, the heavy metals in the soil in the south-central, southern, southwest, and northwestern regions far exceed normal indicators. Soil pollution not only seriously affects the ability of the soil to circulate and destroys sustainable agricultural development, but also endangers public health and food security [2,3]. Incidents, such as cadmium meter incidents, excessive blood lead levels, and arsenic poisoning are frequent [4], showing that the problem of soil heavy metal pollution has become a major problem that cannot be avoided if
China’s economic development is to remain sustainable [5]. Governance of this pollution is essential to the survival and development of the country and its people, as well as to the sustainability of enterprises and societal progress [6,7].

Facing this severe environmental situation, China gradually has begun to introduce a series of environmental laws and regulations to improve the quality of the soil environment. The State Council of China issued the Soil Pollution Control Action Plan, which required the trend of increasing soil pollution nationally be curbed, the overall environmental quality of the soil be stabilized, the soil environmental safety of agricultural land and construction land be guaranteed, and soil environmental risks be reduced in 2020. As the main force of soil heavy metal pollution remediation, corporate entities bear “hard” legal responsibilities. These entities should follow the principles of “who pollutes, who governs” and “polluter pays”. However, the soil pollution remediation implemented by polluters lacks efficiency and effectiveness [8]. To effectively solve this problem, the Third Plenary Session of the Eighteenth Central Committee of the Party promoted a third-party governance model for environmental pollution and achieved the transformation of environmental governance from “who pollutes, who governs” to “polluter pays, professional governance” [9]. The third-party governance of soil pollution is a new model for polluters to entrust environmental service companies for pollution treatment by paying fees according to the contract. The rise of third-party governance companies has improved the efficiency and level of pollution control. Differences have emerged between policy goals and actual results, however, and soil heavy metal pollution treatment remains ineffective [10].

From an environmental policy perspective, there is a major conflict of interest between government and business. The government, as the maker of national policies and the authority that regulates the territory, bears key responsibilities to oversee enterprises on matters of legislative supervision, administrative supervision, and policy support [11]. The government should focus on the outstanding issues pertaining to soil heavy metal pollution control, hold the most direct and important supervision and management responsibilities for pollution control, and effectively control the resource allocation of stakeholders. China’s governance model mainly follows government-led, top-down administrative methods to control the pollution behavior of enterprises [12–14]. This governance model has led to a significant lack of government law enforcement capacity because the relevant laws and policies cannot be effectively implemented. Additionally, under environmental constraints, corporate responsibility and behavior often run counter to each other. Most polluting companies have a natural motive for profit, and the trade-offs between pollution gains and governance costs are aimed at achieving optimal returns and being free of environmental regulations, thereby increasing the difficulty of government enforcement of regulations [15,16].

From the perspective of environmental governance, polluting companies also have conflicts of interest with third-party governance companies. Compared with soil-polluting companies, third-party governance companies have more specialized pollution control technologies that can improve the efficiency of soil pollution control and reduce associated costs [17]. These independent third-party entities may effectively alleviate the problem of information asymmetry [9]. China’s third-party governance mechanism is still in its infancy, however, and it often faces the risks of imperfect contract operation mechanisms between polluting companies and third parties, as well as a lack of equilibrium in stakeholder games [9]. At the same time, environmental third-party governance has increased the costs and risks of government supervision. Environmental third-party governance companies have more professional counterfeiting capabilities, which enables them to avoid environmental supervision more covertly and worsens societal impacts [18]. Soil-polluting companies and third-party governance companies have conspired to seek rent, promoted the emergence of a “polluted paradise”, violated the original intention of environmental policy design, and weakened the effect of soil governance [19].

The current research mainly has explored and analyzed the influencing factors of soil heavy metal pollution treatment and has taken the perspective of the subject game, which has provided a rich theoretical basis for this study [20]. Woods (2006) [21] and Konisky and Woods (2012) [22], from the government’s perspective, examined the effectiveness of environmental supervision. By establishing a
competition model between governments, the researchers noted that government competition would lead to inefficient implementation of environmental policies. Brunnermeier and Cohen (2003) [23] and Liu et al. (2017) [24] examined the impact of environmental regulation on enterprises from the perspective of the relationship between environmental regulation and corporate competitiveness. Moledina et al. (2013) [25] used dynamic game theory to study the influence mechanism of government policies on the pollution control behavior of soil-polluting companies. In addition, some studies also analyzed the important role of third-party governance punishment strategies and “public–private cooperation” models in achieving economic benefits. These studies constructed an evolutionary game model of third-party governance companies and governments from the perspective of third-party governance [9]. However, the current game research based on soil heavy metal pollution subjects remains relatively limited and is rarely related to dynamic game. The government, soil-polluting companies, and third-party governance companies have not yet been placed in the same research framework. Therefore, from the perspective of third-party governance, exploring the role mechanism of multiparty game players in soil pollution management holds theoretical and practical value.

The tripartite evolutionary game model in Zhou et al. (2019) [26] and Xu et al. (2019) [9] are useful references for our study. Zhou et al. (2019) [26] discussed the acting paths of fiscal policies on third-party environmental pollution control in a tripartite evolutionary game model involving the local government, the polluting company, and the third-party governance company. However, Zhou et al. (2019) [26] did not distinguish different types of pollution. Unlike air and water pollution, heavy metal pollution in soil is covert and long-term. The cost of government supervision is high which increases the difficulty for supervision [27]. Therefore, the probability of collusion between the soil-polluting company and third-party governance company is high when governing heavy metal pollution in soil. It is necessary to study and formulate relevant incentive and punishment policies to regulate the behavior of the soil-polluting company and third-party governance company, rectify false governance, and effectively improve the level of heavy metal pollution governance. Our study extended the research of Zhou et al. (2019) [26] to include the collusion in the analytical framework between the soil-polluting company and third-party governance company.

Xu et al. (2019) [9] also use a tripartite evolutionary game to analyze actions of the government, the polluting company, and the third-party governance company interactively. They further studied the rent-seeking action of the third-party governance company from the polluting company. However, the third-party governance company needs to build a reputation for cooperation with government. In order to gain recognition by the government and obtain long-term benefits, participants usually consciously abide by the rules and regulate their own behavior [28]. Additionally, according to opinions of the General Office of the State Council of the People’s Republic of China on promotion of third-party treatment of environmental pollution, the polluting company undertakes the main responsibility for environmental pollution control. There is only a contractual relationship between the polluting company and third-party governance company for pollution treatment. The fault of the third-party governance company in pollution treatment cannot be the reason for the polluting company’s exemption from environmental administrative penalties. Therefore, the polluting company is under more pressure for pollution governance than the third-party governance company. According to the “pressure/opportunity” model of organizational misconduct [29], the polluting company has more rent-seeking incentives than the third-party governance company. Based on the above considerations, we analyzed the rent-seeking action of polluting companies from third-party governance companies. Furthermore, we included the action of whistle-blowing in the analytical framework and observed the influence of whistle-blowing when the third-party governance company refused to accept rent-seeking of the soil-polluting company. Additionally, compared with a system dynamics model to analyze pollution governance in Xu et al. (2019) [9], we used numerical simulation analysis to observe the evolution process of the government, soil-polluting companies, and third-party governance companies based on the parameters of typical cases of third-party treatment of environmental pollution.
To better understand conflicts of interest related to soil pollution control, and overcome the problems of limited rationality and dynamic processes that neglect games in traditional theories, we based this study on evolutionary game theory from the perspective of third-party governance. We built a three-party evolutionary game model of government, soil-polluting companies, and third-party governance companies, and explored the strategic choices of each subject under different strategic combinations. The main contributions of this study are as follows. First, this study was not limited to the perspective of the game between the two parties. By constructing a three-party evolutionary game model of the government, soil-polluting companies, and third-party governance companies, we deepened the research on the subject of soil heavy metal pollution control. Second, we explored the new governance model of third-party governance, analyzed the interaction mechanism of various agents, evaluated the implementation of policies, and proposed effective countermeasures for better pollution control. Third, we added rent-seeking action of the polluting company from the third-party governance company and whistle-blowing action of the third-party governance company in an analytical framework, broadening the research perspective in a tripartite evolutionary game model. Finally, based on the evolutionary game perspective, we conducted an evolutionary process for each agent. This numerical simulation analysis broadened the research fields and methods of soil pollution control and provided a theoretical basis for improving the effectiveness of policy governance and controlling the risk of soil heavy metal pollution.

The rest of this paper is organized as follows. Section 2 constructs a three-party evolutionary game model. Section 3 conducts an evolutionary game analysis of stakeholders. Section 4 introduces the evolutionary stability strategies in different situations through numerical simulation and illustrates the impact of parameter changes on these strategies. Finally, Section 5 discusses the conclusions of this study and proposes corresponding policy recommendations.

2. Construction of Evolutionary Game Models

2.1. Game Subject Analysis

Due to the complexity and persistence of soil heavy metal pollution, the treatment of soil heavy metal pollution cannot be effectively resolved by the efforts of any one party alone, and requires the cooperation of multiple stakeholders. The government, as the law enforcer of environmental regulations, has supervision responsibility for the polluting enterprises and governance subjects. Due to the existence of a “blind zone” in supervision, polluters (who are oriented by their interests) have rent-seeking incentives. The original motive of a third-party governance company is also to make profits instead of protecting the environment. A moral hazard is associated with conspiring with soil-polluting companies. It is difficult to achieve the best of both sides because of the difference of the goals pursued by the players. Therefore, based on the new governance model of soil heavy metal pollution, this study took the government, soil-polluting companies, and third-party governance companies as the main body; explored the internal mechanism of the interaction between the various bodies; and constructed a tripartite conceptual model (Figure 1).

(1) Government and soil-polluting companies. In soil pollution control, the government is the “supervisor” and through the formulation of various laws and regulations on soil pollution control, the violations of soil-polluting companies are controlled. In addition, the government also acts as a “helper” for soil pollution control by providing policy support and tax incentives for enterprises to urge them to carry out pollution control [30,31]. The relationship between the government and soil-polluting companies is shown as a regulated relationship. The government department supervises the implementation of a contract with the soil treatment enterprise. When the soil treatment enterprise violates the relevant laws or contract provisions and soil pollution is not properly controlled, the government can hold the soil-polluting company responsible according to the relevant laws or contract provisions [32]. As a supervised entity, soil-polluting
companies should take their pollution control responsibilities seriously, report pollution control information to the government in a timely manner, and accept supervision.

(2) Government and third-party governance companies. The government is the formulator and promoter of the third-party governance system for soil pollution. Thus, the game relationship between the government and the third-party governance company mainly exhibits the relationship between supervisor and supervision [33]. The soil-polluting company entrusts the third-party governance company with the responsibility to control the pollution. The government has the right to supervise its governance to evaluate the effect of soil pollution treatment [34]. If a third-party governance company is fraudulent in its pollution control activities, it shall (a) be responsible for the environmental pollution and ecological damage caused, (b) be punished in accordance with the relevant laws and regulations, and (c) pay compensation for the breach of contract by the soil-polluting company [35]. The government builds a platform for the implementation of third-party governance, establishes support for collaborative relationships, provides preferential policies and financial support for third-party enterprises that strictly control pollution, and increases the enthusiasm of third-party governance companies [36].

(3) Soil-polluting companies and third-party governance companies. In soil pollution management, the relationship between soil-polluting companies and third-party governance companies is represented by the relationship of agency and rent-seeking. Soil-polluting companies bear the responsibility of pollution control and also bear the costs of pollution control and restoration. The third-party governance company shall assume the contracted pollution control responsibilities according to the entrusted requirements of the soil-polluting company [37]. The interests of third-party governance companies are linked closely to the interests of soil-polluting companies. In the process of maximizing profits by both parties, they usually have a tendency to conspire together. The soil-polluting company chooses rent-seeking for the third-party governance company and they conspire to deceive government regulatory agencies. The entrusted pollution control cost is usually much lower than the cost of performing the contract legally [38]. At the same time, the third-party governance company also obtains higher profits as a result of a lack of strict governance, and the environment and the public become the ultimate victims.

![Tripartite relationship in soil heavy metal pollution control.](image)

**Figure 1.** Tripartite relationship in soil heavy metal pollution control.

### 2.2. Basic Assumptions

The following are the basic assumptions of this study.

**Assumption 1.** The game in this study involved three participants: government departments, soil-polluting companies, and third-party governance companies, and all three parties had limited rationality. The set of
government behavior strategy was \( S_1 = \{\text{supervision, nonsupervision}\} \), where “supervision” refers to the government’s input of human, material, and financial resources to supervise and manage the pollution control actions of soil-polluting companies, third-party governance, environmental subsidies, and administrative penalties. The set of behavior strategies of soil-polluting companies was \( S_2 = \{\text{compliance, noncompliance}\} \), where “compliance” means that soil-polluting companies carefully treat soil pollution according to laws and regulations (not rent-seeking). The set of behavior strategies of third-party companies was \( S_3 = \{\text{strict pollution control, non-strict pollution control}\} \), where “strict pollution control” means that third-party governance companies accept the commission of soil-polluting companies, strictly perform their duties and obligations, and control soil pollution.

**Assumption 2.** The probability that the government department chooses to supervise was \( X(0 \leq X \leq 1) \), and the probability that it chooses not to supervise was \( 1-X \). The probability that the soil-polluting company chooses to comply was \( Y(0 \leq Y \leq 1) \), and the probability that it chooses noncompliance was \( 1-Y \). The probability that the third-party governance company chooses to strictly control of soil pollution was \( Z(0 \leq Z \leq 1) \), and the probability that it chooses not to strictly control the likelihood of soil pollution was \( 1-Z \).

**Assumption 3.** The daily operating income of a soil-polluting company was \( R_1 \). The treatment fee stipulated in the contract with the third-party governance company was \( C_1 \) when the soil-polluting company is in compliance with the law to control pollution, while the soil-polluting company does not comply with the law, it would choose rent-seeking for the third-party governance company. If two parties colluded, the third-party governance company will give corresponding discounts to the soil-polluting company. At this time, the treatment fee stipulated in the contract with the third-party governance company was \( C_2 \), and the rent-seeking fee paid to the third-party governance company was \( C_3 \), \( C_1 \geq C_2 + C_3 \).

**Assumption 4.** The revenue from pollution control by a third-party governance company was equal to the amount on the contract with the soil-polluting company. When a third-party governance company was entrusted to strictly control pollution, the governance cost was \( C_4 \), and when the pollution was not strictly controlled, the governance cost was \( C_5 \), available \( C_4 \geq C_5 \). When the government supervised, a corresponding subsidy would be given to the third-party governance company that strictly controlled pollution \( W_1 \). If the soil-polluting company complied with the law, and the third-party governance company did not strictly control pollution, it would be compensated by the soil-polluting company for liquidated damages \( C_6 \) and be fined by the government \( F_2 \). If the soil-polluting company failed to comply with the law and the third-party governance company refused to accept soil-polluting company’s rent-seeking, it would report the situation to the government and passed the rent-seeking fee \( C_3 \) to the government. Therefore, the public image of the third-party governance company could be improved, and potential profits \( E_1 \) could be obtained. The soil-polluting company would be fined \( F_1 \) accordingly. If the third-party company accepted rent-seeking and the government strictly monitored it, the government would find rent-seeking behavior and fine the soil-polluting company \( F_1 \) and fine the third-party governance company \( F_2 \).

**Assumption 5.** When the government supervised, it would establish a good government image and obtain potential social benefits \( R_2 \), and also bear the human and material costs invested during the supervision \( C_7 \). If the third-party governance company did not strictly control pollution, it would bring additional government costs. The cost of environmental pollution control was \( C_8 \) (such as ex-post recovery costs).

On the basis of these assumptions, Table 1 lists the variables related to evolutionary games.
Table 1. Variables and description of evolutionary games.

| Variable | Meaning |
|----------|---------|
| \(R_1\) | Benefits from daily operations of soil-polluting companies |
| \(R_2\) | The social benefits of establishing a good image during government supervision |
| \(C_1\) | Soil-polluting companies strictly abide by the law (no rent-seeking) and the treatment fee stipulated in the contract with the third-party governance company |
| \(C_2\) | Soil-polluting companies do not strictly abide by the law (rent-seeking) and the treatment fee stipulated in the contract with the third-party governance company |
| \(C_3\) | Rent-seeking fees paid by soil-polluting companies to third-party governance companies |
| \(C_4\) | The cost of strict pollution control by third-party governance companies |
| \(C_5\) | Costs of third-party governance companies not strictly controlling pollution |
| \(C_6\) | When the soil pollution companies abide by the law, the third-party enterprise does not strictly control the pollution and is found by the government supervision, it shall compensate the soil pollution enterprise for the liquidated damages |
| \(C_7\) | The labor and material costs of government supervision when government chooses to supervise |
| \(C_8\) | Environmental pollution control costs to the government when third parties do not strictly control pollution |
| \(W_1\) | Subsidies given by the government when third-party companies strictly control pollution |
| \(F_1\) | Penalties imposed by the government on soil-polluting companies when the soil-polluting companies do not comply with the law |
| \(F_2\) | When a third-party governance company does not strictly control pollution, the government will punish the third-party governance company |
| \(E_1\) | Potential benefits of public image improvement when third-party companies reject rent-seeking |

2.3. Model Construction

According to the game strategy choices of the government, soil-polluting companies, and third-party governance companies, we derived the following eight game combination strategies: \{supervision, compliance, strict pollution control\}, \{supervision, compliance, non-strict pollution control\}, \{supervision, noncompliance, strict pollution control\}, \{supervision, noncompliance, non-strict pollution control\}, \{nonsupervision, compliance, strict pollution control\}, \{nonsupervision, compliance, non-strict pollution control\}, \{nonsupervision, noncompliance, strict pollution control\}, and \{nonsupervision, noncompliance, non-strict pollution control\}. Table 2 shows the specific benefit analysis.
Table 2. Game strategy portfolios and benefits of governments, soil-polluting companies, and third-party governance companies.

| Strategy Portfolio                                      | Government (X)                    | Soil-Polluting Companies (Y) | Third-Party Governance Companies (Z) |
|---------------------------------------------------------|-----------------------------------|-----------------------------|-------------------------------------|
| [Supervision, Compliance, Strict pollution control]     | $R_2 - C_7 - W_1$                 | $R_1 - C_3$                 | $C_1 + W_1 - C_4$                   |
| [Supervision, Compliance, Non-strict pollution control]| $R_2 + F_2 - C_7 - C_8$          | $R_1 + C_6 - C_1$           | $C_1 - C_3 - C_6 - F_2$             |
| [Supervision, Noncompliance, Strict pollution control] | $R_2 + C_3 + F_1 - C_7 - W_1$    | $R_1 - C_2 - C_3 - F_1$    | $C_2 + W_1 + F_1 - C_4$             |
| [Supervision, Noncompliance, Non-strict pollution control] | $R_2 + F_1 + F_2 - C_7 - C_8$    | $R_1 - C_2 - C_3 - F_1$    | $C_2 + C_3 - C_5 - F_2$             |
| [Nonsupervision, Compliance, Strict pollution control] | $R_1 - C_1$                      | $C_1 - C_4$                 |                                      |
| [Nonsupervision, Compliance, Non-strict pollution control] | $-C_8$                           | $R_1 - C_1$                 | $C_1 - C_5$                         |
| [Nonsupervision, Noncompliance, Strict pollution control] | $C_3 + F_1 - W_1$                 | $R_1 - C_2 - C_3 - F_1$    | $C_2 + W_1 + F_1 - C_4$             |
| [Nonsupervision, Noncompliance, Non-strict pollution control] | $-C_8$                           | $R_1 - C_2 - C_3$           | $C_2 + C_3 - C_5$                   |

Note: The third-party governance company signals the information of strict control of pollution if it refused to accept soil-polluting company rent-seeking and reported the situation to the government in this scenario that government has not supervised. Therefore, the government can also pay subsidy $W_1$ to the third-party governance company in combination strategy [Nonsupervision, Noncompliance, Strict pollution control].

3. Evolutionary Game Analysis

3.1. The Replication Dynamic Model of the Game Subject

 Governments, soil-polluting companies, and third-party governance companies were the rational game players. Evolutionary game theory abandons the assumption of complete rationality, and regards the adjustment process of group behavior as a dynamic system, in which the behavior of each individual and its relationship with the group are separately characterized. In order to better understand the conflicts of interest related to soil pollution control, clarify the game relationship between the various subjects, and put forward effective countermeasures to solve the practical dilemma of comprehensive remediation of heavy metal pollution in soil, we constructed the game players based on the “replicator dynamics” and “evolutionary game strategies”. The replicator dynamics are used to express the evolutionary dynamics of entity called replicator which has means of making more or less accurate copies of itself.

Assuming that the government chooses the “supervision” strategy with an expected rate of return of $U_{11}$, the “nonsupervision” strategy has an expected rate of return of $U_{12}$, and the average expected rate of return is $U_1$, as follows:

$$U_{11} = \begin{align*} &yz(R_2 - C_7 - W_1) + y(1 - z)(R_2 + F_2 - C_7 - C_8) + z(1 - y)(R_2 + C_3 + F_1 - C_7 - W_1) \\ &+ (1 - y)(1 - z)(R_2 + F_1 + F_2 - C_7 - C_8) \end{align*}$$ (1)

$$U_{12} = y(1 - z)(-C_8) + z(1 - y)(C_3 + F_1 - W_1) + (1 - y)(1 - z)(-C_8)$$ (2)

$$U_1 = xU_{11} + (1 - x)U_{12}$$ (3)

Therefore, the replicated dynamic equation of the government’s “supervision” strategy is as follows:

$$F(x) = \frac{dx}{dt} = x(U_{11} - U_1) = x(1 - x)[(R_2 + F_1 + F_2 - C_7) + y(zF_1 - zW_1 - F_1) - z(F_1 + F_2)]$$ (4)
According to replicated dynamic equation \[39\], \(\frac{dx}{dt}\) is the rate of change in the proportion that the government department chooses to supervise. Similarly, suppose that the expected rate of return of the soil-polluting company choosing the “compliance” strategy is \(U_{21}\), and the expected rate of return of the “noncompliance” strategy is \(U_{22}\), and the average expected return is \(U_2\), as follows:

\[
U_{21} = xz(R_1 - C_1) + x(1 - z)(R_1 + C_6 - C_1) + z(1 - x)(R_1 - C_1) + (1 - y)(1 - z)(R_1 - C_1)
\]

\[
U_{22} = xz(R_1 - C_2 - C_3 - F_1) + x(1 - z)(R_1 - C_2 - C_3 - F_1) + z(1 - x)(R_1 - C_2 - C_3 - F_1)
\]

\[
+ (1 - x)(R_1 - C_2 - C_3 - F_1)
\]

\[
U_2 = yU_{21} + (1 - y)U_{22}
\]

Therefore, the replicated dynamic equation of the soil-polluting companies adopting the “compliance” strategy is as follows:

\[
F(y) = \frac{dy}{dt} = y(U_{21} - U_2)
\]

\[
= y(1 - y)[(C_2 + C_3 - C_1) + x(C_6 + F_1) + z(F_1 - xF_1 - xC_6)]
\]

Similarly, if the expected rate of return for a third-party governance company to choose the “strict pollution control” strategy is \(U_{31}\), the expected rate of return for the “non-strict pollution control” strategy is \(U_{32}\), and the average expected return is \(U_3\), as follows:

\[
U_{31} = xy(C_1 + W_1 - C_4) + x(1 - y)(C_2 + W_1 + E_1 - C_4) + y(1 - x)(C_1 - C_4)
\]

\[
+ (1 - y)(1 - x)(C_2 + W_1 + E_1 - C_4)
\]

\[
U_{32} = xy(C_1 - C_5 - C_6 - F_2) + x(1 - y)(C_2 + C_3 - C_5 - F_2) + y(1 - x)(C_1 - C_5)
\]

\[
+ (1 - y)(1 - x)(C_2 + C_3 - C_5)
\]

\[
U_3 = zU_{31} + (1 - z)U_{32}
\]

Therefore, the replication dynamic equation of the “strict pollution control” strategy adopted by third-party governance companies is as follows:

\[
F(z) = \frac{dz}{dt} = z(U_{31} - U_2)
\]

\[
= z(1 - z)[(W_1 + E_1 + C_5 - C_3 - C_4) + x(F_2 + yC_6 + yW_1) + y(C_3 - W_1 - E_1)]
\]

3.2. Government Evolution Stability Strategy

A partial derivative of the replicated dynamic equation of the government’s choice of “supervision” strategy can be obtained, as follows:

\[
\frac{d(F(x))}{dx} = (1 - 2x)[(R_2 + F_1 + F_2 - C_7) + y(zF_1 - zW_1 - F_1) - z(F_1 + F_2)]
\]

When \(z = \frac{yF_1 - (R_2 + F_1 + F_2 - C_7)}{y(W_1 - W_1 - F_1)}\), any level is in a stable state; when \(z < \frac{yF_1 - (R_2 + F_1 + F_2 - C_7)}{y(W_1 - W_1 - F_1)}\), \(x = 1\) is an evolutionary stability strategy; and when \(z > \frac{yF_1 - (R_2 + F_1 + F_2 - C_7)}{y(W_1 - W_1 - F_1)}\), \(x = 0\) is an evolutionary stability strategy.

Figure 2 shows the replicator dynamics and evolutionary stability strategies of the government’s choice of “supervision”.

\[\text{Figure 2}\]
The volume of region $I_z$ represents the probability that the government will select “supervision” and the volume of region $\prod_z$ represents the probability that the government will select “nonsupervision”, as follows:

$$I_z = \int_{(F_1-W_1)}^{F_1} \frac{yF_2-(R_2+F_1+F_2-C_2)}{yF_1-F_1} \int_{(F_1-W_1)}^{F_1} dx dy dz$$

$$\prod_z = 1 - \int_{(F_1-W_1)}^{F_1} \frac{yF_2-(R_2+F_1+F_2-C_2)}{yF_1-F_1} \int_{(F_1-W_1)}^{F_1} dx dy dz$$

**Conclusion 1.** The probability of the government choosing “supervision” decreased as the probability of “strict pollution control” by third-party governance companies and the “compliance” of soil-polluting companies pollution control companies increased.

**Proof of Conclusion 1.** We used the derivative dynamic model of the government’s selection of “supervision” to obtain partial derivatives. The correlation function between the probability of government supervision $x$ and the probability of strict pollution control by a third-party governance company $z$ can be obtained, as follows:

$$x = [0, 1]$$

$$z = \begin{cases} 0, & x > \frac{yF_1-(R_2+F_1+F_2-C_2)}{yF_1-F_1} \\ \frac{yF_1-(R_2+F_1+F_2-C_2)}{yF_1-F_1}, & x = 1 \\ \frac{yF_1-(R_2+F_1+F_2-C_2)}{yF_1-F_1}, & x = 0 \end{cases}$$

When $z > \frac{yF_1-(R_2+F_1+F_2-C_2)}{yF_1-F_1}$, $x = 0$ was the evolutionary stability strategy (the ESS point). When the third party’s motivation for choosing “strict pollution control” was higher than a certain value, the government was more inclined to not supervise and save supervision costs. The strategy chosen stabilized at 0; when $z < \frac{yF_1-(R_2+F_1+F_2-C_2)}{yF_1-F_1}$, $x = 1$ was an evolutionary stabilization strategy. When the probability of “strict pollution control” by a third-party governance company was lower than a certain value, the third-party governance company tended to accept rent-seeking or polluting companies. To save costs and increase profits, government departments increased supervision and severely punished third parties for improper corporate governance. The strategy chosen stabilized at 1.

Similarly, we obtained the correlation function between the probability of government supervision $x$ and the probability of compliance of polluting companies with respect to $y$. When $y > \frac{z(F_1+F_2)-(R_2+F_1+F_2-C_2)}{2F_1-ZW_1-F_1}$, $x = 0$ was an evolutionary stability strategy. When polluting companies were inclined to comply with laws and regulations, the government relaxed supervision and
preferred not to supervise. Therefore, the strategy chosen by the government stabilized at 0; when \( y < \frac{z(F_1 + F_2 - (K_2 + F_1 + F_2 - C_2))}{(1 - z)(F_1 - C_6)} \), \( x = 1 \) was an evolutionary stability strategy. When polluting companies tended to violate the law, the government departments increased their supervision and punished the polluters for improper behavior. The strategy stabilized at 1. □

**Conclusion 2.** The probability that the government chooses “supervision” increased with an increase in social benefits, decreased with an increase in human and material costs during supervision, and decreased with fines imposed on third-party governance companies and soil-polluting companies in the long term. Therefore, quota increased.

**Proof of Conclusion 2.** Social benefits \( R_2 \), regulatory costs \( C_7 \), third-party governance companies \( F_2 \), and soil-polluting companies \( F_1 \) that affect the effect of government regulation could be obtained by partial guidance \( \frac{\partial(l_1)}{\partial F_1} = \frac{1}{(1 - z)W_1}ln\frac{F_2 + W_1}{F_1 + F_2} > 0 \), which indicated that the improvement of social benefits led to an increase in the probability of government regulation. In daily work, the government needs to provide more publicity and education to the public, so that the public can better understand the dynamic information of soil-polluting companies, promote two-way interaction between the government and the public, and improve the social benefits of government supervision and public well-being. Then, \( \frac{\partial(l_1)}{\partial C_7} = \frac{1}{(1 - z)W_1}ln\frac{F_2 + W_1}{F_1 + F_2} < 0 \), which indicated that an increase in government supervision cost would reduce the probability of government supervision. □

A large amount of human and material input can create a stumbling block for the government’s strict supervision. With the advent of the artificial age, however, the government can improve the efficiency of supervision by means of the Internet and big data and can reduce the cost of supervision by means of network supervision. Thus, \( \frac{\partial(l_1)}{\partial F_2} = \frac{\partial(F_1 + W_1 - F_2)}{(1 - z)W_1}ln\frac{F_2 + W_1}{F_1 + F_2} + \frac{F_1 + W_1 - F_2}{(F_1 - W_1)(F_2 + W_1)} - \frac{\partial(F_1 + W_1 - F_2)}{(F_1 - W_1)(F_2 + W_1)} > 0 \), which indicated that an increase in the amount of government fines for third-party governance companies would increase the probability of government supervision in the short term. Similarly, an increase in the government’s fines for soil-polluting companies also would increase the probability of government supervision in the short term. The government can pressure third-party governance companies and soil-polluting companies to curb their environmental misconduct. In addition, the government can strengthen cooperation with third-party governance companies, which can effectively save government regulatory costs and improve the ecological environment, and also can increase the potential benefits of third-party governance companies. With the improvement of environmental governance due to fines, the probability of government supervision decreases in the long term.

### 3.3. Evolutionary Game Strategies of Soil-Polluting Companies

The partial dynamics of the replicated dynamic equation for the soil-polluting company’s choice of “compliance” strategy can be obtained as follows:

\[
\frac{d(F(y))}{dy} = (1 - 2y)[(C_2 + C_3 - C_1) + x(C_6 + F_1) + z(F_1 - xF_1 - xC_6)]
\]

(17)

When \( x = \frac{2F_1 + (C_2 + C_3 - C_1)}{(1 - z)(F_1 - C_6)} \), any level was in a stable state; when \( x > \frac{2F_1 + (C_2 + C_3 - C_1)}{(1 - z)(F_1 - C_6)} \), \( y = 1 \) was an evolutionary stability strategy; and when \( x < \frac{2F_1 + (C_2 + C_3 - C_1)}{(1 - z)(F_1 - C_6)} \), \( y = 0 \) was an evolutionary stability strategy.

Figure 3 shows the trend of replicator dynamics and evolutionary stability strategies of soil polluting companies choosing “compliance”.
The probability that a soil-polluting company chooses “compliance” increased with an increase in the probability that the government chooses “supervision” and the third-party governance company chooses “strict pollution control”. When \( z < \frac{F_1 + (C_3 + C_2 - C_1)}{(1-z)(f_1 - C_a)} \), \( y = 1 \) was an evolutionary stability strategy. When the government’s motivation to choose “supervision” was lower than a certain value, the government department relaxed its vigilance, soil-polluting companies had the opportunity to seek rent from third-party governance companies, and the cost of governance reduced greatly. At this time, the company’s “compliance” strategy stabilized at 0.

In the same way, we obtained the functional relationship between the probability that a polluting company chooses compliance \( y \) and the third-party governance company chooses strict pollution control \( z \). When \( z > \frac{x(C_a + F_1) + (C_3 + C_2 - C_1)}{f_1 + z(C_6 + F_1)} \), \( y = 1 \) was an evolutionary stability strategy. When the third-government company was inclined to select “strict pollution control”, the rent-seeking fee of
the third-party governance company would be handed over to the government by the third-party governance company, and the company would suffer. To avoid this risk of the government’s punishment, the polluting company’s strategy of choosing “compliance” stabilized at 1. In contrast, when the probability of “strict pollution control” by the third-government company was lower than a certain value, then collusion incentives for the soil-polluting company and the third-party governance company were even greater. Polluting companies rent to third-party governance companies and both parties saved costs. Soil-polluting companies selected a law-abiding strategy that stabilized at 0.

**Conclusion 4.** The probability that an enterprise chooses “compliance” decreased with an increase in the governance costs stipulated in the contract with the third-party governance company and increased with an increase in the cost of rent-seeking for the third-party governance company and the amount of government fines.

**Proof of Conclusion 4.** For the influencing factors that affected the probability of compliance of soil-polluting companies, the governance costs paid to third-party governance companies $C_1$, rent-seeking costs to third-party governance companies $C_3$, and fines for illegal violations $F_1$ were as follows: $\frac{\partial (q_1)}{\partial C_1} = \frac{1}{C_1 + F_1} ln \frac{F_1 + C_3 + C_2 - C_1}{F_1} < 0$, which indicated that as the governance costs required by third-party governance companies increased, the probability of corporate compliance decreased. To effectively reduce the probability of noncompliance, government departments increased subsidies for soil-polluting companies and third-party governance companies, and standardized the fees charged by third-party governance companies. At the same time, soil-polluting companies and third-party governance companies strengthened cooperation and exchanges for mutual benefit to create a win–win situation. Then, $\frac{\partial (q_1)}{\partial C_3} = -\frac{1}{C_3 + F_1} ln \frac{F_1 + C_2 + C_3 - C_4}{F_1} > 0$, which indicated that as the cost of rent-seeking for third-party governance companies increased, the probability of compliance would increase. The government strictly regulated the industry regulations of third-party governance companies, strictly punished the third-party companies that accept rent-seeking, and publicly criticized illegal third-party governance companies on government websites, which increased the rent-seeking costs of soil-polluted companies and reduced the likelihood that soil-polluting companies would not comply with the law. Then, $\frac{\partial (q_1)}{\partial F_1} = \frac{C_2 + C_3 - C_1}{(C_2 - F_1)^2} - \frac{C_6 + C_2 + C_3 - C_4}{(C_6 - F_1)^2} ln \frac{F_1 + C_2 + C_3 - C_1}{F_1} > 0$, which indicated that as the amount of fines imposed by the government on soil-polluting companies increased, the probability of compliance would increase. This would intensify government punishment, put pressure on the soil-polluting companies to avoid government fines and social reputation punishment, and actively guide the public to participate in “supervision” to achieve zero tolerance for the pollution behavior of soil-polluting companies.

3.4. **Evolutionary Game Strategies for Third-Party Governance Companies**

The partial dynamics of the replication dynamic equation of the third-party governance company’s “strict pollution control” strategy can be obtained as follows:

$$\frac{d(F(z))}{dz} = (1 - 2z)[(W_1 + E_1 + C_3 - C_4)] + x(F_2 + yC_6 + yW_1) + y(C_3 - W_1 - E_1)$$  \hspace{1cm} (21)

When $y = -\frac{xF_2-(W_1+E_1+C_6-C_4)}{xC_6+xW_1+C_3-W_1-E_1}$, any level was in an evolutionary stable state; when $y > -\frac{xF_2-(W_1+E_1+C_6-C_4)}{xC_6+xW_1+C_3-W_1-E_1}$, then $z = 0$ reached an evolutionary stable state; and when $y < -\frac{xF_2-(W_1+E_1+C_6-C_4)}{xC_6+xW_1+C_3-W_1-E_1}$, then $z = 1$ was an evolutionary stable strategy.

Figure 4 shows the replicator dynamics and evolutionary stability strategies of third-party governance companies choosing “strict pollution control”.
"strict pollution control" and the volume of area $I_s$ represents the probability that the third-party governance company chooses “non-strict pollution control”, as follows:

$$I_s = 1 - \frac{\int \int \int -\frac{-x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1} \, dx \, dy \, dz}{\frac{W_1 + E_1 - C_3}{C_6 + W_1}}.$$

$$\Pi_s = \frac{W_1 + E_1 - C_3}{C_6 + W_1} - \left[ \frac{W_1 + E_1 + C_3 - C_4}{C_6 + W_1} + \frac{f_2(W_1 + E_1 - C_3)}{(C_6 + W_1)^2} \right] \ln \left( 1 + \frac{C_6 + W_1}{f_2} \right).$$

Conclusion 5. The probability that a third-party governance company chooses “strict pollution control” increased as the government chooses “supervision” and decreased as the probability of “compliance” increased.

Proof of Conclusion 5. The third-party governance company selected the “strict pollution control” replication dynamic model to find partial derivatives. The correlation function between the probability of strict pollution control of the third-party governance company $z$ and the probability of compliance of the enterprise $y$ can be obtained, as follows:

$$z = \begin{cases} 
0, & y < -\frac{x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1} \\
y, & -\frac{x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1} \leq y \leq -\frac{-x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1} \\
1, & y > -\frac{-x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1} 
\end{cases}$$

When $y < -\frac{-x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1}$, $z = 1$ was an evolutionary stability strategy. When the motivation of the company to choose “compliance” was lower than a certain value, the company would arbitrarily discharge sewage and cause serious damage to the soil environment, which increased the probability of being regulated by the government and of third-party governance. In this case, the company would choose a “strict pollution control” strategy and stabilized at 1, to avoid government punishment. Similarly, when $y > -\frac{-x f_2 - (W_1 + E_1 + C_3 - C_4)}{x C_6 + x W_1 + C_3 - W_1 - E_1}$, $z = 0$ was an evolutionary stability strategy. When the motivation of the company to choose “compliance” was higher than a certain value, the enterprise strictly controlled pollution and established a good public image. The government then relaxed the supervision of the enterprise. On the basis of maximizing their interests, the third-party governance companies tended to choose the “non-strict pollution control” strategy and stabilized at 1.

In the same way, the functional relationship between the third-party governance company $z$ and the government $x$ can be obtained. When $x > \frac{y(W_1 + E_1 - C_3) - (W_1 + E_1 + C_3 - C_4)}{f_2 + x + g W_1}$, $z = 1$ was an evolutionary stability strategy. When the government was biased toward “supervision”, third-party
governance companies avoided penalties from the government and refused rent-seeking behavior of enterprises. Its “strict pollution control” strategy stabilized at 1. On the contrary, when the probability of “supervision” by the government was lower than a certain value, the incentive for third-party governance companies to cooperate with enterprises increased. Third-party governance companies would consider rent-seeking, save governance costs, and increase their profits based on individual considerations. Therefore, third-party governance companies would choose “strict pollution control”. This strategy stabilized at 0. □

Conclusion 6. The probability that a third-party governance company chooses “strict pollution control” decreased as the rent-seeking costs of soil-polluting companies increased.

Proof of Conclusion 6. We derived the influencing factors that affect the probability of strict pollution control of third-party governance companies (the process of derivation is omitted here). The probability that a third-party governance company could strictly control pollution $I_S$ was negatively related to the rent-seeking cost of soil-polluting companies $C_3$; it was positively related to the fines suffered by the law $F_2$, government subsidies $W_1$, and the potential benefits of public image improvement $E_1$. The decision of the third-party governance company was closely related to the decisions of the soil-polluting company and the government. To promote third-party governance companies to better fulfill their strict governance obligations, the government should clearly distinguish between rewards and penalties, establish a reasonable policy system, increase penalties for rent-seeking behaviors, and recognize and strictly support third-party governance companies with legal support and financial support. In addition, the public should be actively guided to help the government implement supervision and work together to create an excellent governance environment. □

4. Evolutionary Simulation Analysis

In a three-party game, changes in various parameters affected the strategic choice of the game subject to varying degrees, and then affected the dynamic changes in the evolution process. This study analyzed the evolution of each parameter by simulating the evolution process of the government, soil-polluting companies, and third-party governance companies by assigning values to the parameters and using Matlab tools.

To truly reflect the actual situation of soil pollution treatment, we assigned values to various variables with reference to relevant cases (typical cases of third-party treatment of environmental pollution (the first batch) published by the National Development and Reform Commission of the People’s Republic of China in 2017). Based on the previous assumption ($C_1 \geq C_2 + C_3, C_4 \geq C_5, R_2 > C_7 + W_1, R_2 + F_1 + F_2 > C_7 + C_8, C_2 + W_1 + E_1 > C_4$), we choose $C_3$ and $C_5$ equal to 1 as the benchmark, and let $R_2 = 2.8, C_1 = 5, C_2 = 3, C_3 = 1, C_4 = 4.5, C_5 = 1, C_6 = 2.3, C_7 = 3, C_8 = 2, W_1 = 1.5, F_1 = 1.2, F_2 = 1.8$, and $E_1 = 2.5$. Figure 5 shows the specific simulation results.

Figure 5a shows that when the soil-polluting company complied with the law and the third-party governance company was responsible for pollution control, regardless of the probability that the government department initially chose to supervise, it eventually stabilized at a probability of zero. For further analysis, as a new soil pollution control model, we examined whether a third-party governance company could assist in government regulation. Figure 5b shows that under the condition that the third-party governance company was controlled to maintain a high probability of governance, by adjusting the strategy of the soil-polluting company, the government’s supervision probability was related mainly to the third-party governance company’s strict pollution control probability. This finding indicated that the third-party governance company was affected by the government. The decision-making strategy occupied a more important position: the more the soil-polluting companies complied with the law, the faster the government supervision probability reached 0. This result indicated that the behavioral decisions of soil-polluting companies affected the government’s decision-making speed and the implementation of related policies.
When soil-polluting companies opportunistically sought rent-seeking behaviors, and third-party governance companies colluded with soil-polluting companies to maximize their interests (see Figure 5c), the probability that the government chose to “supervise” stabilized at 1. Third-party governance companies also took a dominant position in this evolutionary process. Regardless of whether the soil-polluting companies complied with the law, the government’s supervision probability was affected mainly by the third-party governance companies’ strict pollution control probability. Figure 5d shows that when soil pollution companies did not abide by the law, they accelerated the evolution of government supervision.

As shown in Figure 6, when a third-party governance company strictly performed its governance responsibilities in accordance with standards and the government strictly enforced the law, regardless of the probability that the soil-polluting company initially selected “compliance”, the company avoided government penalties and avoided being reported by third-party governance companies. When these companies tended to comply with the law, the ultimate probability stabilized at 1; when the third-party governance companies did not strictly control pollution, the government’s supervision was weak, and the two formed a relatively loose governance environment. Then, the probability of soil-polluting companies selecting “compliance” tended to stabilize at 0. The role of the government and third-party governance companies on supervising soil-polluting companies was relatively consistent. Under the existing market conditions, by strengthening the government’s law enforcement efforts and creating a good third-party governance environment, it effectively suppressed corporate misconduct and established more sound and effective governance of the environment.

Figure 5. Evolution of government supervision strategies.
We found that the more soil-polluting companies abided by the law, the faster the rate of strict pollution control. Sustainability (2020, 12, x) FOR PEER REVIEW 17 of 21

(a) Evolution curve of the y value in the range [0,1] with high z and x values
(b) Evolution curve of the y value in the range [0,1] with low z and x values

Figure 6. Probability evolution of compliance of soil-polluting companies.

Figure 7a illustrates the impact of soil-polluting companies’ and the government’s policy choices on the strategies of third-party governance companies. When soil-polluting companies did not abide by the law and the government was negligent, regardless of the probability that a third-party governance company initially selected “strict pollution control”, it eventually stabilized at a probability of 0. In addition, by adjusting the law-abiding probability of soil-polluting companies, we found that their impact on the strict pollution control of third-party governance companies was weak, and government regulatory decisions were more dominant in the decision-making choices of third-party governance enterprises. Figure 7b controls for the probability of strict compliance by the government, adjusts the probability of compliance of soil-polluting companies, and places the two evolutions at the same level. We found that the more soil-polluting companies abided by the law, the faster the rate of strict pollution control by third-party governance companies approached 0. When the probability of government supervision was low, third parties slackened their efforts to control pollution to maximize the benefits. We also found that strict government supervision played an important role in balancing the pollution control market and promoting the positive development of soil pollution control.

(a) Evolution curve of the y value in the range [0,1] with different y and low x values
(b) Evolution curve of the y value in the range [0,1] with different y and low x values
(c) Evolution curve of the x value in the range [0,0.5] with different y and low x values
(d) Evolution curve of the x value in the range [0,1] with different y and high x values

Figure 7. Probability evolution of strict pollution control by third-party governance companies.
As shown in Figure 7c, when soil-polluting companies strictly complied and the government strictly supervised them, regardless of the probability that a third-party governance company initially strictly controlled pollution, it eventually stabilized at a probability of 1. By adjusting the law-abiding probability of soil-polluting companies, we found that the strength of government supervision was the main factor affecting the decision of third-party governance companies. As shown in Figure 7d, whether the soil-polluting companies complied with the law had little impact on the evolutionary process of strict pollution control by third-party governance companies, and its strict pollution control depended mainly on the vigorous government supervision.

5. Conclusions and Recommendations

This study constructed an evolutionary game model to analyze the evolutionary process of governments, soil-polluting companies, and third-party governance companies in controlling soil pollution. We explored the interaction mechanism among various subjects. The study made the following conclusions: (1) the strength of government supervision depended on the amount of manpower, material costs, and fines; (2) the law-abiding behavior of polluting companies depended on governance costs, rent-seeking costs, and government fines; and (3) pollution control behavior depended on the rent-seeking costs of polluting enterprises, the amount of government fines, government subsidies, and the potential social benefits of an improved public image. In addition, we found that active guidance of cooperation between government and third-party governance companies can effectively improve the efficiency and effectiveness of soil pollution control. On the basis of these research conclusions, we propose the following:

1. Strengthen government supervision and punishment. As the policy maker and executor, the government should establish a long-term supervision mechanism with high-pressure and normalized trend that places equal emphasis on supervision and enterprise inspection, comprehensively uses policy implementation methods, and strictly punish enterprise inaction and governance. Aiming at the emerging industry of third-party governance companies, the government should actively guide these companies to exert their governance effects and use their responsibilities to effectively alleviate the pressure of government supervision and reduce the cost of governance of polluting enterprises. The nature and amount of punishment and “zero tolerance” for counterfeiting of soil pollution control effects should be established.

2. Establish an open and effective information disclosure system. Government departments can use Internet technology to establish a special “Soil Pollution Control Disclosure Website”, forcing companies to publicize the results of governance, increase information disclosure, and effectively promote external public supervision. In addition, the government can create a blacklist of companies who violated regulations and(or) provided fraudulent data; establish a joint liability system to weaken the probability of collusion between polluting companies and third-party governance companies and ensure that the responsibilities of various entities are fulfilled.

3. Improve the incentive mechanism for third-party governance companies. Increase commendations and rewards for serious and responsible third-party governance companies; promote the excellent performance of soil pollution control of enterprises through network platforms, radio, television, and newspapers; build a good image for enterprises; and create a virtuous circle of pollution control. Establish a relevant credit evaluation system and issue a government certification medal for third-party governance companies that meet high technical standards and maintain a good reputation. Polluting companies can prioritize the selection of excellent governance companies when purchasing soil pollution repair services.

4. Build a multi-governance mechanism. In contemporary society, the construction of ecological civilization can be established only when all subjects cooperate in unison. The traditional soil pollution control model has promoted the gray area of supervision and has reduced the effect of policy implementation. Therefore, it is necessary to establish a new governance model of mutual assistance and mutual benefit that supports a win–win situation. Diversity
and co-governance of soil pollution should be based on principles of equality, openness, and collaboration. The participating parties should better recognize these comprehensive, multi-angle, and systematic governance needs through the flexible allocation of social resources, and in so doing, meet the public’s urgent need for sound ecological environments.

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