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Research Article

Analysis of the Construction of an Enterprise Emergency Management System under Government Supervision: The View of Evolutionary Game Theory

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The establishment of an emergency management system has obvious complexity, and the establishment of an enterprise's emergency management system is influenced by external factors such as assessment agencies and regulatory departments as well as by the internal influence of various factors within the enterprise itself, such as profits and personnel quality. In order to study the impact of different factors on the construction of emergency management systems of enterprises under the current regulatory environment and under the existing reward-penalty mechanism, this study introduces factors such as rent-seeking behavior and economic level to build an evolutionary game model composed of enterprises, third-party safety assessment agencies, and government regulators. Based on the official statistics published in China and the field evidence of enterprises, third-party agencies, and emergency management departments in Nanjing, Jiangsu Province, China. The evolution path of the game system and the influence of the reward-penalty mechanism, rent-seeking behavior, and economic level on the strategy evolution process of the game model were analyzed by numerical simulation. The results show that there is a mechanism of mutual promotion in the strategy evolution of the game subjects, and the strategy choice of each subject shows the following characteristics: (1) reasonable subsidies and penalties play a positive role in promoting the construction of emergency management systems by enterprises. (2) Increasing the rent-seeking costs of enterprises and the reputational impact of regulators can promote the positive evolution of enterprises' and regulators' strategies. (3) Reducing the cost of the establishment can help enterprises establish emergency management systems, but it will reduce the probability of strict supervision by the regulators. Therefore, the government should develop a reasonable reward-penalty mechanism to replace fixed payments to enterprises and third-party agencies with tax reductions. In addition, local governments should establish an information and consultation mechanism and make the system construction and evaluation process public.

1. Introduction

The safe production of enterprises has always been related to people's lives and health, social and economic development, and national stability, and has always been one of the hot issues that has attracted much attention [1]. As an important way to improve the antirisk ability of enterprises and regions, the emergency management system has received more and more attention from the government and researchers [2]. The government has formulated a series of emergency-related plans, established relevant systems, mechanisms, and laws for emergency management, and formed an emergency management system that can be applied in relevant fields [3–5]. However, the frequent production safety accidents in recent years have exposed the low level of emergency management in enterprises, which cannot adapt to the requirements of emergency management in the new environment [6]. Therefore, it is an inevitable trend to improve the emergency management capability of enterprises to meet the current environmental emergency management requirements [7]. An enterprise emergency management system is a component of a national emergency management system that creates a framework for the procedures, responsibilities, and processes required to prevent accidents and reduce accident losses and casualties. Enterprises form an enterprise emergency management system by developing various emergency measures, stocking emergency materials, and improving the emergency capability of staff [8]. Improve the whole emergency response capability of society by connecting the enterprise emergency management system with the national emergency management system [9]. Although the construction cost of the emergency management system is large, it can reduce the probability of accidents and the loss from accidents [10]. In order to encourage enterprises to establish emergency management systems, regional governments have developed reward-penalty mechanisms to compensate for corporate profits [11, 12]. However, due to the different economic development of each region, there are differences in the expenditure costs of enterprises in the process of building emergency management systems, and government subsidy incentives are not enough to offset the construction costs [13]. In addition, because enterprise managers often lack emergency-related expertise, it is difficult to establish a perfect emergency management system simply by relying on the enterprise itself [14]. In order to improve this situation, the government has introduced a third-party safety assessment agency to participate in emergency management work. On the one hand, third-party agencies can provide technical support related to emergency management for enterprises [15]. On the other hand, third-party safety assessment agencies provide emergency management assessment services for governments and enterprises, which can complement government regulation and eliminate the “trust crisis” of society in government supervision [16]. Therefore, in the new regulatory environment, local governments need to adjust regulatory policies in time to respond to the behavior strategies of enterprises and third-party agencies.

The rent-seeking theory was introduced to China by Wu [17] in 1988 for the study of rent-seeking and corruption. Rent-seeking is an unproductive activity carried out by departments or individuals with common power, which they use to promote their own interests [18, 19]. As for-profit organizations, third-party agencies are bound to accept rent-seeking situations from enterprises for the sake of their own interests [20]. The rent-seeking phenomenon in the process of establishing the emergency management system of enterprises is mostly manifested as a corruption phenomenon caused by interpersonal relationships or money. The existence of rent-seeking makes regulation a mere formality [21]. Espinosa et al. [22] found that unreasonable policies encouraged the rent-seeking behavior of enterprises. Zhu and Zhang [23] analyzed the impact of rent-seeking behavior on the regulatory system and found that the long-term existence of rent-seeking behavior would hinder the improvement of the regulatory system. Jiang et al. [24] found that subjects who accepted rent-seeking would conceal the actual state of the enterprise or ignore the existence of hidden dangers, which declined the level of security of the enterprise. Feng et al. [25] found that rent-seeking behavior could increase the number of corporate accidents while weakening the effectiveness of the regulatory system by analyzing corporate survey data. With limited government regulation, enterprises seek rent from third-party safety assessment agencies to pass emergency management assessments [26]. Driven by interests, third-party agencies are bound to have the possibility of accepting rent-seeking [27]. Rent-seeking behavior leads to low levels of enterprise emergency management and increases the likelihood of accidents [28]. Therefore, the opportunity to profit from the low level of enterprise emergency management still exists at this stage [29]. Moreover, if an enterprise notices that other enterprises are gaining excess revenue through rent-seeking, it will imitate the mentality and implement imitation [30]. This will reduce the overall emergency management level of the industry, and will weaken the degree of connection between enterprises and the government emergency management system, and ultimately reduce the national emergency response capability. Therefore, it is necessary to take the rent-seeking behavior of enterprises into consideration and conduct an in-depth study.

With the arrival of the big data era, new elements such as big data analysis, big data decision-making, and big data management have been injected into emergency management, giving full play to the unique advantages of big data [31]. In terms of theory, the current research mainly focuses on the problems and countermeasures faced by emergency management in the age of big data. Bu [32] analyzed the application of big data in emergency management and pointed out that it was necessary to define the application strategies of big data in different emergency management stages, which ensured that the application value of big data could be fully exerted. Yang et al. [33] analyzed the development status of big data and emergency management and found that the application of big data had a significant impact on the emergency management system framework and emergency management efficiency. In terms of technology, Pérez-González et al. [34] built a data analysis platform to integrate data from different cities and provide data support for decision-making in emergency management. On the basis of big data analysis, Zhang et al. [35] used artificial intelligence technology to assist emergency management, improving risk prediction and emergency response capabilities. In order to realize the emergency management technology driven by data intelligence, it was necessary to analyze a large amount of data to obtain effective data. Therefore, it is necessary to improve the infrastructure of the emergency management system in order to obtain a large amount of data [36]. At present, the construction of the national emergency management system has achieved initial results, and how to improve enterprises’ emergency management systems needs further analysis.

Game theory is a mathematical programming method to describe the process in which participants choose the optimal solution to the strategy in the game process. In recent years, many scholars have proposed many game methods in the field of game theory. Romanuke [37] outlined a theory of refining pure strategy efficient Nash equilibria in finite noncooperative games under uncertainty. The theory is based on guaranteeing the corresponding payoffs for the participants by using maximultimin, which is an expanded version of maximin. Romanuke [38] suggested a tractable method of solving noncooperative 2-person games in which strategies are staircase functions. The solution is meant to be Pareto-efficient. Giri and Dey [39] established two game models of different recovery methods for supply chain recovery, developed three-game theory methods, and analyzed the optimal pricing decisions and corresponding profits of each participant. Evolutionary game is a new research method based on traditional game theory [40]. Unlike traditional game theory, evolutionary games assume that human rationality is limited and that complete information conditions are unnecessary [41]. Currently, evolutionary game theory has good applications in many fields such as economics, computer science, and management. Long et al. [42] and Zheng et al. [43] analyzed the supply chain decision-making model of construction and demolition waste (CDW) under different backgrounds using evolutionary game theory, providing a reference for the government to formulate a regulatory plan. Jamali et al. [44] used the evolutionary game model to analyze the pricing decision-making process of the Iranian manufacturing industry and found that, with the support of the government, enterprises will change their strategies in a shorter time. Colivicchi and Iannucci [45] found that insurance may play an active role in improving pollution by building a game model between insurance companies and pollution enterprises. These studies provide a reference for the application of evolutionary game theory in emergency management. Many researchers have applied evolutionary game theory to the field of emergency management [46, 47]. The government hopes that enterprises can improve their own emergency response capabilities to reduce the occurrence of accidents, but enterprises usually ignore the construction of emergency management systems because improving emergency response capabilities will raise their operating costs and increase their burden. Therefore, regulators need to provide subsidies as a means for enterprises to increase their profits. However, subsidies can increase the expenses of the regulator and make the regulator hesitate in formulating the incentive system [48]. On the basis of this research, Xu et al. [49] added a third-party agency to the game model and studied the impact of regulatory policies on the decision-making behavior of game players. Chen et al. [50] considered the impact of rent-seeking behavior on the strategic selection of all parties and proposed a series of measures to control rent-seeking behavior. These studies show that evolutionary game theory is an effective method for studying how to adjust policies when there are conflicts of interest among multiple subjects.

In summary, in the current environment, enterprises' construction of emergency management systems is not only affected by their own knowledge level and expenditure costs but is also affected by third-party agencies and the behavior of government regulators. For the sake of their own interests, game participants will make behaviors in line with their own interests under the premise of limited rationality. This choice of behavior is consistent with evolutionary game theory. Therefore, the evolutionary game model can accurately simulate the behavioral choices of game participants. The research on evolutionary game theory in the field of emergency management has made positive contributions to improving the level of emergency management. Limited by the selection of parameters and the development level of emergency management, there are still the following shortcomings: (1) There is a lack of study of the overall strategy evolution process of game participants by analyzing the single decision process of game participants because it is focused on the influence of a single factor on the subject's decision choice. However, in the process of repeated games, enterprises, third-party agencies, and governments will continuously adjust their own strategies according to the changes in each other's strategies and finally reach dynamic equilibrium [51]. (2) Although the existing research has introduced more parameters into the model, the parameters introduced in the model are not comprehensive, and there are still deficiencies in the current environment. As a component of the national emergency management system, the enterprise emergency management system determines the level of the national emergency response capability. By improving the enterprise emergency management system, the collection of big data on emergency management can be improved, and the development of emergency management digitalization and the application of intelligent technology can be promoted. In recent years, the government has formulated many policies to improve the emergency management system. The implementation of these policies means that the factors affecting the strategic choices of enterprises and third-party agencies have also increased correspondingly. More critically, existing studies have ignored the impact of regional economic differences on the construction of emergency management systems, which makes the cost of enterprises constructing emergency management systems different. These parameters will affect the decision-making choices of game participants. Then, how do the construction cost and rent-seeking cost of the system affect the decision-making behavior of enterprises? What is the dynamic evolution of the decision-making choices of the game participants? In the new regulatory environment, how can we improve the enthusiasm of an enterprises toward establishing emergency management system?

The purpose of this study is to analyze the effects of rent-seeking behavior, system construction costs, and government reward-penalty mechanisms on the construction of an enterprise's emergency management system and to reveal the optimal strategies of game participants in different situations. Find the best way to improve the enthusiasm for enterprise emergency management system construction under existing regulatory policies, improve the current situation of enterprise emergency management, and improve the regional emergency management level. To the best of the authors' knowledge, this study introduces the system construction coefficient into the research of emergency management for the first time. By adjusting the construction coefficient, we can analyze the dynamic evolution process of the strategy selection of game participants in different regions under the current regulatory mode, which improves the availability of the model. On the one hand, this study establishes an evolutionary game model in line with the current situation of emergency management system construction, which makes up for the shortcomings of existing models and improves the accuracy of simulation results. On the other hand, this paper provides a decision basis for the construction cost and rent-seeking behavior in different conditions of strategy selection. It also provides a reference for the government to develop a reasonable reward-penalty and supervision mechanism, which is conducive to the improvement of regional emergency management.

This paper is organized as follows: Section 2 establishes the evolutionary game model of enterprises, third-party agencies, and regulators. Section 3 analyzes the strategy stability of each game subject. Section 4 carries out a numerical simulation and analyzes the influence of various parameters on the evolution process of each party's strategy selection. Section 5 discusses the simulation results. Section 6 summarizes the conclusions and limitations of this paper.

2. Model Assumptions and Construction

Evolutionary game theory breaks through the completely rational assumption of traditional game theory, and participants are also transformed into groups with specific commonalities. On the basis of theoretical analysis, it studies the stable equilibrium strategy formed by the continuous evolution of behaviors, such as imitation and learning among groups. At this time, if the external conditions or the internal cognition of the participants change, the game group will adjust the group behavior according to these changes to achieve a new stable equilibrium. Different from traditional game theory, evolutionary game theory pays more attention to the strategy selection process of game participants than to exploring how to obtain the optimal strategy. Therefore, evolutionary game theory is more appropriate for studying the development and choice of things in the real world. Evolutionary game theory is of great significance to interdisciplinary research. In this paper, enterprises, third-party agencies, and regulators are regarded as game participants to study their behavior choices and stability strategies under their own income judgments and regulatory environments.

2.1. Problem Description. In the current process of national emergency management system construction, government regulatory authorities in different regions establish emergency management systems according to regional conditions and guide local enterprises to effectively interface with government emergency management systems. At the same time, the government encourages profit-making third-party safety assessment agencies to act as external supervisory forces to provide emergency management system consulting and assessment work for enterprises.

In the construction of the enterprise emergency management system, the third-party safety assessment agency, according to the enterprise's own situation and in combination with the establishment requirements of the emergency management system of the local government, helps the enterprise establish and improve the emergency management system, perfectly connects with the government regulatory department, and organizes experts to evaluate the establishment of the enterprise emergency management system. By analyzing the current situation of emergency management in various regions and the relevant information disclosed by the government, it is concluded that the regulatory authorities in different regions have developed reward-penalty mechanisms that can be used to supervise the performance of enterprises and third-party agencies in emergency management. At the same time, the government has proposed a "blacklist" system and a whistleblowing system for production safety, made the process of building emergency management systems for enterprises and third parties open, and strengthened the supervision of public opinion in the emergency management system. To a certain extent, the implementation of these systems has influenced the decision-making choices of enterprises in establishing emergency management systems.

For the regulators, it is difficult to supervise enterprises and third-party agencies in all aspects, and the regulatory cost is high, resulting in deregulation. For enterprises, the increased workload and capital investment required to establish an emergency management system will reduce the enthusiasm for system construction. But considering the regulatory factors of the supervisory department, enterprises will make rent-seeking from third-party agencies. For third-party agencies, the stronger the enterprises' willingness to rent-seeking, the higher the cost of rent-seeking, and the higher the feasibility of their accepting rent-seeking. Therefore, there is an obvious game relationship among the enthusiasm of enterprises to establish the system, the rent-seeking choice of the third-party agencies, and the supervision strength of the supervisory department.

In summary, in the current supervision environment, in addition to the reward-penalty mechanism, the government has also formulated the "blacklist" system and a whistleblowing system in the field of production safety. The existence of the reward-penalty mechanism means that the enterprises and the third-party agencies face rewards and punishments. The blacklist system and the whistle-blowing system in the field of production safety mean that social public opinion supervision has been introduced in the field of emergency management, which also indicates that the government regulatory department has the impact of reputation loss.

2.2. Basic Assumptions and Parameter Settings. According to the previous description, this research constructs a dynamic game model of enterprises, third-party safety assessment agencies, and government regulatory departments, as shown in Figure 1. Under the current environment, according to the actual situation of the enterprise emergency management system construction, the following assumptions are made. The definition of each parameter in the model is shown in Table 1.

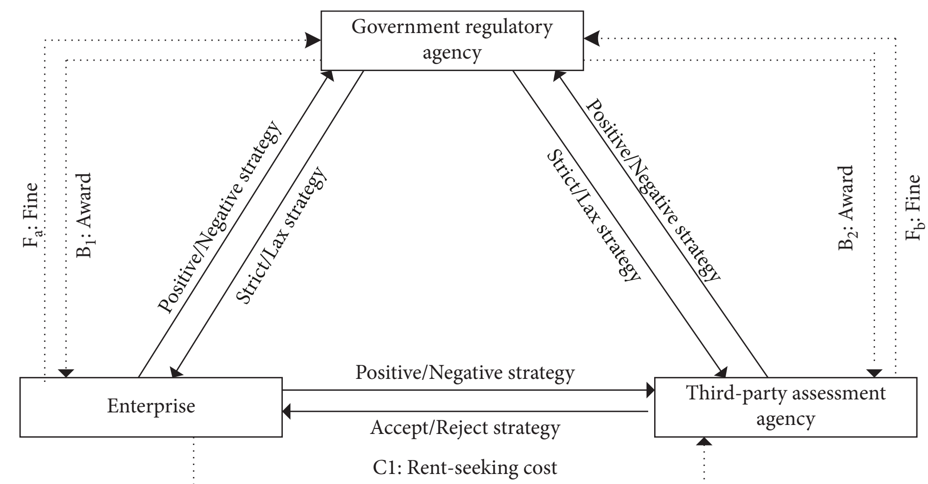

Figure 1: Tri-party evolutionary game relationship.

Table 1: Definition of parameters.

Parameter	Definition
C_0	The costs for enterprises to passively set up emergency management systems.
θ	The establishment effect coefficient of the emergency management system.
C_1	Rent-seeking costs for enterprises.
C_2	Speculative costs for enterprises.
C_3	Speculative costs of third-party safety assessment agencies.
C_4	The cost of strict supervision by government regulators.
C_5	Cost of governance spent by government regulators.
R	Benefits of the enterprise after passing the emergency management assessment.
P	Assessment benefits of third-party safety assessment agencies.
B_1	Government subsidies to enterprises that pass emergency management assessments.
B_2	Government subsidies to third-party safety assessment agencies.
F_a	Fines paid by enterprises.
F_b	Fines paid by third-party safety assessment agencies.
M	Social benefits obtained by government regulatory departments.
N	Reputational loss is incurred by government regulatory departments when they choose a lax supervision strategy.

Assumption 1. Enterprises, third-party safety assessment agencies, and government regulatory departments all participate in the game. The three parties are all participants with bounded rationality, and their strategic choices gradually evolve over time to stabilize and optimize strategies.

Assumption 2. The strategic choice space of enterprises is $S_1 =$ (active, passive), the strategic choice space of third-party safety assessment agencies is $S_2 =$ (accept rent-seeking, reject rent-seeking), and the strategic choice space of government regulatory departments is $S_3 =$ (strict supervision, lax supervision). The probability that the enterprise chooses the strategy of actively establishing the emergency management system is X, the probability that the third-party safety assessment agency chooses to reject the rent-seeking strategy is Y, and the probability that the government regulatory department chooses the strict supervision strategy is Z.

Assumption 3. After the enterprise has passed the emergency management assessment, the income obtained by continuing production is R. When the enterprise passively establishes the emergency management system, it will lower the standard and reduce the construction cost. We set the cost of enterprises passively constructing emergency management systems as C_0. Considering the variability of economies and technologies in different regions, the costs noted by companies in different regions to improve their emergency management will vary. Therefore, the establishment coefficient θ is introduced in this study, and the higher the coefficient, the higher the construction cost of enterprises in the region under the same conditions. The cost of an enterprise's active construction of an emergency management system is $(1 + \theta)C_0$, $(0 < \theta \leq 1)$, that is, θC_0 represents the cost difference between an enterprise's active and passive establishment of an emergency management system. If an enterprise constructs an emergency management system passively, to pass the assessment, it will seek rent from a third-party safety assessment agency. The rent-seeking cost is C_1 $(C_1 < \theta C_0)$. Rent-seeking costs mainly include the enterprise's speculative cost (C_2) and the cost of bribing third-party agencies. The cost of speculation mainly includes the cost of falsifying various emergency management files and records.

Assumption 4. The company must be evaluated by a third-party safety assessment agency. After the evaluation is qualified, the company can continue production. The third-party agency charges the enterprise a certain appraisal fee as the revenue of the third-party agency, set as P. When an enterprise passively establishes an emergency management system, if the third-party safety assessment agency refuses to seek rent, the assessment is unqualified. If the third-party agency intends to seek rent, it will engage in rent-seeking behavior with the enterprise to help it pass the emergency management assessment. At this point, the third-party agency needs to help the enterprise falsify records and issue false evaluation reports, which requires a certain cost. These costs are the speculative costs of the third-party agency, set as C_3.

Assumption 5. The cost of strict supervision by the government regulatory department is C_4, it is mainly used to hire experts in the field of emergency management who can check the current status of emergency management of enterprises. When the government chooses a strict supervision strategy, enterprises that passively establish an emergency management system will be fined F_a, and third-party safety assessment agencies that intend to rent-seek will be fined F_b. If the enterprise passes the emergency management status assessment, the government regulatory department will give the enterprise and the third-party safety assessment agency certain subsidies, set as B_1, B_2.

Assumption 6. Enterprises actively establishing emergency management systems are conducive to economic development and social stability and reduce government spending on accident disposal and rescue. It will bring social benefits M to the government. When enterprises passively establish emergency management systems and enter into rent-seeking agreements with third-party agencies, they reduce social emergency response capabilities and lead to frequent accidents, which will increase the cost of social governance. The government will spend C_5 to rectify the status quo of the enterprise's emergency management. When the government regulatory department adopts a lax supervision strategy, it will lead to a lack of supervision and the public will lose trust in the government, which will cause reputational damage to the government regulatory department, which is quantified as N.

2.3. Model Construction. Based on the abovementioned assumptions, combined with evolutionary game theory, the decision tree of the three-party behavioral evolutionary game system can be obtained according to the interactive impact of the three actors and their corresponding interests, as shown in Figure 2. The decision tree can be obtained from the mixed strategy gain matrix of the three-party behavioral evolutionary system, as shown in Table 2. The order of the three gain and loss expressions in the table corresponds to the enterprise, the third-party safety assessment agency, and the government regulatory department, in turn.

3. Model Analysis

3.1. Strategic Stability Analysis of the Enterprises. According to the game system strategy decision tree and the benefit matrix, the expected benefit E_{a1} for an enterprise to choose an active strategy, the expected benefit E_{a2} for passively building an emergency management system, and the average expected benefit $\overline{E_a}$ can be obtained, respectively,

$$\begin{cases} E_{a1} = yz[R + B_1 - (1+\theta)C_0] + (1-y)z[R + B_1 - (1+\theta)C_0] \\ +y(1-z)[R - (1+\theta)C_0 + (1-y)(1-z)[R - (1+\theta)C_0], \\ E_{a2} = yz(-C_0 - C_1 - F_a) + (1-y)z(R - C_0 - C_1 - C_2 - F_a) \\ +y(1-z)(-C_0 - C_2) + (1-y)(1-z)(R - C_0 - C_1 - C_2), \\ \overline{E_a} = xE_{a1} + (1-x)E_{a2}. \end{cases} \quad (1)$$

The replication dynamic equation for the enterprise's strategy choice is

$$F(x) = x(1-x)[C_1 + C_2 - \theta C_0 - y(C_1 - R) + z(B_1 + F_a)]. \quad (2)$$

The strategy evolution phase diagram of the enterprise is shown in Figure 3. The area of A_1 in the figure indicates the probability that the enterprise chooses an active strategy, and the area of A_2 indicates the probability that the enterprise chooses a passive strategy.

According to the enterprise strategy evolution phase diagram, when y is less than y_0, it means that the probability that the third-party safety assessment agency has moved toward rent-seeking is higher. Compared with actively establishing an emergency management system, adopting rent-seeking and speculation to pass the emergency management present situation assessment can cost less; therefore, enterprises will be inclined to choose the passive strategy. When y is greater than y_0, it indicates that the probability that the third-party safety assessment agency chooses to reject rent-seeking is higher. At this point, rent-seeking behavior cannot help enterprises pass the emergency management present situation assessment. Enterprises will choose the active strategy to avoid being punished by government regulatory departments and reduce their own losses.

Similarly, when Z is greater than Z_0, government regulatory departments have a higher probability of choosing a strict supervision strategy, and vice versa, government regulatory departments tend to choose a lax regulation strategy. When government regulator departments choose a strict supervision strategy, influenced by factors such as fines, rent-seeking costs, and speculation costs, enterprises realize that the only way to pass government regulation and avoid fines is to actively establish an emergency management system and improve the level of emergency management of enterprises. On the other hand, when government regulatory departments loosely regulate, the probability of enterprises choosing an active strategy tends to be 0 at this time because of incomplete access to information and the inability to determine the status of enterprises' emergency management.

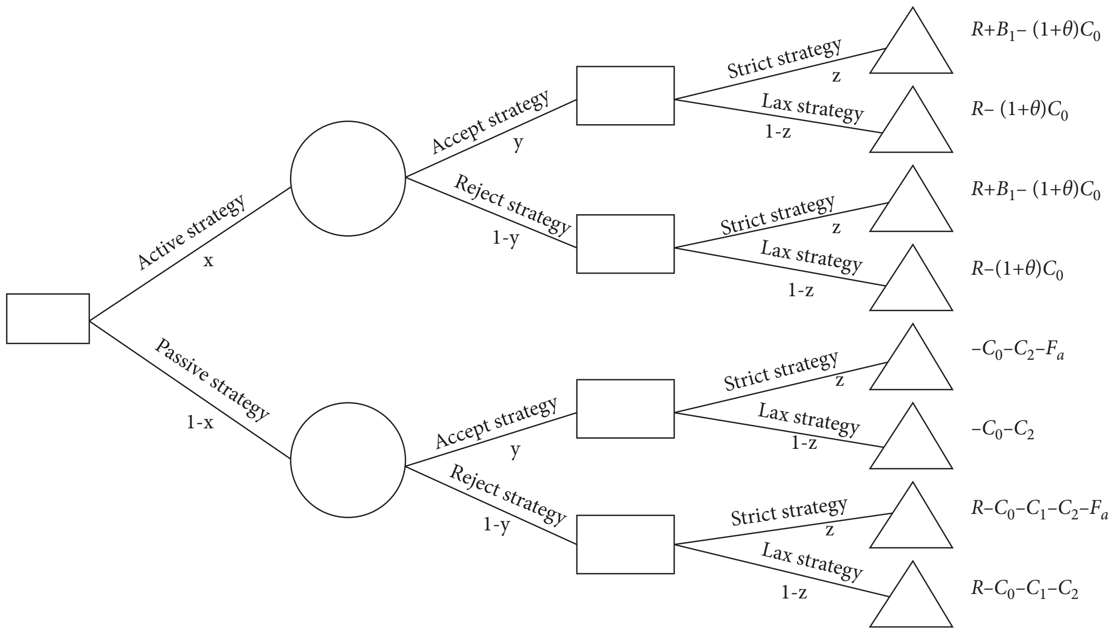

Figure 2: Decision tree for gaming system strategy.

Table 2: Mixed strategy game matrix of enterprises, third-party safety assessment agencies, and government regulatory departments.

		Third-party safety assessment agencies	Government regulatory department	
			Strict supervision z	Lax supervision $1-z$
Enterprises	Active x	Reject y	$R+B_1-(1+\theta)C_0$, $P+B_2$, $M-B_1-B_2-C_4$	$R-(1+\theta)C_0$, P, M
		Accept $1-y$	$R+B_1-(1+\theta)C_0$, $P-C_3-F_b$, $M+F_b-B_1-C_4$	$R-(1+\theta)C_0$, $P-C_3$, M
	Passive $1-x$	Reject y	$-C_0-C_2-F_a$, $P+B_2$, $F_a-B_2-C_4$	$-C_0-C_2$, P, 0
		Accept $1-y$	$R-C_0-C_1-C_2-F_a$, $P-C_3+C_1-F_b$, $F_a+F_b-C_4-C_5$	$R-C_0-C_1-C_2$, $P+C_1-C_3$, $-C_5-N$

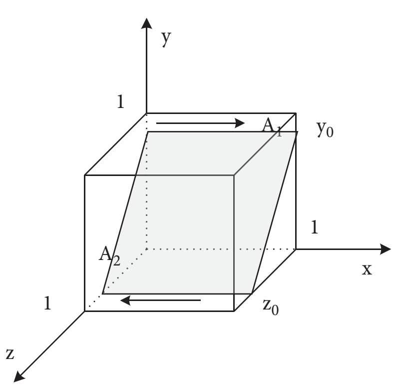

Figure 3: Phase diagram of the evolution of enterprise strategy selection.

3.2. Strategic Stability Analysis of the Third-Party Assessment Agencies. According to the game system strategy decision tree and income matrix, the expected income E_{b1} of the third-party safety assessment agency's rejection of rent-seeking, the expected income E_{b2} of accepting rent-seeking, and the average expected return $\overline{E_b}$ are

$$\begin{cases} E_{b1} = xz(P+B_2) + (1-x)z(P+B_2) \\ \quad +x(1-z)P + (1-x)(1-z)P, \\ E_{b2} = xz(P-C_3-F_b) + (1-x)z(P-C_3+C_1-F_b) \\ \quad +x(1-z)(p-C_3) + (1-x)(1-z)(P+C_1-C_3), \\ \overline{E_b} = yE_{b1} + (1-y)E_{b2}. \end{cases} \tag{3}$$

The replicated dynamic equations for the strategy selection of the third-party safety assessment agency are

$$F(y) = y(1-y)\left[C_3 + (x-1)C_1 + z(B_2+F_b)\right]. \tag{4}$$

The strategy evolution phase diagram of the third-party safety assessment agency is shown in Figure 4. The area of B_1 in the figure indicates the probability that the third-party safety assessment agency chooses to reject the rent-seeking strategy, and the area of B_2 indicates the probability that the third-party safety assessment agency chooses to accept the rent-seeking strategy.

According to Figure 4, the probability that a third-party safety assessment agency chooses to reject rent-seeking is higher when Z is greater than Z_0. Similarly, when z is less than Z_0, the probability that a third-party safety assessment

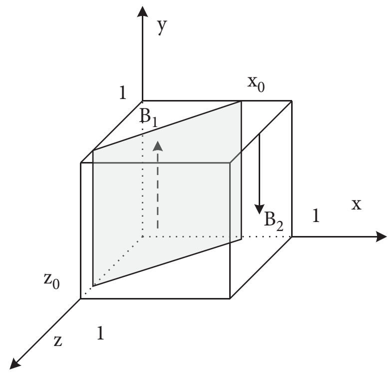

FIGURE 4: Phase diagram of the evolution of the strategy of the third-party safety assessment agency.

agency chooses to reject rent-seeking is lower. This indicates that when the probability of government regulatory departments adopting a strict supervision strategy is higher than the critical value Z_0, the third-party safety assessment agency stabilizes on a rent-seeking rejection strategy as the evolution of the system continues. At this point, the third-party safety assessment agency avoids government fines and receives a reward. If the probability of government regulatory departments adopting a strict supervision strategy tends to 0, the third-party safety assessment agency's rent-seeking rejection strategy also tends to 0, indicating that the reward-penalty mechanism alone cannot effectively restrain the third-party safety assessment agency from accepting corporate rent-seeking behavior.

For enterprises, when the probability of choosing an active strategy is greater than x_0, the third-party safety assessment agency cannot profit from accepting rent-seeking from enterprises, and there is also the risk of being discovered by government regulatory departments. To avoid being punished by government regulatory departments, the probability that the third-party safety assessment agency chooses to reject the rent-seeking strategy increases. At this point, the third-party safety assessment agency is also able to obtain incentives from the government regulator. Conversely, when the enterprise's activity to establish an emergency management system is low, the enterprise's willingness to seek rent is strong, the reward-penalty mechanism is less binding for the third-party safety assessment agency, and the probability of accepting rent-seeking increases.

Therefore, increasing the probability of rejecting rent-seeking by third-party safety assessment agencies can improve the probability of enterprises improving their emergency management and the probability of strict supervision strategies by government regulation.

3.3. Strategic Stability Analysis of the Government Regulator's. According to Figure 2 and Table 2, the expected return E_{c1} for strict supervision by government regulatory departments, the expected return E_{c2} for lax supervision, and the average expected return $\overline{E_c}$ can be obtained as follows:

$$
\begin{cases}
E_{c1} = xy\left(M - C_4 - B_1 - B_2\right) + (1-x)y\left(F_a - C_4 - B_2\right), \\
+x(1-y)\left(M - C_4 - B_1 + F_b\right) + (1-x)(1-y)\left(F_b + F_a - C_4 - C_5\right), \\
E_{c2} = xyM + x(1-y)M + (1-x)(1-y)\left(-C_5 - N\right), \\
\overline{E_c} = zE_{c1} + (1-z)E_{c2}.
\end{cases}
\tag{5}
$$

The replicated dynamic equations for the government regulatory departments strategy choice are

$$
F(z) = z(1-z)\left[-C_4 + F_a + F_b + N - x\left(B_1 + N + F_a\right) - y\left(B_2 + F_b + N\right) + xyN\right]. \tag{6}
$$

Therefore, we can obtain a phase diagram of the evolution of the government regulatory department's strategy, as shown in Figure 5. The area of C_1 in the figure indicates the probability of government regulatory departments choosing strict supervision, and the area of C_2 indicates the probability of government regulatory departments choosing lax supervision.

As seen from Figure 5, when the probability of enterprises choosing active strategies is higher than x_0, the C_2 region shrinks, at which time the probability of government regulatory departments choosing strict supervision decreases, and conversely, government regulatory departments will tend to choose the strategy of strict supervision. When enterprises choose a passive strategy, it will cause adverse social impacts and reduce the social benefits of government regulatory departments. Government regulatory departments face increased governance costs, residual losses, and reduced social benefits, making it more difficult for the government to govern. The increased difficulty of governance will increase the cost of governance, which will further reduce the willingness of government regulatory departments to regulate, so the probability of government regulatory departments choosing strict supervision will be reduced to some extent. However, due to the reduction of

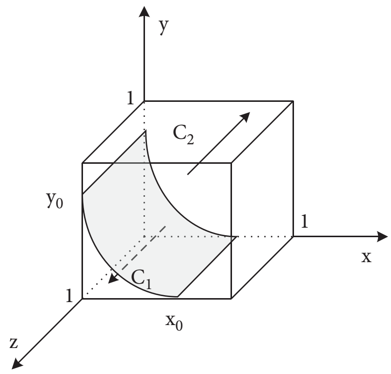

Figure 5: Phase diagram of the evolution of government regulatory departments' strategies.

regulation, public trust in the government decreases, and the probability of strict supervision by the government regulatory departments will gradually increase under the influence of residual loss.

From the perspective of the third-party safety assessment agency, when the probability of the third-party safety assessment agency choosing to reject rent-seeking is higher than the critical value y_0, it is difficult for enterprises to pass the assessment of the current state of emergency management through rent-seeking, and they will actively establish the emergency management system to avoid being punished by the government. At this time, government regulatory departments can reduce the expenditure of supervision costs and gain more benefits by the lax supervision. When the probability that the third-party safety assessment agency chooses to reject rent-seeking is lower than the critical value y_0, it means that the third-party safety assessment agency has a higher probability of accepting rent-seeking from the enterprise, and the enterprise will seek rent from the third-party safety assessment agency to pass the emergency management status assessment and reduce the cost of expenditure. At this point, government regulatory departments face a decrease in social benefits and an increase in governance costs and reputation loss, forcing government regulatory departments to shift to a strict supervision strategy. When government regulatory departments shift to a strict supervision strategy, enterprises will actively establish emergency management systems, and third-party safety assessment agencies will choose to reject the rent-seeking strategy.

4. Model Simulation Analysis

Numerical simulation analysis is used to visualize the evolution of the strategy choices of enterprises, third-party safety assessment agencies, and government regulatory departments in the game model and to analyze the trajectory of the influence of changes in various parameters on the strategy choices of each party. Based on the official statistics published in China and the field evidence of enterprises, third-party safety assessment agencies, and emergency management departments in Nanjing, Jiangsu Province, China, the parameters in the game model are set. Assume that $R = 150$, $\theta = 0.85$, $C_0 = 100$, $C_1 = 40$, $C_2 = 10$, $C_3 = 10$, $C_4 = 15$, $F_a = 40$, $F_b = 20$, $B_1 = 20$, $B_2 = 15$, $N = 40$ and set the initial policy value to (0.2, 0.2, 0.2), and analyze the impact of $C_1, F_a, F_b, B_1, B_2, N, \theta$ on the process and outcome of the evolutionary game.

4.1. The Effect of C_1 on the Evolution of the System.

First, to analyze the effect of C_1 changes on the evolutionary game process and results, C_1 is assigned values of 30, 40, 50, 60, and 70, and the simulation results of replicating the system of dynamic equations evolving 100 times over time are shown in Figure 6.

Figure 6 shows the evolution of the game model under different rent-seeking costs. As seen in Figure 6, the game system is stable at (1, 1, 0) after evolution, indicating that the stable strategy combination formed by the system after evolution is an active establishment, rent-seeking rejection, and lax supervision. When $C_1 = 30$ and 40, the strategy choices of the enterprises have a tendency to converge toward 0. As C_1 increases, the enterprises converge toward 1, and the convergence trend increases. The strategy choice of third-party safety assessment agencies is exactly the opposite. This indicates that when the speculative cost is small, after measuring the benefits, enterprises tend to pass the emergency management status assessment by rent-seeking from third-party safety assessment agencies, but as the rent-seeking cost increases, enterprises gradually tend to choose the strategy of actively establishing the emergency management system. For third-party safety assessment agencies, the impact of rent-seeking costs on third-party safety assessment agencies is opposite to that of enterprises. When rent-seeking costs are high, the probability of third-party safety assessment agencies choosing to reject rent-seeking first shows a decreasing trend and then rapidly increases, and when rent-seeking costs are low, third-party safety assessment agencies have no tendency to wait and see when making strategy choices and rapidly converge to 1. From the perspective of government regulatory departments, regardless of the changes in C_1 values, the strategy choice of government regulatory departments first converges to 1, and after reaching the interval of 0.8–0.9, it converges to 0, and finally evolves to a lenient regulatory strategy.

In general, enterprises and third-party safety assessment agencies are more affected by the change in C_1 values, and the strategy choice of government regulatory departments is less affected by the change in C_1 values. Enterprises and third-party safety assessment agencies show a tendency to converge to 0 at smaller and larger values of C_1, respectively, but as the tendency of regulators to converge to 1 grows, both shift their strategy choices and begin to converge to 1. When the probability of enterprises and third-party safety assessment agencies choosing active establishments and rejecting rent-seeking strategies is higher, government regulatory departments begin to converge toward 0 and evolve into a strategy of lenient regulation.

Therefore, the government can increase the rent-seeking cost of enterprises to enhance the probability of enterprises choosing to actively build emergency management systems

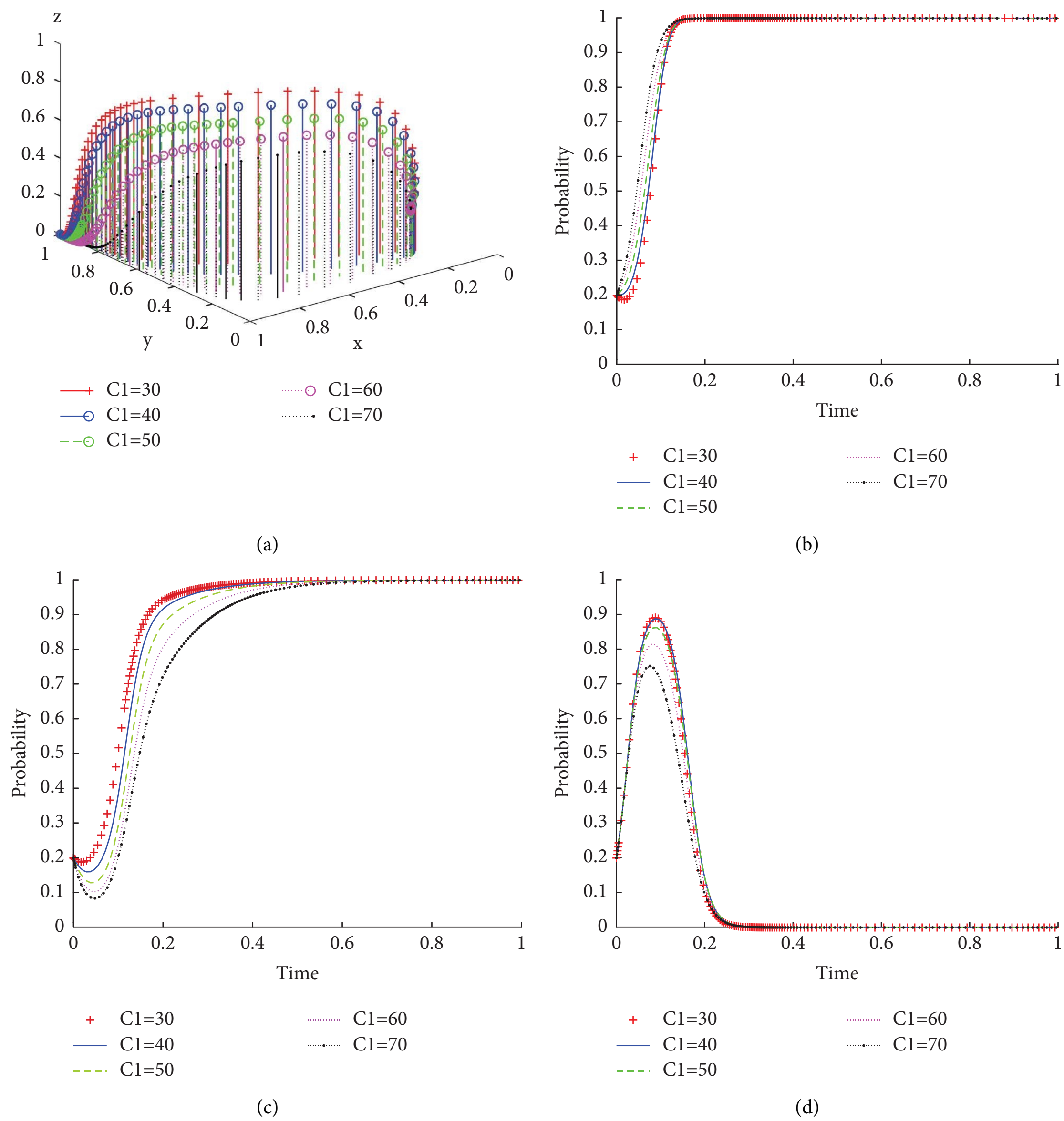

Figure 6: Diagram of system evolution under different C_1 influences: (a) C_1 influence on system evolution; (b) C_1 influence on enterprises; (c) C_1 influence on third-party safety assessment agencies; (d) C_1 influence on government regulatory departments.

by increasing the media's disclosure capability, expanding the influence of enterprises' reputations, and cultivating the public's awareness of emergency response.

4.2. The Effect of F_a on the Evolution of the System.

The effect of the change in F_a on the evolutionary process of the system is shown in Figure 7.

Figure 7 represents the evolution of the game system when F_a is set to 20, 30, 40, 50, and 60. At this point, there is a stable combination of strategy for the game system (active, rejecting rent-seeking, and lax supervision). From the enterprise's perspective, as the value of F_a increases, the enterprise converges to 1 faster, indicating that the enterprise chooses the strategy of actively establishing the emergency management system in a shorter period of time. At this point, the increase in the number of fines forms a sufficient deterrent for enterprises to avoid fines if they actively establish an emergency management system. From the perspective of the third-party safety assessment agencies, when F_a is low, the third-party safety assessment agencies converge to 0 at the beginning of the system evolution, then start to converge rapidly to 1, and start to slow down the convergence trend when it is about to converge to 1. As F_a increases, the rate of convergence of the third-party safety assessment agencies to 1 begins to increase. From the perspective of government regulatory departments, at the early stage of system evolution, the rate of convergence to 1 gradually increases with the increase of F_a and starts to converge to 0 gradually after reaching the maximum probability. At the same time, the increase in F_a makes the extreme value of the probability that the government

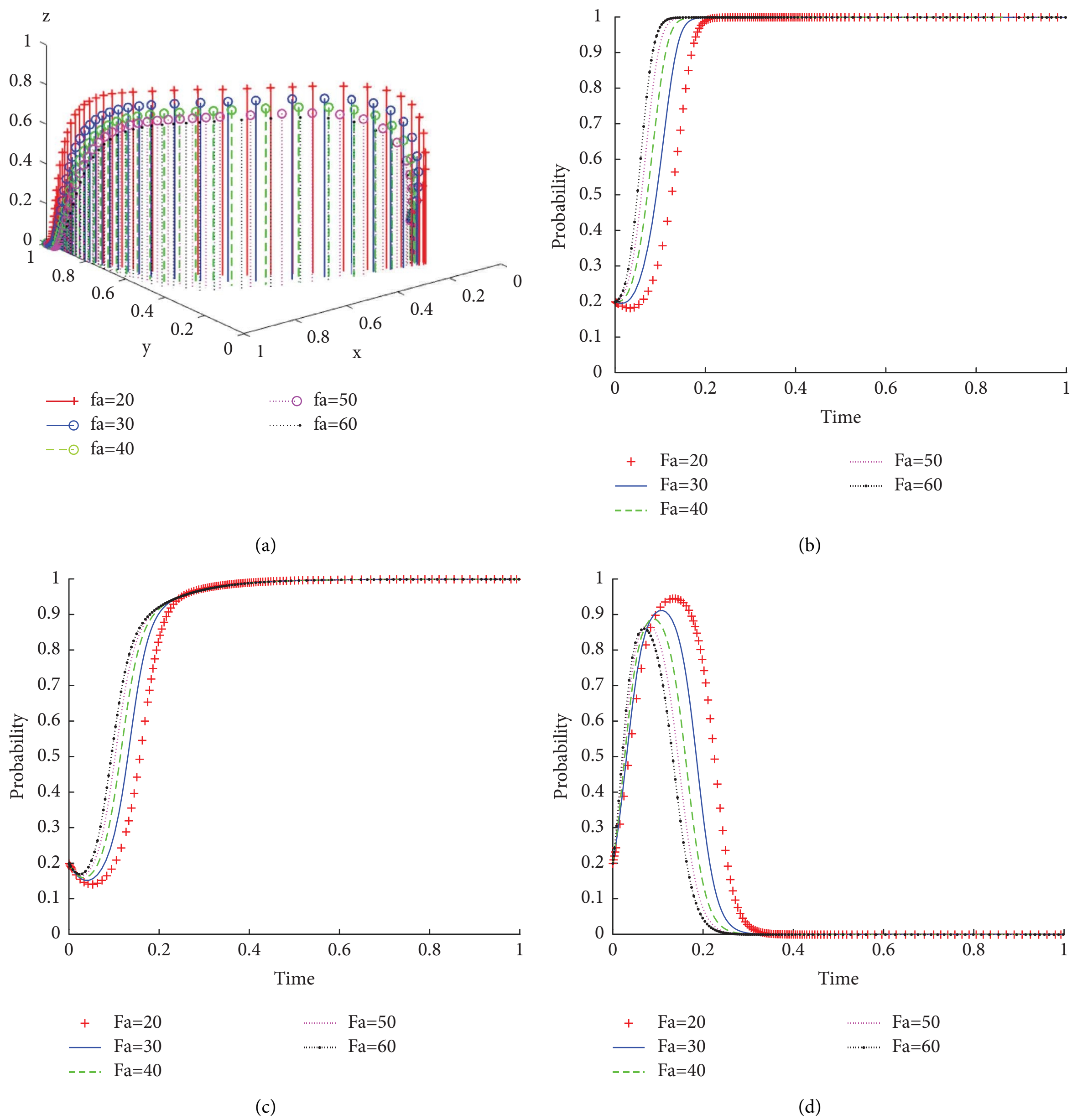

Figure 7: Diagram of system evolution under different F_a influences: (a) F_a influence on system evolution; (b) F_a influence on enterprises; (c) F_a influence on third-party safety assessment agencies; (d) F_a influence on government regulatory departments.

regulatory department chooses a strict supervision strategy decrease, which will shorten the time it takes to reach the maximum probability value.

Overall, an increase in fines can create sufficient deterrence for enterprises, and the probability of enterprises choosing the strategy of improving the emergency management level increases after weighing the benefits and losses. The increase in the number of fines prompts government regulatory departments to increase the probability of choosing strict supervision. When enterprises finally choose an active strategy, the probability of government regulatory departments choosing strict supervision will gradually decrease to reduce overall regulatory costs and eventually choose a lenient regulation strategy. Third-party safety assessment agencies are influenced by the strict supervision strategy of government regulatory departments, which will gradually increase the probability of choosing the rent-seeking strategy of rejection. But with the shift in the regulatory strategy of government regulatory departments, the evolution of the strategy of third-party safety assessment agencies gradually slows down and finally chooses the rent-seeking strategy of rejection. Comparing Figures 7(a)–7(c), the stable strategy of enterprises converges significantly faster than that of third-party safety assessment agencies and government regulatory departments, indicating that enterprises play the main driving role in the evolution of the game system.

4.3. The Effect of F_b on the Evolution of the System. When F_b is equal to 15, 20, 25, 30, and 35, the evolution of the gaming system is shown in Figure 8.

F_b is a fine for a third-party safety assessment agency that makes a false assessment report on the current state of emergency management. Specifically, government regulatory departments use fines to enable third-party safety assessment agencies to remain impartial in assessing the current state of emergency management in enterprises and to ensure that government regulatory departments have the true state of emergency management in enterprises. As seen in Figure 8(b), there is a tendency for third-party safety assessment agencies to accept rent-seeking from enterprises at the beginning of the system evolution, but the increase of F_b can slow down the tendency of accepting rent-seeking from enterprises and speed up the evolution of third-party safety assessment agencies to a rent-seeking rejection strategy. From the perspective of government regulatory departments, at the beginning of the system evolution, the rate of convergence to 1 gradually increases with the increase of F_b and starts to converge to 0 gradually after reaching the maximum probability. At the same time, the increase in F_b makes the maximum value of the probability that the government regulator department chooses a strict supervision strategy decrease, and the time to reach the maximum probability value shortens. From the enterprise's perspective, the change in F_b has a limited impact on the enterprise's strategy evolution, but as the probability of choosing a rejection of the rent-seeking strategy by the third-party safety assessment agency increases, the enterprise increases the probability of choosing an activity strategy.

A comparison of Figures 7 and 8 shows that F_a and F_b have more direct and significant effects on enterprises and third-party safety assessment agencies, respectively. The increase in the number of fines accelerates the evolution of the strategies of enterprises and third-party safety assessment agencies. However, F_b directly affects third-party safety assessment agencies and government regulatory departments, mainly reflects the intensity of punishment imposed by government regulatory departments on third-party safety assessment agencies, and has a limited impact on the strategy choice of enterprises.

4.4. The Effect of B_1 on the Evolution of the System. Figure 9 represents the evolution process of the game system of enterprise emergency management system construction under different values of B_1. When the value of B_1 is low, the game system shows a tendency to evolve toward actively establishing the emergency management system, rejecting rent-seeking, and strict supervision, but at the end of the system's evolution, the game subjects converge quickly toward (1, 1, 0) and finally form a stable strategy combination of actively establishing the emergency management system, rejecting rent-seeking, and lax supervision. When the value of B_1 is higher, the process of system evolution toward (1, 1, 0) is more direct.

When the value of B_1 is set higher, companies are able to gain more from the assessment of the current state of emergency management, so the probability of companies choosing to actively establish the emergency management system has increased. In Figure 9(c), at the beginning of the system evolution, different B_1 values did not affect the tendency of the third-party safety assessment agencies to converge to 1. However, when $B_1 = 20$ and 25, the trend of convergence of third-party safety assessment agencies slows down in the later stages of system evolution. In addition, as shown in Figure 9(d), at lower B_1, the government regulator department gradually converges to $z = 1$ driven by the change in the strategies of both the enterprise and the third-party safety assessment agencies, and then gradually converges to $z = 0$. In addition, at the beginning of the system evolution, although the government regulator department has a tendency to converge to $z = 1$, the larger B_1 is, the lower the probability of the government regulator department choosing a strict supervision strategy. Although the enterprises can overget subsidies after passing the emergency management status assessment, the enterprises are not sensitive to the change of B_1, so the evolution of the stabilization strategy is slow. However, the amount of subsidy has a significant impact on the third-party safety assessment agency and the government regulator department, which indicates that in the game system, the game strategy choice of each subject has the tendency to develop in a coordinated manner and follow the evolution of changes.

4.5. The Effect of B_2 on the Evolution of the System. Figure 10 illustrates the evolutionary trajectory of the gaming system for different values of B_2. The increase in B_2 increases the tendency of the enterprise to converge to $x = 1$, but the change is not significant compared to the third-party safety assessment agency. For the third-party safety assessment agency, the increase in B_2 makes its convergence to $y = 1$ faster. According to Figures 10(b) and 10(c), although enterprises and third-party safety assessment agencies have the same strategic direction in improving B_2, the two strategies evolve differently. When the amount of subsidy given to the third-party safety assessment agency is smaller, the evolution of the third-party safety assessment agency to a rent-seeking denial strategy is more direct. Moreover, the faster the third-party safety assessment agency converges to the rent-seeking strategy when it receives more assessment revenue.

Meanwhile, as evolution advances, the strategy choice of third-party safety assessment agencies shows an evolutionary trend of first choosing the rent-seeking acceptance strategy and then shifting to the rent-seeking rejection strategy. Accordingly, when the third-party safety assessment agency receives low assessment revenue, it will tend to accept rent-seeking at the early stage of system evolution; however, it will shift to a rent-seeking rejection strategy in the subsequent evolutionary process because of the regulatory strategy and subsidy income of the government regulator department.

For government regulatory departments, their strategy choice is mainly influenced by the strategy choices of enterprises and third-party safety assessment agencies.

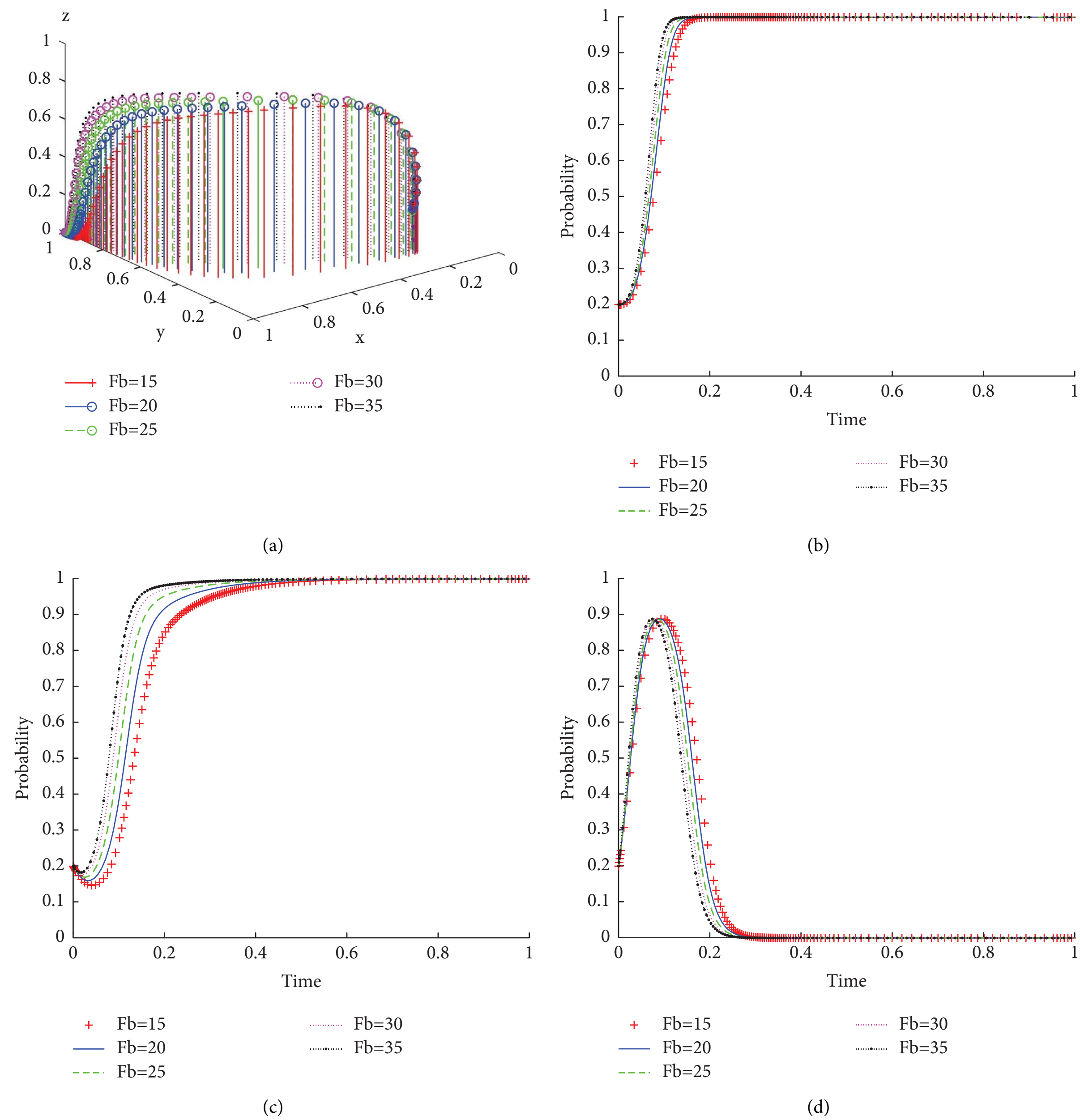

Figure 8: Diagram of system evolution under different F_b influences: (a) F_b influence on system evolution; (b) F_b influence on enterprises; (c) F_b influence on third-party safety assessment agencies; (d) F_b influence on government regulatory departments.

When the probability that enterprises and third-party safety assessment agencies choose to actively establish emergency management systems and reject rent-seeking strategies is low, government regulatory departments will increase the probability of choosing strict supervision strategies. In contrast, when the probability of enterprises and third-party safety assessment agencies choosing to actively establish emergency management systems and rejecting rent-seeking strategies is high, lax supervision strategies become the final choice of government regulatory departments. Therefore, the strategy choices of enterprises, third-party safety assessment agencies, and government regulatory departments are consistent and followable.

4.6. The Effect of N on the Evolution of the System. The residual loss N generated when the government regulator department regulates unfavorably is set to 20, 30, 40, 50, and 60. The evolution trajectory of the game system is shown in Figure 11. The reputational loss generated when the government regulator department regulates unfavorably is an important guarantee for maintaining the strength of government regulation, and by setting the residual loss, it can maintain the strength of government regulation. Specifically, when the emergency management level of enterprises is low, the reputation impact will force government regulatory departments to increase the probability of choosing a strict supervision strategy, improve the supervision of enterprises and third-party safety assessment agencies, force enterprises

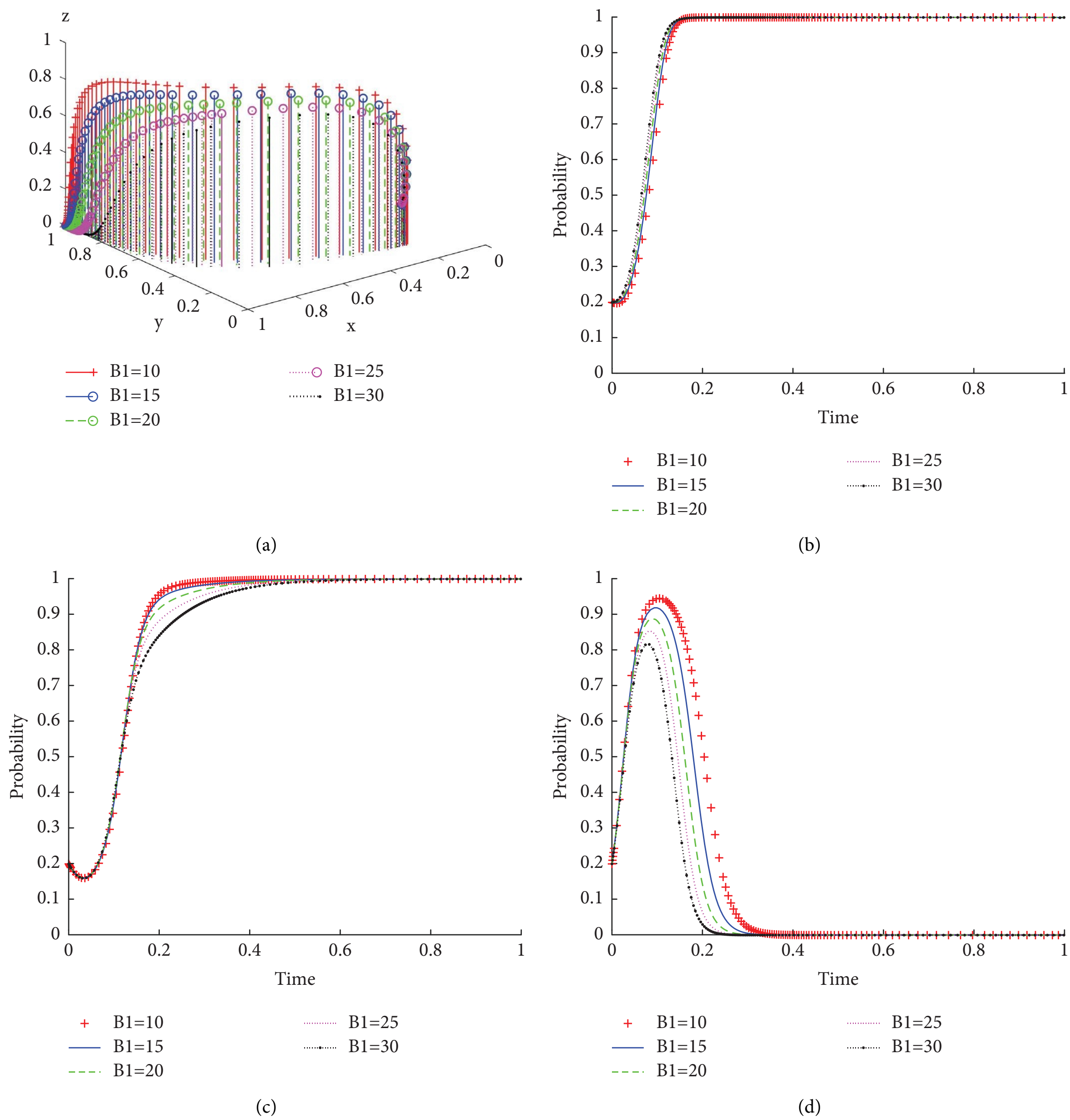

Figure 9: Diagram of system evolution under different B_1 influences: (a) B_1 influence on system evolution; (b) B_1 influence on enterprises; (c) B_1 influence on third-party safety assessment agencies; (d) B_1 influence on government regulatory departments.

to choose the strategy of improving emergency management level, and third-party safety assessment agencies to choose the strategy of rejecting rent-seeking, and finally realize the guarantee that the overall emergency management level of society is at a high position. As seen from Figure 11(d), with the development of evolution over time, the strategy choice of governmental regulatory departments shows an evolutionary trend of choosing a strict supervision strategy first and then shifting to a lax supervision strategy. This means that in the initial stage of evolution, the probability of enterprises choosing to actively establish emergency management systems and third-party safety assessment agencies choosing to reject rent-seeking strategies is low, and government regulatory departments, influenced by the reputation parameter, will rapidly converge to $z = 1$ and increase the probability of strict supervision strategies, forcing enterprises and third-party safety assessment agencies to increase the probability of choosing to actively establish emergency management system strategies and reject rent-seeking strategies to improve the overall emergency management level of society and reduce reputation loss. At the end of the evolution, government regulatory departments shifted to a lax supervision strategy because of the high cost of regulation. In addition, a higher reputation impact can accelerate the speed and tendency of government regulatory departments to converge on $z = 0$ and improve the effectiveness of those regulations. Overall, a higher reputation impact increases the strength and effectiveness of

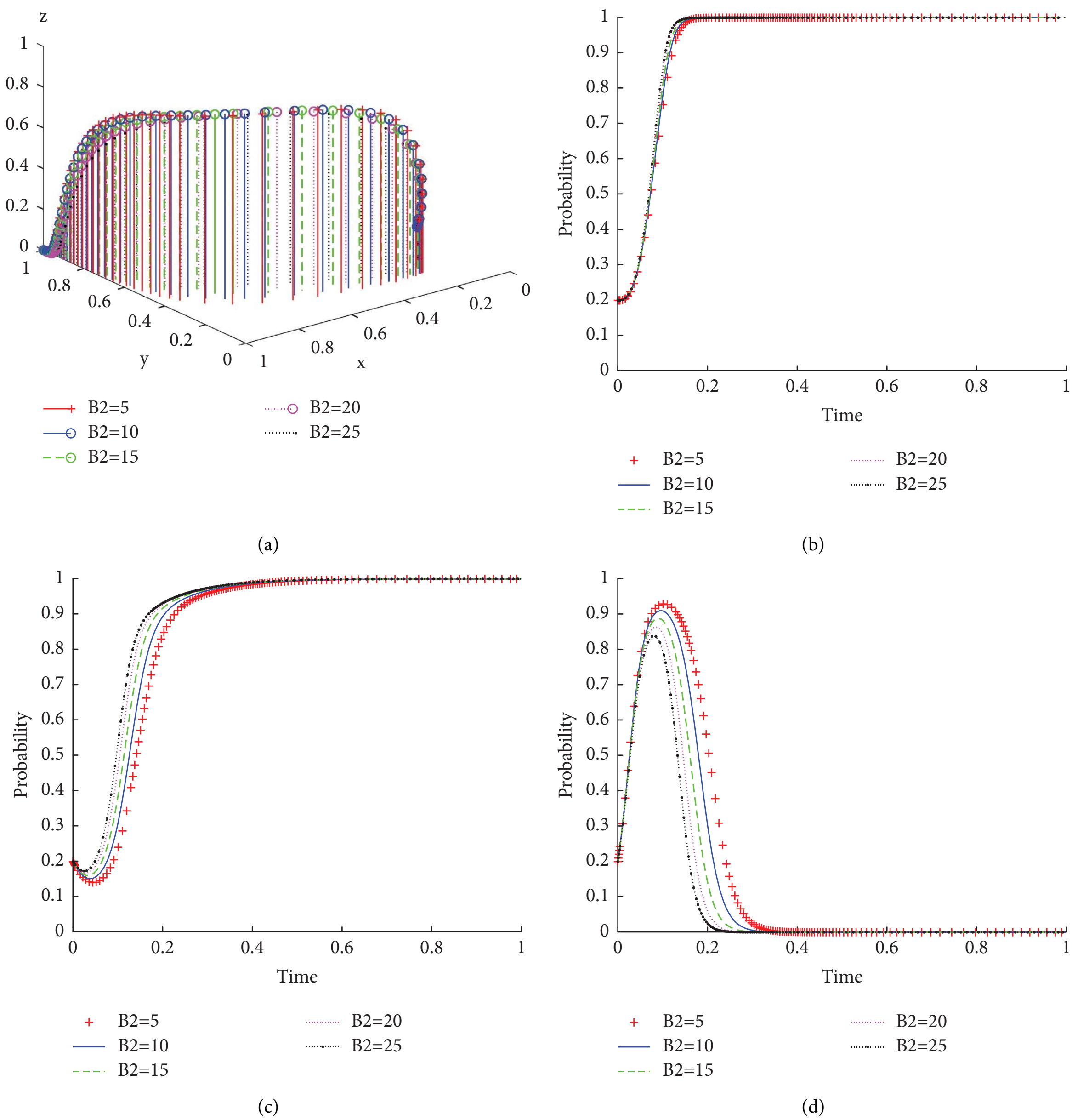

FIGURE 10: Diagram of system evolution under different B_2 influences: (a) B_2 influence on system evolution; (b) B_2 influence on enterprises; (c) B_2 influence on third-party safety assessment agencies; (d) B_2 influence on government regulatory departments.

government regulatory departments' regulations. At the same time, companies and third-party safety assessment agencies are influenced by the regulatory efforts of government regulatory departments and change their strategies more rapidly.

4.7. The Effect of θ on the Evolution of the System. The emergency management system establishment coefficient θ is set to 0.75, 0.80, 0.85, 0.90, and 0.95. The results of the game system evolution are shown in Figure 12. The emergency management establishment coefficient θ is a parameter that describes the intensity of cost of improving emergency management for enterprises in regions with different economic and technological levels. As shown in Figure 12(a), as the establishment coefficient increases, the stable strategy combination of the game system evolves from a direct evolution to (1, 1, 0) to a development path first to (1, 1, 1), and then to (1, 1, 0). In Figure 12(b), an increase in the establishment coefficient raises the construction cost of establishing an emergency management system for enterprises, and therefore, a decrease in the establishment coefficient for enterprises weakens the formation tendency of enterprises to actively establish an emergency management system. Specifically, when θ is at a low level, enterprises can obtain more emergency compensation incentives and lower expenditure costs under the strategy of positively establishing emergency management systems. As θ increases, the cost expenditures faced by enterprises begin to increase, so they have the tendency to choose a passive strategy, but

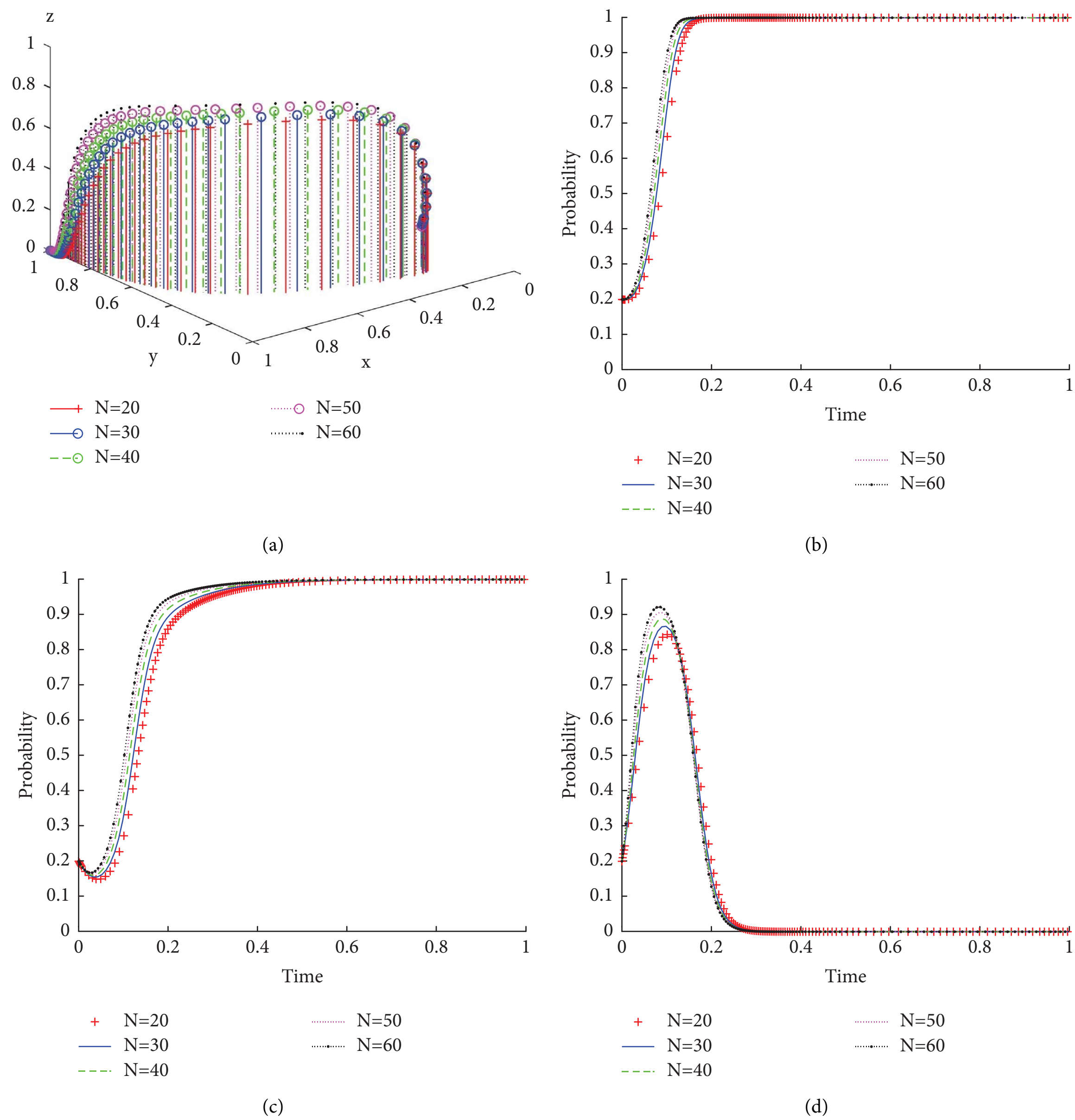

Figure 11: Diagram of system evolution under different N influences: (a) N influence on system evolution; (b) N influence on enterprises; (c) N influence on third-party safety assessment agencies; (d) N influence on government regulatory departments.

under the influence of strict supervision by governmental supervisors, they will shift their strategy choice and gradually increase the probability of choosing an active strategy. In Figure 12(c), when the third-party safety assessment agencies are able to obtain more contingency assessment compensation incentives and less penalty losses under the rent-seeking rejection strategy, the strategy choice of the third-party safety assessment agencies will shift from the tendency to accept rent-seeking to the rent-seeking rejection strategy as θ decreases. In Figure 12(d), when θ is at a high level, the probability of enterprises choosing the strategy to improve their emergency management level is low, so government regulatory departments will choose the strict supervision strategy to motivate enterprises to choose to actively establish their emergency management system. The higher θ is, the greater the degree of convergence of government regulatory departments to $z = 0$ at the early stage of system evolution. When the enterprises converge to $x = 1$, the government regulatory department starts to converge to 0 and eventually chooses a lenient regulatory strategy. Overall, improving the development level of the regional economy and technology, reducing the establishment coefficient θ, and decreasing the establishment cost of enterprise emergency management will motivate enterprises to establish emergency management systems. At the same time, enterprises and government regulatory departments are more responsive to changes in parameters and change their strategies more rapidly.

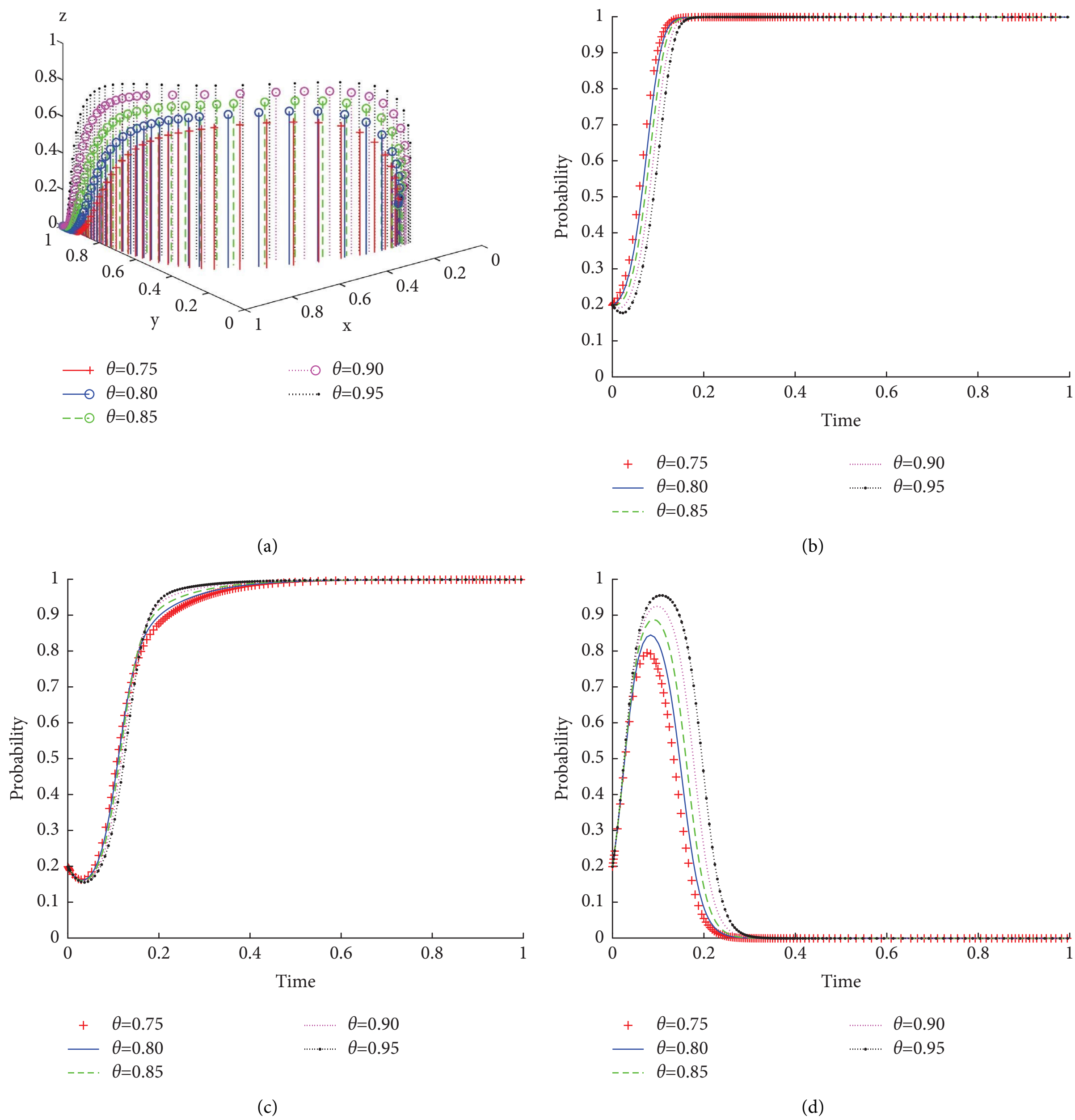

FIGURE 12: Diagram of system evolution under different θ influences: (a) θ influence on system evolution; (b) θ influence on enterprises; (c) θ influence on third-party safety assessment agencies; (d) θ influence on government regulators.

5. Discussion

The establishment of an enterprise emergency management system is a collaborative process involving multiple entities. As the emergency management system involves more content and covers a wider area, the establishment of the enterprise emergency management system needs professional help from the third-party safety assessment agency. The key to improving the perfection of the enterprise emergency management system and the effectiveness of the interface with the local emergency management system is to increase the enthusiasm of the enterprise to establish the emergency management system and to maintain the independence of the third-party safety assessment agency. The game model of an enterprise emergency management system establishment involving enterprises, third-party safety assessment agencies, and governmental regulatory departments effectively describes the problem and provides an effective way to increase the enthusiasm of enterprises in establishing emergency management systems.

According to the results of numerical simulation, the game model of enterprise emergency management system establishment has the direction of following the strategy evolution of enterprises, third-party safety assessment agencies, and government regulatory departments within a certain evolutionary period; therefore, enterprises, third-party safety assessment agencies, and government regulatory departments are the driving forces of each other's strategy evolution, and the strategy evolution of any party will cause the strategy evolution of other game subjects. This indicates that in the game system of enterprise emergency management system establishment, there is a dynamic evolution mechanism of mutual promotion and mutual influence on the strategy evolution of each game subject. To clarify the dynamic evolution mechanism of each subject in the game system of enterprise emergency management system establishment, this paper introduces parameters such as rent-seeking cost, establishment coefficient, reputation loss, and reward-penalty mechanisms to measure the attribute characteristics of the game system and further reveals the influence mechanism of each factor on the game system.

Overall, when the strategy choice of enterprises and third-party safety assessment agencies is not conducive to the establishment of a high-level emergency management system, government regulatory departments will increase the probability of a strict supervision strategy, at which time enterprises and third-party safety assessment agencies will choose a strategy that is conducive to the establishment of a high-level emergency management system. As enterprises and third-party safety assessment agencies shift their strategies, government regulatory departments begin to shift to a lenient regulatory strategy. This shows that the evolution of the game system is dynamic.

By objectively describing the emergency management practice in Chinese, this study proposes a hypothetical model for enterprises to build an emergency management system, which has certain reference value for improving the social emergency management system and improving the supervision mechanism of emergency management. This paper focuses on the interaction between enterprises, third-party safety assessment agencies, and government regulatory departments and the influence of various parameters on the strategy choices of enterprises, third-party safety assessment agencies, and government regulatory departments from the perspective of third-party safety assessment agencies' participation in the establishment of enterprises' emergency management systems. Compared with existing studies, the focus of this study is to explore the influence of parameters such as rent-seeking behavior, establishment coefficients, and reward-penalty mechanisms on the effectiveness of enterprise emergency management system establishment and to broaden the scope and perspective of emergency management research to a certain extent.

6. Conclusions

6.1. Conclusions and Suggestions. Considering the possible rent-seeking behaviors of enterprises and third-party agencies and the difficulty of establishing emergency management systems for enterprises in different regions, this paper constructs a three-party evolutionary game model among enterprises, third-party agencies, and government regulators. The stability of the strategy choice of the parties involved in the game, the evolution direction of the equilibrium strategy combination of the game system, and the influence relationship between the elements are analyzed, and the decision-making process and evolution trajectory of the game system are explored through simulation analysis. First of all, increased subsidies and fines from government regulatory departments can help promote the normative behavior of enterprises to establish emergency management systems and help third-party agencies refuse rent-seeking, but increased subsidies are not conducive to government regulators fulfilling their own supervisory responsibilities. Second, increasing the rent-seeking cost of enterprises can motivate enterprises to actively establish emergency management systems, but it will make third-party agencies accept rent-seeking. Finally, only moderate construction costs can promote the enthusiasm of enterprises to build emergency management systems.

The numerical simulation experiment proves that the local government can affect the enthusiasm of enterprises to build emergency management systems by adjusting the corresponding regulatory policies. Similarly, regulatory authorities should combine dynamic regulatory strategies in a flexibly manner to avoid risks associated with backward policies.

Regulators should consider three aspects when formulating policies. First of all, the government should develop a reasonable reward-penalty mechanism to replace fixed payments to enterprises and third-party agencies with tax reductions. Second, the establishment process and status quo assessment results of the emergency management system of the regulatory authorities can expand the impact of corporate reputation and increase the rent-seeking costs of enterprises. Finally, the government regulators should strengthen the information construction, establish the enterprise emergency management information platform, and master the enterprise emergency management level. Reduce the difficulty of preparing emergency management-related data and accounts, weaken the paperwork related to emergency management, and reduce the difficulty and cost of establishing an emergency management system.

6.2. Limitations and Future Research. Despite our contributions, there are still some limitations. First of all, the evolutionary game model does not consider the impact of the enterprise's internal environment. Second, data collected from a single region may be insufficient. Future research should integrate data from multiple regions with different economic levels, which will enable us to put forward more comprehensive policy recommendations. Finally, for the sustainability of regulatory policies, we will consider the use of repeated games and other game models in future work.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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