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Evolutionary Game Analysis of Non-Governmental Organizations Participating in Garbage Management under the Background of Internet of Things

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Abstract: In the context of the information age, due to the development trend of information technology and the increasingly prominent position of economic activities, Internet of Things technology, as an important part of the new generation of information technology, stands out in the management of municipal solid waste collection and transportation management. At the same time, it has also become an efficient management means to realize waste treatment and construct high-quality urban green infrastructure in the environmental protection industry. Under this reality, environmental non-governmental organizations are becoming increasingly important as an organized social force in limiting national environmental power. It has become a crucial force in municipal solid waste management. Within this context, this study aimed to evaluate the strategic choice relationship among environmental non-governmental organizations, local governments, and garbage disposal enterprises, as well as the impact of environmental non-governmental organizations participating in the supervision of the implementation of information waste classification and management systems. In this study, the game theory method is used to construct the tripartite evolutionary game model of local governments, garbage disposal enterprises, and environmental non-governmental organizations, and the Matlab simulation model is established. The results of model analysis and simulation show that direct supervision, financial support, and punishment from non-governmental organizations, as well as pressure measures by non-governmental organizations, can promote the implementation of Internet of Things technology behavior. High-intensity financial support, low-intensity punishment and pressure measures, and moderate direct supervision have the most significant effect on the implementation of Internet of Things technology.

Keywords: garbage sorting and recycling; internet of things; environmental non-governmental organizations (NGO); evolutionary game model; numerical simulation

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1. Introduction

This study focuses on the role of environmental non-governmental organizations in the process of municipal solid waste disposal supported by Internet of Things technology and emphasizes the importance of environmental non-governmental organizations in effectively coordinating environmental governance conflicts of interest by participating in government environmental decision-making and expressing their views as a third-party regulatory subject.

Information technology and environmental problems are the main challenges of the 21st century [1]. The 19th National Congress of the Communist Party of China makes a point that environmental protection has been put on the work schedule by constructing the environmental governance system with the leadership of the government, the enterprise serving as the main body, the participation of the social organization, and the participation

of the public [2]. The key to handling the "garbage besieged city" is mainly to carry out garbage classification and recycling from the source, but the practical effect of more than 20 years is not ideal [3]. The main reasons are as follows: 1. Residents do not know enough about the methods of garbage classification and recycling and are unable to accurately identify recyclable waste, kitchen waste, other waste, and harmful waste; 2. Garbage cans are overfilled and spilled into the surrounding environment, resulting in urban garbage lanes becoming sanitary corners, which breed mosquitoes and flies to produce odors and ultimately harm the environment and humans; 3. The physique of garbage classification management by the relevant management departments is not perfect, which leads to the overload operation of the government, the neglect of participation by the social subjects, and a lack of support from the market subjects; 4. China's garbage collection is mainly done by individual practitioners. Because of the irregular management, lack of inspection, and restraint conditions, garbage collection, transportation, and treatment can easily cause serious secondary pollution in the processes of collection, transportation, and treatment [4]. These pain points need to be solved quickly. The main reason for these pain points is the lack of information management in municipal solid waste treatment. As a result, the Internet of Things technology has quickly become a tool because it can not only solve the problem of modern domestic waste management through its information technology but also construct the reverse logistics management mode of municipal solid waste to achieve garbage resource management [5]. Nowadays, information technology has become the key factor in garbage treatment. According to this, more and more environmental protection enterprises regard the "Internet of Things + recycling of waste resources" as their key garbage classification and recycling model of the future. At present, there are many high-tech enterprises in China with the operation mode of "Internet of things + garbage classification and recycling", such as Incom Resources Recovery Recycling, Ai Recycling, Haolei Community, Xiandou recycling, Huge Recycling, Feimayi Recycling, Vortexinfo [6].

The garbage classification and collection systems based on Internet of Things technology are mainly composed of radio frequency identification devices, infrared induction, metal detection, and moderate detection modules [7]. Based on drawing lessons from foreign advanced experience and combining them with the reality of garbage classification in China, the system adds five parts: intelligent trash can product line; intelligent recycling product line; Internet door-to-door recycling service system; reverse logistics management system; and an integrated management platform [8]. It involves the classification of the previous paragraph, the middle end of the clearance, and the back-end recovery of the logistics management process, which can cover the community, public places, schools, restaurants, shopping centers, and other areas. Facts show that, with the help of Internet of Things technology, the development of an effective garbage classification and recovery system can not only improve the municipal solid waste management mechanism but also ensure the flow of renewable resources and the maximum recycling of urban solid waste resources, resulting in a green circular economy [9].

The implementation of Internet of Things technology in waste disposal belongs to environmental protection, which means that the government should play a leading role in environmental protection. However, the government cannot perform the "public trust function" all the time, mainly for the following reasons. First of all, to pursue the performance of regional economic growth, local government officials may not strictly control the garbage disposal standards; the penalties for environmental protection enterprises that do not dispose of garbage properly and cause secondary environmental pollution are insufficient. In some places, there may even be unreasonable phenomena of "replacing the law with punishment" and "replacing the law with the right", which leads to the weak awareness of environmental protection enterprises to environmental pollution [10]. Secondly, due to the characteristics of the hierarchical system of power operation under the "rational bureaucracy", the government's goal of garbage information management is alienated and deviated from the original goal after sub-contracting layer by layer, resulting in "government failure" in municipal solid waste management. Last but not least, our nation's current

municipal solid waste management system is a single, central management model put in place by the government as a whole. This system lacks a management system for administrative oversight and public participation, which results in the "absence" of the main body of social governance's participation. As a result, it is challenging to inspire the general populace to help with garbage management. To eliminate the problems of government failure, the low efficiency of traditional garbage treatment, and the insufficient motivation of the masses, it is necessary to break the monopolisitc management of municipal solid waste management. Therefore, environmental non-governmental organizations, which are not subject to any official organizations, should participate in the information waste management system, effectively integrate community forces based on their professionalism, and form interactions with local governments and garbage disposal enterprises in the process of information waste treatment [11]. So, external forces need to be constrained.

In fact, our research is also about the sustainable development of municipal solid waste classification and management, which is often based on innocuity, reduction, and resource utilization as the main purposes and development direction [12]. The fundamental methods for sustainable development of municipal solid waste treatment are classified as collection, recycling and resource utilization, and informatization of municipal solid waste disposal [13]. By studying the example of the supervision system of garbage collection and transportation by using Internet of Things technology and information means in China, Shang Ziqiao found that Internet of Things technology is beneficial to improve the level of garbage classification, optimize the collection and transportation mode, plan the collection and transportation path, reduce the cost of collection and transportation, and control environmental pollution [14].

However, there are few empirical studies on the participation of environmental non-governmental organizations in the garbage classification and management system of Internet of Things technology. Although countries' understanding and attention to environmental governance are increasing, there are still many problems in the measures related to the use of scientific and technological means to dispose of garbage. According to Peng Liangjun and others, the government's allocation of the garbage treatment model is not perfect and cannot effectively curb the bad environmental pollution caused by garbage growth [12]. At the same time, it further shows that there is a lot of room for the optimization of garbage treatment in China. The present research aims to evaluate the impact of the participation of environmental non-governmental organizations on the information waste classification and treatment system. Another reason for this survey is that many studies pay attention to the impact of local governments on garbage treatment, but few people pay attention to the impact of environmental non-governmental organizations on garbage treatment. The purpose of this study is to fill this gap and to further understand the relationship between environmental non-governmental organizations and the local government. It is in this context that this study aims to assess the impact of the participation of environmental non-governmental organizations on the use of Internet of Things technology for garbage classification and treatment. The focus of this paper is to further promote the role of environmental non-governmental organizations in environmental governance, including how to achieve the legitimacy of the main body in the participation of environmental governance and the effectiveness of the results of participation. Therefore, it is necessary to review the participation of environmental non-governmental organizations and the role of their functions in environmental governance to fully understand the precedents and consequences of environmental non-governmental organizations. Based on the previous research [15], the theoretical basis of this paper is to assume that environmental non-governmental organizations are commissioned by residents to establish the main tasks, including participation in environmental decision-making, the enhancement of social credibility, and the coordination of environmental conflicts of interest. The assumptions of this study are based on previous studies [16]. The study of references cannot prove that the level of residents' participation in garbage classification is directly related to government supervision [16], and there is no use of information technology to improve the garbage classification and treatment

system. There is no study on the role of environmental non-governmental organizations in monitoring the garbage treatment system, whether the current garbage classification and collection system is sustainable or not, or whether it is limited to general environmental treatment.

This study is divided into four parts. The first part contains a review of the literature on Internet of Things technology, environmental non-governmental organizations, and evolutionary games. The second part is the model methodology, which introduces the research model developed according to the literature review of each variable studied. In the third part, we summarize and discuss the impact of the participation of environmental non-governmental organizations on the results of information waste classification and treatment. In the last part, the main conclusions are introduced, which integrate the contributions of research and methodology, the enlightenment to garbage management, the limitations of the study, and suggestions for future research. The specific structure of the paper is shown in Figure 1.

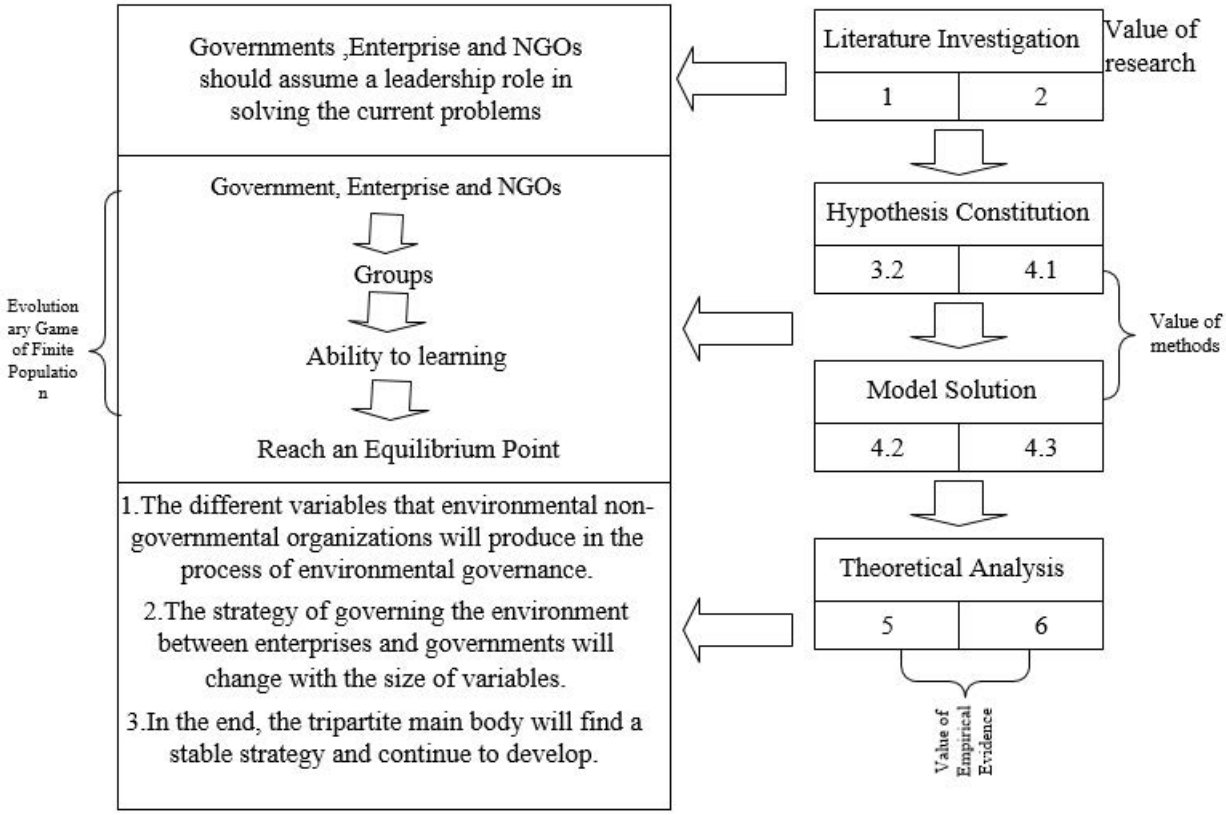

Figure 1. Paper structure diagram.

2. Related Literature

(1) Research on the Internet of Things

The original concept of the Internet of Things came from the Massachusetts Institute of Technology in the United States. With the in-depth study of the Internet of Things by different industry workers, it can be divided into two meanings. The Internet of Things can digitize and network everything, provide high-level application services for "things", and enable efficient information processing of interactions between objects, people, and the real world [17,18]. Due to the increase in environmental pollution and human health risks, the collection and treatment of garbage are the most concerning pain points in today's society. To solve these pain points, scholars at home and abroad have usually explored and discussed a lot of garbage disposal work from the perspective of Internet of Things technology. For example, with the rapid development of Internet of Things

technology, Li Y found that this technology can be applied to the field of environmental protection and then developed into environmental protection Internet of Things technology to realize the environmental governance scheme to meet the needs of environmental protection and economic development [19]. Zhu M believes that to solve the serious disposal problem of municipal solid waste classification and recycling in China, supply-side reform measures need to be taken, and the Internet of Things + third-party treatment is the key to completing the supply-side reform of garbage classification and collection, which is helpful to improve the efficiency of garbage classification and collection [20]. By studying the garbage classification and collection system based on Internet of Things technology, Xia and others found that the system can realize the function of information collection, transmission, and monitoring to change the garbage management mechanism and the disadvantages of waste collection backwardness [21]. Wu Fan et al., through the study of garbage classification and collection management systems, found that they have problems with management confusion and low information maturity. They are based on Internet of Things technology, so the system has developed into an efficient information management system [22]. Through an in-depth study of the Internet of Things technology, Wang and others found that it can effectively realize intelligent identification, positioning, and other related functions in the garbage classification and collection system so that the garbage classification and collection system can be managed by information [23]. Given the main problems of waste disposal in Oman, Kumaravel G et al. proposed to provide a perfect management and monitoring system for waste disposal based on Internet of Things technology to effectively solve the problems faced [24]. Ridha Ouni et al. proposed combining wireless sensor networks with the Internet of Things technology and forming a smart city to solve the existing environmental problems [25].

(2) Evolutionary game theory research

The original basic idea of evolutionary game theory originated from the field of biology and evolved from the competition between biological species and populations. After that, it combines a variety of scientific theories and research applications so that it can solve group game behavior in many fields [26]. Based on the fact that society is at the background of economic transformation and ecological civilization, scholars at home and abroad usually use evolutionary game theory to analyze the evolutionary stability strategies between different enterprises and governments. For example, Dong and others built a dynamic evolutionary game model between the government and developers, and the government and the bank. Through the analysis, they found that economic incentives help to promote balanced development between the government and developers, and effectively promote the development of green buildings [27]. Based on the background of reverse logistics of abandoned household appliances, Du established the game model of the government-enterprise-resident tripartite main body and analyzed the equilibrium solution of his mixed strategy according to the income of the correlation matrix to better establish the relevant design of an incentive and promotion mechanism for reverse logistics [28]. Based on the environmental behavior supervision system of Chinese enterprises, Zhao and others constructed the evolutionary game model of enterprises, the government, and the residents, and further analyzed the stability and progressive stability of the model. Finally, it is found that the dynamic penalty is the key factor in solving environmental governance [29]. Based on the technological innovation of enterprises, Zhang and others analyzed the influence of government incentive mechanisms on enterprises by establishing an evolutionary game model between the government and enterprises, and they finally found that the incentive mechanism is an effective measure for technological innovation [30]. Based on the background of the Internet of Things industry, Hou and others constructed the tripartite evolution game model of the government, telecom equipment manufacturers, and telecom operators. Analyzing the equilibrium stability and evolutionary stability strategy of the model further provides ideas for the government and the main body of the industry [31]. Wang et al., using evolutionary game theory, constructed an asymmetric evolutionary game model between social organizations and the government and analyzed

the choice of strategies between social organizations and the government according to the benefits and costs of collaborative cooperation between the two sides [32]. Based on the background of "Internet +", Cao Xiyu and others constructed an evolutionary game model of organization, evaluation organization, and government. By analyzing the equilibrium strategy of each subject, the stability condition of the game subject, and the numerical simulation, they found that "Internet +" can not only promote the information level of social organization but also help the social organization [33]. Yi Shi et al. used evolutionary game theory to analyze the influence of three different environmental regulations on enterprise green science and technology innovation and finally found that combined environmental regulation is beneficial to the development of enterprise technological innovation [34]. According to the rent-seeking phenomenon of enterprises in pollution prevention and control, Zhu et al. constructed a tripartite evolutionary game model among enterprises, local governments, and the central government and finally found that the government reward strategy is helpful to the choice of enterprise strategy in an ideal state [35].

(3) Environmental non-governmental organizations' theory research

In the era of sustainable development, environmental non-governmental organizations have become an important force in the field of global environmental governance [36]. The term "non-governmental organization" dates back to 1950 and was coined by the United Nations at that time [37]. Since 1978, Chinese environmental non-governmental organizations have been around for 40 years, and their functions are becoming more and more important in social development. At present, environmental non-governmental organizations have formed a relatively complete system, which has become the main force in promoting the development and progress of global environmental protection. This system also plays an important role in promoting sustainable development and value creation [16].

Environmental non-governmental organizations can address a wide range of environmental issues, including biodiversity conservation, energy conservation, air and water pollution, and large dam and hydropower projects [38–42]. Environmental non-governmental organizations play a variety of roles in environmental governance. Couto Fernandes points out that environmental non-governmental organizations are one of the main stakeholders related to environmental protection enterprises in environmental governance [43,44]. Paul Jepson points out that environmental non-governmental organizations should strengthen governance and accountability systems to strengthen their role in environmental governance [45]. In the face of managing an organization and taking action to solve specific environmental problems, Mermet points out that the implementation of strategic environmental management by environmental non-governmental organizations can go beyond the effectiveness of using public strategies to solve environmental problems, and it is more sustainable [46].

Due to the special national conditions of China, environmental non-governmental organizations and the government should maintain benign interaction and consultation [47]. Virginie Arantes argues that complex environmental issues are guiding local governments to cooperate with environmental non-governmental organizations in the field of urban environmental governance [48]. Divya points out that the benign cooperation between the government and environmental non-governmental organizations in the management of deep forests can help to make up for each other's limitations and to realize the synergy in natural resource management [49]. Tan Chenghua and others pointed out that environmental non-governmental organizations play an important role in dealing with the neighborhood avoidance movement and are reliable partners of the government [50].

To sum up, the existing research confirms the role of Internet of Things technology and government-related policies in environmental governance. Although the above-mentioned literature only emphasizes the importance of government regulation of group behavior, it ignores the possible "failure" of the government. Given this, this requires the participation of environmental non-governmental organizations to make up for the shortcomings in environmental governance and to effectively improve the "government failure" [51]. Aoyama

Y pointed out that the social activities managed by the government should let citizens, communities, social organizations, and other pluralistic subjects actively participate in the management to solve the problems of market failure and government failure, and realize the coordinated governance ability of grass-roots social organizations [52]. Zhu Mei believes that the existence of social organizations can not only carry out in-depth publicity and education for citizens but also create a large number of employment opportunities for young citizens [20]. On the premise of mastering the characteristics of dynamic game behavior between government and social organizations, Tan and others constructed an evolutionary game model of cooperative governance between government and society. Through the analysis of the stability strategy of the game between the two sides, scholars find that the participation of social organizations in government governance helps clarify the relationship between power and responsibility and enhances public trust in the government [53].

3. Establishment of the Evolutionary Game Process and RELATED Assumptions

3.1. Evolutionary Game Process

Due to the continuous development of information technology and the importance attached to environmental governance in various countries, more and more countries combine information technology with environmental management, so "classified management of information waste" ushered in a good period of great development and cooperation. Garbage classification and treatment supported by information technology can improve the operational efficiency of environmental protection enterprises and reduce transportation costs (take oil costs as an example). However, in the absence of the participation of non-governmental organizations, the optimization of the environmental governance system cannot bring greater economic benefits, especially in information technology-supported garbage classification and treatment. There are many complex factors, such as small batches, many batches, and many kinds of municipal solid waste, which will affect the efficiency of garbage collection and classification in the information waste classification and treatment system, leading to low economic benefits. The collection and classification of garbage mainly depend on social residents. However, enterprises and governments do not meet all the needs of society, and in the absence of important services or social cohesion, non-governmental organizations play a key role in governance and the creation of social ends [54].

At present, different subjects in the information waste classification and treatment system will start from their interests to form the evolutionary game relationship. They are mainly manifested in the cooperative relationship of each subject in the garbage classification and treatment system. Although the process of forming a cooperative relationship is not easy, especially when the tripartite parties choose different strategic directions, the synergies they create can be powerful [55].

Based on the Internet of Things technology of municipal solid waste classification and recycling systems, the relevant stakeholders are local governments, enterprises, and environmental non-governmental organizations. In the market where the government dominates the "Internet of Things" technology, the implementation of the Internet of Things technology is mainly involved in the early classification, medium-term transportation, and post-recovery garbage disposal work. The garbage classification and recycling systems based on Internet of Things technology are mainly composed of radio frequency identification devices, ZigBee terminals, infrared sensors, global positioning systems, laser scanners, and so on, which can identify, locate, track, and monitor domestic waste. In the early stage of treatment, enterprises first use the RFID function of Internet of Things technology to classify and dispose of garbage and then monitor the internal situation of the garbage can in real-time through infrared sensors. If the trash can is full, the sensor will send a signal. After that, the central processing module will obtain the specific location of the trash can through the satellite positioning system and schedule the garbage transport vehicle for garbage handling tasks [56]. GPS can also locate each garbage truck in real-time, thereby

reducing the waste of transportation costs. Based on the background of government-led enterprises implementing Internet of Things technology to deal with domestic waste, the government and third-party regulatory organizations can encourage more enterprises to carry out innovative technology through subsidies, tax relief, and other incentive means. Moreover, environmental non-governmental protection organizations will be involved in all aspects of garbage disposal. First of all, the organization will guide community residents to use machinery and equipment that can identify the types of waste and further promote the importance of waste sorting to popular science. Secondly, as a third-party regulatory organization, environmental non-governmental organizations will supervise and check whether enterprises implement Internet of Things technology and whether the government drives the enterprise market, and so on [57]. If there are illegal acts by enterprises and governments, environmental non-governmental organizations will take disciplinary measures to impose sanctions. At the same time, the organization will establish rules and regulations to restrain them [58]. Finally, an effective garbage treatment system is formed [7]. The process of garbage classification and collection based on Internet of Things technology is shown in Figure 2.

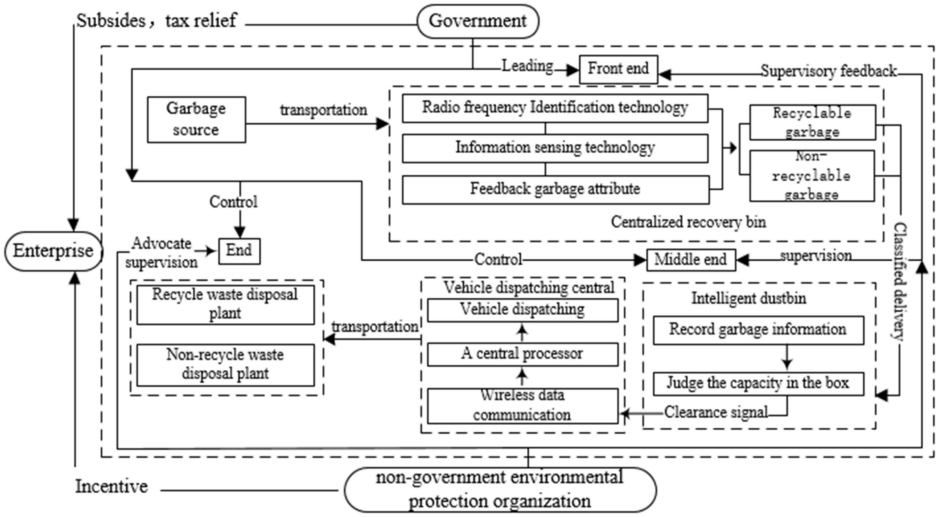

Figure 2. Internet of Things Urban Waste Treatment System.

3.2. Model Assumption

(1) Game subject

In the "natural" environment, it is assumed that the main body of the game includes garbage disposal enterprises, environmental non-governmental organizations, and local government. These three stakeholders are independent individuals, limited-rational people with incomplete information and the ability to learn constantly. The main reason why enterprises apply Internet of Things technology to garbage disposal is because they want to improve the management and recovery of municipal solid waste, which is lagging behind social needs.

(2) Game subject strategy hypothesis and parameter setting

Hypothesis 1 (H1). The strategy of environmental non-governmental organizations (ENGOs): environmental non-governmental organizations are commissioned by residents and are directly involved in supervision as a bottom-up social organization. Its existence is to safeguard the community's environmental governance and the interests of the masses [59]. When the government has problems with environmental regulations, the organization can hold it accountable for its administration (referred to as direct supervision) [60,61] or, as a top-down affiliated with the relevant government office, assist them in implementing relevant regulatory work (referred to as indirect supervision) [62]. The probabilities of choosing the two strategies are x and 1-x. The strategy of enterprise: the behavior of using Internet of Things technology to classify and release garbage and recy-

cling can solve the problem of chaotic management of municipal solid waste or secondary pollution of the environment (referred to as implementation technology). Some enterprises do not use the Internet of Things technology and still use traditional methods for garbage disposal (referred to as non-implementation of technology). The probabilities of choosing the two strategies are y and 1-y. The strategy of local government: local government leads enterprises to implement Internet of Things technology for municipal solid waste disposal and takes considerable incentive or punitive measures (referred to as dominant). Alternatively, if the local government does not lead the enterprises to implement Internet of Things technology but must pay for the secondary pollution caused by the enterprise (referred to as not dominant), the probabilities of choosing the two strategies are z and 1-z.

Hypothesis 2: If the local government leads the promotion of the Internet of Things technology, it is necessary to invest a certain amount in the formulation of industry standards. At the same time, to encourage enterprises to implement the Internet of Things technology, it is necessary to guide the enterprise using tax reliefs or financial subsidies. Assuming that the cost of local government leading and promoting the implementation of Internet of Things technology is C_e, the financial subsidy given by the local government to enterprises implementing Internet of Things technology is S, and the economic support of local government to environmental non-governmental organizations directly involved in supervision is S_1. In light of the foundation of the execution of Internet of Things technology in government-driven endeavors, if undertakings carry out Internet of Things technology, the secret risks in trash characterization and assortment will be essentially decreased. Simultaneously, the chance of optional contamination of the climate will likewise move toward nothing. This will not only benefit the government's performance and reputation but will also gradually reduce the cost of the organization's supervision of enterprises. Assuming that the government obtains the economic and social environmental benefits, R_1. the direct participation of environmental non-governmental organizations in supervision will save the cost incurred by the government, C_1. If the enterprise does not implement the Internet of Things technology, it is necessary to pay the corresponding fine to the local government as P_0, but the government needs to pay the cost of environmental pollution control, which is H. While environmental non-governmental organizations are directly involved in the supervision of enterprises, it is found that the government will not lead enterprises to implement Internet of Things technology, resulting in a loss for the government. The loss is C_5.

Hypothesis 3: The benefit of implementing traditional technology is R_2, the expense is C_2, and the benefit of implementing Internet of Things technology is R_3, and the expense is C_3. In addition, under the background that the local government leads the Internet of Things technology, if the enterprise implements the Internet of Things technology to deal with the work, it can obtain a certain financial subsidy, which is S. At the same time, environmental non-governmental organizations will give relevant support to the technology innovation of enterprises, the benefit of which is Si. If the enterprise does not implement the Internet of Things technology, the local government with the dominant strategy will impose a fine on the enterprise, which is P_0. If the environmental non-governmental organization indirectly supervises and finds that the enterprise does not implement the Internet of Things technology, then the organization will inform the public about the unreasonable behavior of the enterprise. At the same time, the organization will take the means of resistance or expose the unreasonable behavior of the enterprise through the network media, which will cause certain losses to the enterprise. The loss is E_1. If the environmental non-governmental organization directly supervises the enterprise and finds that the enterprise has secondary environmental pollution behavior, it will engage in the following behavior: 1. Resist the wrong behavior of enterprises by disclosing this to the public or through online media exposure; 2. Pressure enterprises through environmental public interest litigation, causing huge losses to enterprises [63]; these losses are E_2.

Hypothesis 4: Because it is easier for the government to establish a trusting relationship with the bottom-up non-governmental organization, when the environmental

non-governmental organization participates in the supervision of the enterprise, the organization will receive the corresponding financial support from the government through the provision of services, which is S_1. At the same time, environmental non-governmental organizations have to pay the cost of supervision, which is C_4. When environmental non-governmental organizations are directly involved in supervision as bottom-up institutions, they have to pay attentional monitoring costs because of the extensive scope and extent of their participation, which is ΔC.

On the basis of the foregoing assumptions, the strategic combination between the local government, enterprise, and organizations can be obtained, as shown in Tables 1 and 2.

Table 1. Payoff matrix among the government, enterprises, and organizations.

Strategy Matrix		Enterprises			
		Implementation	**Non-Implementation**		
Non-governmental environmental protection organization	Direct supervision	R_3-C_3+S+S_i	R_2-C_2-P_0-E_1-E_2	Dominant	Local government
		S_i-C_4-ΔC	S_1-C_4-ΔC		
		R_1-Ce-S-S_1+C_1	C_1+P_0-C_e-S_1-H		
	Indirect supervision	R_3-C_3+S+S_i	R_2-C_2-P_0-E_1		
		S_1-C_4	S_1-C_4		
		R_1-C_e-S_1-S	P_0-C_e-H-S_1		
	Direct supervision	R_3-C_3+S_i	R_2-C_2-E_1-E_2	Non-dominant	
		-ΔC-C_4	-C_4-ΔC		
		R_1-C_5	-H-C_5		
	Indirect supervision	R_3-C_3+S_i	R_2-C_2-E_1		
		0	0		
		R_1	-H		

Note: The relationships of all formulas in the table are derived from the above assumptions.

Table 2. Definition of variables within the model.

Symbols	Definition
C_1	Environmental non-governmental organizations directly monitor the costs saved for the government
C_2	The cost of implementing traditional garbage disposal behavior in enterprises
C_3	The cost of implementing Internet of Things technology in enterprises
C_4	Supervision costs of environmental non-governmental organizations
C_5	The loss caused by the government not leading enterprises to implement the Internet of Things
C_e	Cost of local government leading and promoting the implementation of Internet of Things technology
ΔC	Additional supervision costs of environmental non-governmental organizations
R_1	The economic and social environmental benefits of local governments
R_2	Benefits from the implementation of traditional garbage disposal in enterprises
R_3	Benefits from the implementation of Internet of Things technology in enterprises
E_1	Indirect supervision by environmental non-governmental organizations discovered the loss caused by enterprises' failure to implement Internet of Things technology.
E_2	Direct supervision by environmental non-governmental organizations discovered the loss caused by enterprises' failure to implement Internet of Things technology.
S	Local governments provide financial assistance to businesses that use the Internet of Things technology.
S_1	Economic support for environmental non-governmental organizations under the direct supervision
S_i	Benefits from innovative support to enterprises by environmental non-governmental organizations
P_0	Enterprise fines for failing to implement Internet of Things technology
H	Enterprises' environmental governance costs for not implementing Internet of Things technology

4. Model Analysis

4.1. Evolutionary Game Model Construction

(1) The expected benefits of direct and indirect supervision of environmental non-governmental organizations are Ui_1; Ui_2, respectively, and the average expected benefit is Ui.

Expected benefits of direct supervision by non-governmental environmental protection organizations:

$$\begin{aligned} Ui_1 &= y[z(S_i - C_4 - \Delta C) + (1-z)(-C_4 - \Delta C)] + \\ &(1-y)[z(S_i - C_4 - \Delta C) + (1-z)(-C_4 - \Delta C)] \\ &= zS_i - C_4 - \Delta C \end{aligned} \tag{1}$$

Expected benefits of indirect supervision by environmental non-governmental organizations:

$$\begin{aligned} Ui_2 &= z[y(S_1 - C_4) + (1-y)(S_1 - C_4)] \\ &= z(S_1 - C_4) \end{aligned} \tag{2}$$

Average expected earnings of environmental non-governmental organizations:

$$Ui = xUi_1 + (1-x)Ui_2 \tag{3}$$

The replication dynamics equations of environmental non-governmental organization strategies are as follows:

$$F(x) = \frac{dx}{dt} = x(Ui_1 - Ui) = x(1-x)[z(S_i + C_4 - S_1) - C_4 - \Delta C] \tag{4}$$

(2) The expected benefits of enterprises choosing to implement Internet of Things technology and not to implement Internet of Things technology are denoted as Li_1 and Li_2, respectively, and the average expected benefit is Li:

Expected benefits of the Internet of Things technology by enterprises:

$$\begin{aligned} Li_1 &= x[z(R_3 - C_3 + S + S_i) + (1-z)(R_3 - C_3 + S_i)] \\ &+(1-x)[z(R_3 - C_3 + S + S_i) + (1-z)(R_3 - C_3 - S_i)] \\ &= R_3 - C_3 + S_i + zS \end{aligned} \tag{5}$$

Expected benefits of no Internet of Things technology by enterprises:

$$\begin{aligned} Li_2 &= x[z(R_2 - C_2 - P_0 - E_1 - E_2) + (1-z)(R_2 - C_2 - E_1 - E_2)] + \\ &(1-x)[z(R_2 - C_2 - P_0 - E_1) + (1-z)(R_2 - C_2 - E_1)] \\ &= R_2 - C_2 - E_1 - xE_2 - zP_0 \end{aligned} \tag{6}$$

Average expected earnings of enterprises:

$$Li = yLi_1 + (1-y)Li_2 \tag{7}$$

The replication dynamics equations of enterprise strategies are as follows:

$$\begin{aligned} F(y) &= \tfrac{dy}{dt} = y(Li_1 - Li) \\ &= y(1-y)[(R_3 - C_3 - R_2 + C_2) + (S_i + E_1) + xE_2 + z(S + P_0)] \end{aligned} \tag{8}$$

(3) The expected benefits of local governments choosing to lead and non-leading enterprises to adopt Internet of Things technology are denoted as Ni_1 and Ni_2, respectively, and the average expected benefit is Ni:

Expected benefits of leading enterprises to adopt the Internet of Things by local government:

$$\begin{aligned} Ni_1 &= x[y(R_1 + C_1 - C_e - S - S_1) + (1-y)(P_0 + C_1 - S_1 - H - C_e)] \\ &+(1-x)[y(R_1 - C_e - S_1 - S) + (1-y)(P_0 - C_e - H - S_1)] \\ &= y(R_1 + H - S - P_0) + (P_0 - C_e - H - S_1) + xC_1 \end{aligned} \tag{9}$$

Expected benefits of not leading enterprises to adopt the Internet of Things by local government:

$$\begin{aligned} Ni_2 &= x[y(R_1 - C_5) + (1-y)(-H - C_5)] + (1-x)[yR_1 + (1-y)(-H)] \\ &= y(R_1 + H) - xC_5 - H \end{aligned} \tag{10}$$

Average expected earnings of local government:

$$Ni = zNi_1 + (1-z)Ni_2 \tag{11}$$

The replication dynamics equations of local government are as follows:

$$\begin{aligned} F(z) &= \tfrac{dz}{dt} = z(Ni_1 - Ni) \\ &= z(1-z)[P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5)] \end{aligned} \tag{12}$$

So that F(x) = F(y) = F(z) = 0, we get nine equilibrium points of the evolutionary game among non-governmental environmental protection organizations, enterprises and local governments, all of which are: A1:(0,0,0), A2:(0,0,1), A3:(0,1,1), A4:(1,0,0), A5:(1,0,1), A6:(1,1,0), A7:(0,1,0), A8:(1,1,1), M(x*,y*,z*).

The same reason can be obtained:

$$x^* = \tfrac{(R_2+C_3-R_3-C_2)-(S_i+E_1)-z(S+P_0)}{E_2}, y^* = \tfrac{x(C_1+C_5)+P_0-S_1-C_e}{S+P_0}, z^* = \tfrac{C_4+\Delta C}{S_i+C_4-S_1}$$

4.2. Stability Analysis Strategies of Different Agents in the Evolution

4.2.1. Evolutionary Stability Conditions for Environmental Non-Governmental Organizations

According to the replicational dynamic Equation (4), the game strategies adopted by environmental non-governmental organizations are as follows.

Situation 1: If $z = z^* = C_4 + \Delta C/S_i + C_4 - S_1$, then $F(x) \equiv 0$, so x takes any value as an evolution stable state in this situation. At the same time, it also shows that the environmental non-governmental organizations have stable strategies regardless of their choice of strategies and will not change with time.

Situation 2: If $z \neq z* \neq C_4 + \Delta C/S_i + C_4 - S_1$, let $F(x) = 0$, then x = 0 and x = 1 are two stable points of $F(x)$.

The derivation of $F(x)$ is obtained:

$$F^{'}(x) = \frac{\partial(dx/dt)}{\partial x} = (1-2x)[z(S_i + C_4 - S_1) - C_4 - \Delta C] \tag{13}$$

According to the theory of the evolutionary game, when the evolutionary stability strategy must satisfy $F^{'}(x) < 0$ condition, x can become the stable point of the evolutionary game.

a. When $z > C_4 + \Delta C/S_i + C_4 - S_1$, then $F^{'}(0) > 0$ and $F^{'}(1) < 0$, so x = 1 is the evolutionary equilibrium point of environmental non-governmental organizations. When the government chooses "dominant" enterprises to implement the technology strategy of the Internet of Things, the organization can predict that the government will subsidize the direct supervision of the organization. Therefore, environmental non-governmental organizations will adopt the strategy of "direct supervision" as the strategy of evolution and stability.

b. When $z < C_4 + \Delta C/S_i + C_4 - S_1$, then $F^{'}(0) < 0$ and $F^{'}(1) > 0$, so x = 0 is the evolutionary equilibrium point of non-governmental environmental protection organizations. When the government has a low probability of choosing "dominant" companies to implement the technology strategy of the Internet of Things, the organization can predict that the government will give fewer subsidies to its direct supervision. Therefore, the high supervision cost will make the environmental non-governmental organizations adopt the "indirect supervision" strategy as the evolution stability strategy.

4.2.2. Evolutionary Stability Conditions of Enterprise

According to the replicational dynamic Equation (8), the game strategies adopted by enterprises are as follows.

Situation 1: If $x = x* = (R_2 + C_3 - R_3 - C_2) - (S_i + E_1) - z(S + P_0)/E_2$, then $F(y) \equiv 0$, so y takes any value as an evolution stable state in this situation. This shows that no matter what strategy an enterprise chooses, it is a stable strategy and will not change over time.

Situation 2: If $x \neq x* \neq (R_2 + C_3 - R_3 - C_2) - (S_i + E_1) - z(S + P_0)/E_2$, let $F(y) = 0$, then y = 0 and y = 1 are two stable points of $F(y)$.

The derivation of $F(y)$ is obtained:

$$\begin{aligned} F^{'}(y) &= \frac{\partial(dy/dt)}{\partial y} \\ &= (1-2y)[(R_3 - C_3 - R_2 + C_2) + S_i + E_1 + xE_2 + z(S + P_0)] \end{aligned} \tag{14}$$

a. When $x < (R_2 + C_3 - R_3 - C_2) - (S_i + E_1) - z(S + P_0)/E_2$, then $F^{'}(0) < 0$ and $F^{'}(1) > 0$, so y = 0 is the evolutionary equilibrium point of enterprises. This means that when the probability of environmental non-governmental organizations adopting the strategy of "direct supervision" is small, the possibility of material subsidies to the Internet of Things technology implemented by enterprises is relatively low. At the same time, enterprises can predict that the benefits of implementing Internet of Things technology will be less than the amount they spend, so enterprises adopt the strategy of "not implementing" Internet of Things technology as the evolution and stability strategy.

b. When $x > (R_2 + C_3 - R_3 - C_2) - (S_i + E_1) - z(S + P_0)/E_2$, then $F'(0) > 0$ and $F'(1) < 0$, so y = 1 is the evolutionary equilibrium of enterprise. When environmental non-governmental organizations choose the strategy of "direct supervision", the degree of material support and subsidies for the implementation of the technological behavior of the Internet of Things is also relatively large. At the same time, enterprises can predict that the benefits of the implementation of the Internet of Things technology will be greater than the benefits of not implementing the technology. Therefore, enterprises will choose to "implement" the Internet of Things technology strategy as the evolution and stability strategy.

4.2.3. Evolutionary Stability Conditions of Local Government

According to the replication dynamic Equation (12), the game strategies adopted by the local government are as follows.

Situation 1: When $y = y^* = x(C_1 + C_5) + P_0 - S_1 - C_e/S + P_0$, then $F(z) \equiv 0$, so z takes any value as an evolution stable state. This shows that no matter what strategy a local government chooses, it is a stable strategy and will not change over time.

Situation 2: When $y \neq x(C_1 + C_5) + P_0 - S_1 - C_e/S + P_0$, let $F(z) = 0$, then z = 0 and z = 1 are two stable points of $F(z)$. The derivation of $F(z)$ can be obtained:

$$\begin{aligned} F^{'}(z) &= \frac{\partial(dz/dt)}{\partial z} \\ &= (1-2z)[P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5)] \end{aligned} \tag{15}$$

a. If $y < x(C_1 + C_5) + P_0 - S_1 - C_e/S + P_0$, then $F^{'}(0) > 0$ and $F^{'}(1) < 0$, so z = 1 is the evolution and stability strategy of local government. When the probability of enterprises choosing to "implement" the technology strategy of the Internet of Things is small, many enterprises will use the traditional way, which can easily cause secondary pollution. At this time, the government must adopt a "dominant" strategy to reduce the phenomenon of enterprise pollution. Therefore, the local government will choose the "dominant" strategy as the evolutionary stability strategy.

b. If $y > x(C_1 + C_5) + P_0 - S_1 - C_e/S + P_0$, then $F^{'}(0) < 0$ and $F^{'}(1) > 0$, so z = 0 is the evolution and stability strategy of local government. When enterprises choose to "implement" the technology strategy of the Internet of Things, even if there is no government dominant, the enterprise will spontaneously implement the Internet of Things technology to obtain a competitive advantage. Therefore, the local government will choose the "undominant" strategy as the evolutionary stability strategy.

4.3. Analysis of Stability Strategies of Tripartite Evolutionary Game

First of all, the variables related to environmental non-governmental organizations are taken as constant, and the evolution and stability strategy between local governments and enterprises is analyzed. Secondly, the replicational dynamic equations connect enterprises and local governments. Only when the two conditions $0 \le [P_0 - S_1 - C_3 + y(C_1 + C_5)]/S + P_0 \le 1$ and $0 \le [(R_2 - C_2) - (R_3 - C_3) - (S_i + E_1) - xE_2]/S + P_0 \le 1$ are agreed upon can the local stability of the game equilibrium point be analyzed. The Jacobian matrix is shown below.

$$J_1 = \begin{bmatrix} (1-2y)[R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 + z(S + P_0)] & y(1-y)(S + P_0) \\ z(z-1)(S + P_0) & (1-2z)[P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5)] \end{bmatrix}$$

Through the stability analysis results shown in Table 3, the evolutionary game results of enterprises and local governments have evolutionary game stability points, y = 0, z = 1, and y = 1, z = 1, respectively.

Table 3. The stability of the equilibrium point of the evolutionary game between enterprise and government.

Equilibrium Point	Det J_1	Tr J_2	Result	Stable Condition
$y = 0, z = 0$	-	±	Saddle point	$R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 < 0$; $P_0 - S_1 - C_3 + x(C_1 + C_5) > 0$
$y = 0, z = 1$	+	-	ESS	$R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 + z(S + P_0) < 0$; $P_0 - S_1 - C_e + x(C_1 + C_5) < 0$
$y = 1, z = 0$	+	+	Unstable point	$R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 < 0$; $P_0 - S_1 - C_e - z(S + P_0) + x(C_1 + C_5) < 0$
$y = 1, z = 1$	+	-	ESS	$R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 + z(S + P_0) > 0$; $P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5) > 0$
$y = y*, z = z*$	0	0	Saddle point	Under any condition, it is a saddle point

Similarly, when $R_3 - C_3 + S_i + zS < R_2 - C_2 - E_2 - xE_2 - zP_0$ and $R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 + z(S + P_0) < 0$ are satisfied, the benefits of implementing Internet of Things technology are less than those of traditional garbage disposal methods, and when $P_0 - S_1 - C_e + x(C_1 + C_5) > 0$ is satisfied, that is $C_5 > S_1 + C_e - P_0 - xC_1$. When the cost of the dominant strategy of a local government is less than the cost of the undominant strategy, the game equilibrium point of the two main bodies is y = 0 and z = 1, which means that enterprises do not implement Internet of Things technology, local governments carry out leading strategy behavior. When $R_3 - C_3 - R_2 + C_2 + S_i + E_1 + xE_2 + z(S + P_0) > 0$ is satisfied, that is $R_3 - C_3 + S_i + zS > R_2 - C_2 - E_1 - xE_2 - zP$. When the benefit of implementing the technology behavior of the Internet of Things is greater than its cost, and the cost of the dominant strategy behavior of the local government is less than the cost of the undominant strategy behavior, the game equilibrium points of the two main bodies

are y = 1 and z = 1, which means that the enterprise implements the Internet of Things technology and the local government adopts the dominant strategy.

From the replication dynamic equation of non-governmental environmental protection organizations and local governments, it can be seen that the local stability of the game equilibrium point can be analyzed only when $0 \leq [C_e + S_i - P_0 + y(S + P_0)]/(C_1 + C_5) \leq 1$ and $0 \leq \Delta C/S_1 \leq 1$ are agreed upon. The Jacobian matrix is as follows.

$$J_2 = \begin{bmatrix} (1-2x)[z(S_i + C_4 - S_1) - C_4 - \Delta C] & x(1-x)(S_i + C_4 - S_1) \\ z(1-z)(C_1 + C_5) & (1-2z)[P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5)] \end{bmatrix}$$

According to the stability analysis results shown in Table 4, the evolutionary game results of local governments and non-governmental environmental protection organizations have two evolutionary game stability points, x = 0, z = 0, and y = 1, z = 1, respectively. When $-\Delta C < 0$, the cost of direct supervision by environmental non-governmental organizations is greater than that of indirect supervision. At the same time, when $P_0 - S_1 - C_e - y(S + P_0) < 0$, the cost of implementing the technical behavior of the Internet of Things in the local government-led enterprises is greater than the benefit, the game equilibrium point between the two parties is x = 0, z = 0. Therefore, environmental non-governmental organizations do not take direct supervision, and local governments do not lead enterprises to implement the technical behavior of the Internet of Things. When $zS_1 - \Delta C > 0$, the relevant subsidies of the local government can bear the cost of direct supervision by the non-governmental environmental protection organization. When $P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5) > 0$, The direct supervision of non-governmental environmental protection organizations will help local governments to save the relevant leading costs, and the game equilibrium point between the two main bodies is x = 1, z = 1.This means that environmental non-governmental organizations will adopt a direct monitoring strategy, and local governments will also adopt a leading strategy.

Table 4. The stability of equilibrium point of the evolutionary game between the environmental protection organization and the government.

Equilibrium Point	Det J_2	Tr J_2	Result	Stable Condition
$x = 0, z = 0$	+	-	ESS	$-\Delta C < 0, P_0 - S_1 - C_e - y(S + P_0) < 0$
$x = 0, z = 1$	+	+	Unstable point	$zS_1 - \Delta C > 0, P_0 - S_1 - C_e - y(S + P_0) < 0$
$x = 1, z = 0$	+	+	Unstable point	$-\Delta C < 0, P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5) > 0$
$x = 1, z = 1$	+	-	ESS	$zS_1 - \Delta C > 0, P_0 - S_1 - C_e - y(S + P_0) + x(C_1 + C_5) > 0$
$x = x^*, z = z^*$	0	0	Saddle point	Under any condition, it is a saddle point

5. Numerical Simulation Analysis

In this paper, the Matlab numerical simulation method is used to verify the above analysis results. It is further investigated that when the cost of implementing Internet of Things technology is greater than its benefits, environmental non-governmental organizations participate in the supervision of the promotion of the implementation of Internet of Things technology.

5.1. The Influence of the Proportion of Direct Supervision by Environmental Non-Governmental Organizations

Based on reality, this article sets a set of initial values: R_3 = 15, R_2 = 12, C_3 = 20, C_2 = 5, S_i = 5, E_1 = 3, S=5, S_1 = 3, P_0 = 3, C_e = 3, C_1 = 5, E_2 = 3, C_5 = 3, y = 0.2, z = 0.5. The probability of direct supervision by non-governmental environmental protection organizations is 0.2, 0.4, 0.6, 0.8, and 1.0, respectively, to verify the impact of the supervision mode of the social organization on the implementation of Internet of Things technology and the leading strategy adopted by local governments. In the simulation diagram of the evolution and stability trend of implementing the Internet of Things technology strategy from enterprise (Figure 3. left), it can be found that with the increase in the proportion of direct supervision

by the non-governmental environmental protection organizations, the probability of implementing the technology strategy of the Internet of Things has gradually increased and finally evolved to 1. From the simulation diagram of the evolution and stability trend of the local government-led strategy (Figure 3. right), it can be found that when the cost of implementing the Internet of Things technology in the local government-led enterprises is greater than the economic benefits it obtains, and if the probability of direct supervision by environmental non-governmental organizations is small, the local government will choose the strategy of not leading enterprises to implement Internet of Things technology. However, with the direct supervision probability of non-governmental organizations gradually reaching 0.6, its supervision intensity to the local government is also enhanced. At this time, the local government will take the initiative to take the lead strategy to make enterprises implement the Internet of Things technology. With the increasing intensity of direct supervision by environmental non-governmental organizations, the probability of local governments adopting the leading enterprises to implement the technology strategy of the Internet of Things has also increased.

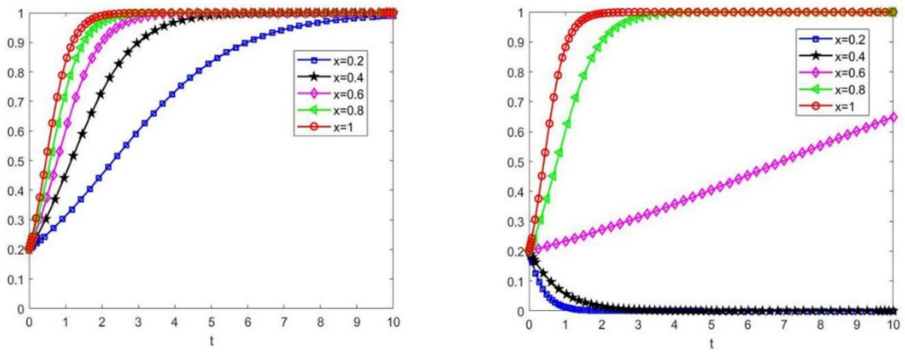

Figure 3. Environmental protection organizations participate in the evolutionary and stable trend of enterprises and government.

5.2. The Influence of the Supervision Mode of Non-Governmental Environmental Protection Organizations on Enterprises and Local Governments

(1) The influence of direct supervision of environmental non-governmental organizations on the choice of enterprise strategy

Based on the above initial value setting, this paper makes x = 0.5. First of all, observe the impact of environmental non-government organizations on the financial support of enterprises to implement the technical behavior of the Internet of Things and give 7, 8, and 9 values, respectively. According to the evolution numerical simulation impact diagram of environmental non-governmental organizations giving financial support to enterprises (Figure 4. left), it can be found that the increase in financial support for the implementation of the Internet of Things technology strategy is also significantly increased. Moreover, its increasing speed is quite fast, which shows that the financial support of environmental non-governmental organizations is helpful for enterprises to implement the technology strategy of the Internet of Things. Secondly, while keeping the other values unchanged, E_2 takes three different values, 4, 5, and 6, respectively, to verify the impact of network exposure and reward and punishment mechanisms on the implementation of Internet of Things technology enterprises through the direct supervision of environmental non-governmental organizations. According to the simulation diagram of the evolution of punishment pressure of environmental non-governmental organizations (Figure 4. right), increasing the organization's deterrence pressure will also play a significant role in promoting the implementation of Internet of Things technology.

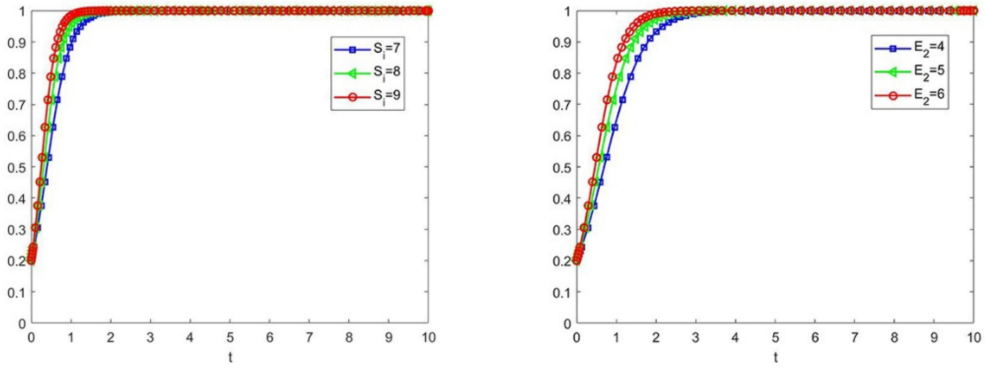

Figure 4. The trend of direct supervision of environmental protection organizations on the choice of corporate strategy.

(2) The influence of direct supervision of environmental non-governmental organizations on the strategic choice of local government

According to the above initial value setting, C_1 takes 6, 7, and 8 values, respectively, to verify whether the direct supervision of environmental non-governmental organizations can have an impact on the choice of local government strategy by changing the value of C_1. According to the numerical simulation chart of evolution and stability trend (Figure 5. left), when the cost saving brought by the direct supervision of environmental non-governmental organizations to the government is 6, the probability of the government choosing the leading strategy approaches 0, but with the increasing value of cost saving. When the value is 7 or 8, the choice of local government turns to the leading strategy sharply. Moreover, the probability of the government choosing the leading strategy is close to 1, which shows that the cost savings brought by the direct supervision of environmental non-governmental organizations can promote the local government to choose the leading strategy. At this time, to verify the impact of direct supervision by non-governmental organizations on the administrative accountability of government inaction, C_5 takes three values: 3, 4, and 5, respectively. According to the numerical simulation of the evolution and stability trend (Figure 5. right), it can be found that when the environmental governance cost to be borne by the local government is low, it also does not choose the dominant strategy because it does not pose a serious threat to the government. However, with the increase in governance costs, the governance pressure required by the government is gradually increasing when the government takes the initiative to change the undominant strategy into the dominant strategy. Therefore, the high-intensity direct supervision of environmental non-governmental organizations will urge the government to choose the dominant strategy.

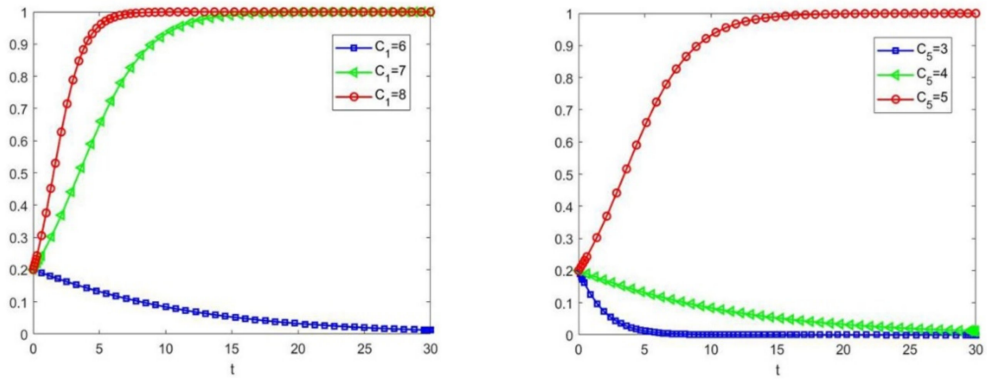

Figure 5. The trend of direct supervision of environmental protection organizations on the choice of government stratagem.

6. Conclusions and Recommendations

From the current study, we can conclude that: 1. The financial support and reward and punishment mechanisms given by environmental non-governmental organizations play a positive role in promoting the implementation of Internet of Things technology in enterprises; 2. The implementation of low-intensity direct supervision by environmental non-governmental organizations can promote enterprises to implement the technology strategy of the Internet of Things, and higher supervision is conducive to promoting the government to adopt the dominant strategy; 3. The high degree of cost-saving and administrative punishment caused by the implementation of direct supervision by environmental non-governmental organizations can vigorously promote the local government to adopt the dominant strategy.

The results of this study show that the participation of environmental non-governmental organizations plays a positive role in the classification and treatment system of urban information waste. At the front end of garbage classification and treatment, the publicity, education, and professional consultation of environmental non-governmental organizations guide residential individuals to participate in the Internet of Things technology garbage classification behavior in an organized manner to achieve individual power protection. At the middle end of garbage classification and treatment, environmental non-governmental organizations are responsible for monitoring the behavior of the government and garbage disposal enterprises, mainly through public opinion, public interest litigation, and other means to cause the media, the public, and consumers to attach great importance to the government and garbage disposal enterprises to perform their respective functions. For example, the Old Summer Palace Environmental Impact Assessment incident [64]. At the back end of garbage classification and treatment, environmental non-governmental organizations, as the middle layer of society, will establish trust, mutual benefit, and fair competition relationships with the main bodies of all parties to further coordinate the conflict of environmental interests [65]. Therefore, the participation of environmental non-governmental organizations in the classified treatment of information waste is sustainable [66].

In light of the above conclusions, the following proposals can be made:

(1) Implement the "one main pluralistic" collaboration model. When the government leads the enterprise to implement the technological behavior of the Internet of Things, as an environmental regulator, it should pay attention to the means of collaborative governance. It not only enables enterprises, environmental non-governmental organizations, and the government to give full play to their strong advantages but also solves the hidden problems existing in garbage disposal work.

(2) Environmental non-governmental organizations should implement a high-intensity direct supervision strategy. The organization can receive material and related subsidies from national governments through the provision of services, as well as financial support for enterprises implementing Internet of Things technology. In the context of high-intensity direct supervision by environmental non-governmental organizations, the organization can constantly check its strength to fill gaps, thereby better improving the professional ability of the organization. Moreover, the high-intensity supervision behavior of environmental non-governmental organizations is more beneficial to public publicity and promotion. At the same time, some inaction by the government and enterprises can also be punished through diversified channels to better promote the implementation of Internet of Things technology.

(3) Improve the technical level of "Internet of Things +" in enterprises. On the one hand, as the direct main body of garbage disposal, enterprises should actively update the relevant technology and improve the control system. With the support of government incentive mechanisms and environmental non-governmental organizations to encourage the promotion and implementation of garbage classification and collection systems based on Internet of Things technology, enterprises reduce the cost of implementing Internet of Things technology through a higher degree of resource

utilization efficiency. On the other hand, if enterprises give priority to upgrading the professional skills of their industries, it can not only open up the blue sea market to obtain huge potential users and benefit funds but also expand the market demand to create a good image of environmental protection for enterprises to gain a greater competitive advantage in the market.

Considering that the objectives proposed for this research have been achieved, some limitations in the research are recognized, such as the inclusion of a restricted range of variables. Therefore, in future research, we should increase the possible variables of the subject under study. For example, the number of environmental protection enterprises implementing Internet of Things garbage classification, the number of garbage classification areas implemented, the satisfaction of residential buildings with information waste classification equipment, and other variables.

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