# Research on Multi-Agent Interaction and Policy Optimization in the Elevator Insurance Market Based on Evolutionary Game Theory

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**Abstract.** This paper uses evolutionary game theory to study the interaction behavior and policy optimization among the government, insurance companies, and elevator usage units in the elevator insurance market. By constructing a tripartite evolutionary game model, the benefits of each agent under different strategy choices are analyzed, and the stability of the model is verified through numerical simulation. The study finds that government intervention(such as subsidies and penalties) has a significant impact on the publicity enthusiasm of insurance companies and the willingness of elevator usage units to purchase insurance. At different stages, the strategy choices of the three parties exhibit dynamic evolutionary characteristics, eventually achieving a stable equilibrium in the insurance market. The research results indicate that reasonable policy design can promote the development of the elevator insurance market and enhance the level of public safety. The research findings not only enrich the theoretical framework of the elevator insurance market but also provide a scientific basis for policy formulation, helping to promote the healthy development of the elevator insurance market and improve public safety.

**Keywords:** Elevator insurance; Evolutionary game theory; Policy optimization; Public safety; Multi-agent interaction.

## 1 Introduction

In modern urban life, elevators have become an indispensable vertical transportation means. In 2023, there were 14 elevator safety accidents in China, resulting in 13 deaths, which aroused widespread social concern. In addition to elevator safety accidents that directly cause casualties, as a special equipment, elevators have a relatively high risk of trapping people in the car, which not only causes great economic and emotional burdens to individuals and families, but also puts forward higher requirements for social public safety management. Against this background, insurance, as an important risk dispersion mechanism, has been introduced into the elevator field,


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which can effectively reduce the economic pressure on elevator usage units and passengers affected by accidents or malfunctions. In China, the elevator-related law "Special Equipment Safety Law" states: "The state encourages the purchase of elevator safety liability insurance". Compared with liability insurances such as work safety, work injury, and motor vehicles that the state has made mandatory requirements through laws, there is much room for improvement in the policy guidance and market promotion of elevator insurance.

Although elevator insurance has great market potential in theory, the actual coverage rate is far from the ideal state. Insurance products are seriously homogeneous, lacking innovation and attractiveness. The information asymmetry between insurance companies and elevator usage units reduces the market operation efficiency of insurance. In addition, the current policy and regulatory framework fails to fully exert its potential and cannot effectively motivate all participants to optimize their strategy choices, resulting in the insurance mechanism not being able to fully play its role. For example: In 2021, an elevator accident occurred in Guangdong Province, resulting in one death. Although the elevator was insured with elevator insurance, because it was insured with a general liability insurance product, it could not be compensated in time, resulting in the victim's interests not being better protected, which was not conducive to the handling after the accident and caused adverse social impacts.

Based on the above background, this study aims to explore the interaction behaviors of multiple agents and the effect of government intervention in the elevator insurance market through evolutionary game theory, in order to enrich the theoretical framework of existing research. Evolutionary game theory can comprehensively analyze the mutual influence and strategic interaction of different market participants (such as the government, insurance companies, and elevator usage units), which is helpful for understanding market dynamics and the impact of policy intervention from a longer-term perspective, and provides a scientific basis for policy optimization.

## 2 Literature Review

### 2.1 Theoretical Research Related to Elevator Insurance

Elevators are complex mechanical and electrical equipment, and the promotion of their insurance has certain requirements for professional technology. Existing research on elevator insurance mainly comes from Chinese scholars, focusing on two aspects: risk governance and product design. In terms of risk governance, as a public product, elevator insurance has great advantages in pre-prevention, in-process control, and post-claims settlement in risk governance[1]. Insurance companies, in combination with the technical characteristics of elevators, innovate the "insurance + service" model, which can effectively supervise the quality of maintenance and improve the quality and safety level of elevators[2]. In addition, insurance also has a positive impact on the improvement of residents' emergency literacy level[3]. In terms of product design, the policyholders can be composed of relevant responsible subjects jointly, and the insurance premium rate should float according to the risk level[4]. Combined with the applicable environment of elevators, the insurance premium rate can also be adjusted according to indicators such as the nature of use, usage conditions, service life, carrying capacity, and speed of the elevator[5].

### 2.2 Foundation and Application of Evolutionary Game Theory

Evolutionary game theory provides a powerful framework for analyzing the strategy choices of market participants and has been successfully applied in liability insurances such as agriculture, healthcare, and the environment. The studies found that loss anticipation and risk dispersion are two main principles of modern insurance [6]; the equilibrium point of all parties can be found through the principle of incentive compatibility [7]; insurance companies often adopt mixed strategies to cope with market uncertainties [8]. In the elevator field, there are few game studies, and few studies have conducted game equilibrium analysis on insurance companies and elevator usage units [9].

### 2.3 The Role of Government Intervention in the Insurance Market

In areas where the promotion effect of liability insurance is good, the government has taken strong intervention measures and determined the compulsory insurance system through legislation. Effective government intervention strategies can significantly increase the insurance penetration rate, thereby enhancing the public's sense of security and guarantee level [10][11]. Existing studies have proposed that the healthy development of elevator liability insurance is inseparable from the guidance of government management departments, especially the standardization of responsibility division and pricing mechanisms [1]; the government plays an active role in the starting, growth, and maturity stages of elevator liability insurance, and government subsidies are a necessary condition for the smooth promotion of elevator liability insurance [9].

To sum up: Although existing studies have discussed the impact of insurance mechanisms and government policies on elevator safety, the achievements based on evolutionary game theory to study the multi-party interaction and its evolutionary path in the elevator insurance market are still very limited. Especially in terms of how to design effective policy tools (such as subsidies and penalties) to optimize the insurance market structure and improve elevator safety, the insights provided by existing studies are insufficient. Therefore, this study attempts to reveal how the strategy choices of different participants in the elevator insurance market evolve under the influence of government policies by constructing and analyzing the evolutionary game model, and put forward countermeasures and suggestions, in order to promote the healthy development of the elevator insurance market and ultimately improve the level of public safety.

## 3 The Tripartite Agent Evolutionary Game Model

The parameters and variables of this article are shown in Table 1.

**Table 1.** Explanations of Parameters and Variables

| **Parameter or Variable** | **Symbol Explanation** |
|---|---|
| $F$ | When elevator accidents occur, the government imposes penalty fees on the user units.($F > 0$) |
| $\epsilon$ | The probability of accident occurrence.$\epsilon \in [0,1]$ |
| $G$ | The social benefits obtained by the government taking actions to intervene in the market and promote elevator insurance.($G > 0$) |
| $S_1$ | The fixed subsidy given by the government to insurance companies when they promote elevator insurance.($S_1 > 0$) |
| $S$ | The unit subsidy given by the government to insurance companies according to the situation of insurance purchase by user units.$S \in [0,1]$ |
| $C_M$ | The publicity cost of insurance companies.($c_n > 0$) |
| $B_1$ | The insurance purchase fees of user units. Correspondingly, it is the income of insurance companies.($B_1 > 0$) |
| $B_2$ | The compensation fees given by insurance companies to user units when elevator accidents occur.($B_2 > 0$) |
| $C_A$ | The loss fees of user units when elevator accidents occur.($C_A > 0$) |

### 3.1 Model Assumptions

In this study, we have made several key assumptions to construct the evolutionary game model of the elevator insurance market. These assumptions are reasonable and grounded in real-world scenarios:

Bounded Rationality: We assume that market participants, such as insurance companies and customers, operate under bounded rationality. This means they make decisions based on limited information and past experiences. This assumption reflects the reality that participants do not always have access to complete information and must learn and adapt over time.

Government Intervention: The assumption that the government intervenes in the market through regulatory policies is grounded in actual policy mechanisms. Governments often implement regulations to ensure market stability and protect consumers, which is a common practice in the insurance industry.

Promotion vs. Non-Promotion Strategies: We assume that insurance companies choose between promotion and non-promotion strategies. Promotion involves actively marketing and advertising insurance products to increase uptake, while non-promotion relies on passive sales. This assumption reflects real business practices where companies adopt different marketing strategies to attract customers.

Dynamic and Repetitive Interactions: The assumption that interactions among market participants are dynamic and repetitive is based on the core principle of evolutionary game theory. In reality, market dynamics are continuously evolving, with participants adjusting their strategies in response to market conditions and competitive pressures.

To explore the decision-making behaviors of the government (G), insurance companies (I), and elevator-using units (U) in the game process and influencing factors of promoting elevator liability insurance, the following basic assumptions are proposed.

- *Assumption 1.* The basic idea of evolutionary game theory is the dynamic and repetitive game among all parties under the condition of bounded rationality. Therefore, it is assumed that the government, insurance companies, and elevator-using units involved in the promotion of elevator liability insurance are all rational economic individuals with learning ability. Under the principle of maximizing utility, they will make the best decision-making behaviors through dynamic imitation learning.
- *Assumption 2.* It is assumed that the government implements two strategies, "intervention" and "non-intervention", in the game process. The government influences the behaviors of elevator-using units and insurance companies through the intensity of subsidies (S) or penalties (P). Moreover, if the probability that the government chooses "intervention" is x ($0 \leq x \leq 1$), and the probability that the government chooses "non-intervention" is $(1 - x)$, then $x = 1$ indicates that the government adopts the "intervention" strategy, while $x = 0$ indicates that the government adopts the "non-intervention" strategy. The government's revenue function considers the cost of subsidies, the revenue from penalties, and changes in social welfare.
- *Assumption 3.* The goal of insurance companies is to maximize economic benefits. To reduce costs, they may choose not to promote insurance, and to obtain a larger market, they may choose to take promotional measures. Therefore, the strategic choices of insurance companies are "promotion" and "non-promotion". Then, if the probability that insurance companies choose promotion is y ($0 \leq y \leq 1$), and the probability of not promoting is (1 - y), then y = 1 indicates that the manufacturer adopts the promotion strategy, while y = 0 indicates that the manufacturer adopts the non-promotion strategy. The revenue function of insurance companies includes promotion costs and insurance sales revenue.
- *Assumption 4.* Elevator-using units can choose "purchase insurance" and "not purchase insurance". If the proportion of consumers choosing to purchase insurance is z ($0 \leq z \leq 1$), and the proportion of choosing not to purchase is (1 - z), then z = 1 indicates the adoption of the purchase insurance strategy, and z = 0 indicates that the elevator-using unit is unwilling to purchase insurance. The revenue function of elevator-using units considers insurance costs, possible penalties (if implemented by the government), and compensation benefits in the event of an accident.

## 3.2 Revenue Function

The revenue functions of all subjects are represented in the revenue matrix, as shown in Table 2.

**Table 2.** Revenue Matrix

| Insurance Company | Elevator-using units | Government Intervention $(x)$ | Intervention $(1-x)$ |
|---|---|---|---|
| Promote (y) | Purchase (z) | $-S_1 - SB_1 + F\epsilon - C_A\epsilon + G$<br>$B_1 - C_M - \epsilon B_2 + S_1 + SB_1$<br>$(B_2 - C_A) * \epsilon - B_1 - F\epsilon$ | $-C_A\epsilon$<br>$B_1 - C_M - \epsilon B_2$<br>$(B_2 - C_A) * \epsilon - B_1$ |
| | Non-purchase (1-z) | $-S_1 + F\epsilon - C_A\epsilon + G$<br>$-C_M + S_1$<br>$-F\epsilon - C_A\epsilon$ | $-C_A\epsilon$<br>$-C_M$<br>$-C_A\epsilon$ |
| Non-promote (1-y) | Purchase (z) | $F\epsilon - C_A\epsilon + G$<br>$B_1 - \epsilon B_2$<br>$-F\epsilon - C_A\epsilon$ | $-C_A\epsilon$<br>$B_1 - \epsilon B_2$<br>$(B_2 - C_A) * \epsilon - B_1$ |
| | Non-purchase (1-z) | $(B_2 - C_A) * \epsilon - B_1 - F\epsilon + G$<br>0<br>$-F\epsilon - C_A\epsilon$ | $-C_A\epsilon$<br>0<br>$-C_A\epsilon$ |

The expected returns of government intervention and non-intervention, as well as the average expected return are:

$$\pi_{11} = yz(-S_1 - SB_1 + F\epsilon - C_A\epsilon + G) + y(1-z)(-S_1 + F\epsilon - C_A\epsilon + G) + (1-y)z(F\epsilon - C_A\epsilon + G) + (1-y)(1-z)(F\epsilon - C_A\epsilon + G)$$

$$\pi_{12} = yz(-C_A\epsilon) + y(1-z)(-C_A\epsilon) + (1-y)z(-C_A\epsilon) + (1-y)(1-z)(-C_A\epsilon)$$

$$\bar{\pi}_1 = x\pi_{11} + (1-x)\pi_{12} = x(G + F\epsilon - y(SzB_1 + S_1))$$

According to the Malthusian dynamic equation, the replicator dynamic equation for the government's choice of "intervention" is:

$$F(x) = \frac{\mathrm{dx}}{\mathrm{dt}} = x(\pi_{11} - \bar{\pi}_1) = x(1-x)(\pi_{11} - \pi_{12})$$
$$= -((-1 + x)x(G + F\epsilon - y(SzB_1 + S_1)))$$

Similarly, the replicator dynamic equation for the insurance company's choice of "publicity" can be obtained:

$$F(y) = -((-1 + y)y(SxzB_1 - C_M + xS_1))$$

The replicator dynamic equation for the elevator user unit to choose "purchase" is:

$$F(z) = (-1 + z)z(B_1 - \epsilon B_2)$$

Thus, the replicator dynamic system of the government, the insurance company and the elevator user unit is obtained:

$$\begin{cases} F(x) = -((-1+x)x(F\epsilon - y(SzB_1 + S_1))) \\ F(y) = -((-1+y)y(SxzB_1 - C_M + xS_1)) \\ F(z) = (-1+z)z(B_1 - \epsilon B_2) \end{cases}$$

First, when x, y, and z are 0 or 1, F(x) = F(y) = F(z) = 0. It is easy to obtain eight equilibrium points: (0,0,0), (0,0,1), (0,1,0), (0,1,1), (1,0,0), (1,0,1), (1,1,0), (1,1,1). Let $F(x) = F(y) = F(z) = 0$, and solve the replicator dynamic system equation to obtain two possible equilibrium points $(x = \frac{C_M}{S_1}, y = \frac{F\epsilon}{S_1}, z = 0)$, $(x = \frac{C_M}{SB_1+S_1}, y = \frac{F\epsilon}{SB_1+S_1}, z = 1)$.

### 3.3 Evolutionary Stability Analysis

The Jacobian matrix of the system is $J = \begin{bmatrix} \frac{\partial F_x}{\partial x} & \frac{\partial F_x}{\partial y} & \frac{\partial F_x}{\partial z} \\ \frac{\partial F_y}{\partial x} & \frac{\partial F_y}{\partial y} & \frac{\partial F_y}{\partial z} \\ \frac{\partial F_z}{\partial x} & \frac{\partial F_z}{\partial y} & \frac{\partial F_z}{\partial z} \end{bmatrix}$.

Among them, $\frac{\partial F_x}{\partial x} = -\left((-1+2x)\left(G + F\epsilon - y(SzB_1 + S_1)\right)\right)$, $\frac{\partial F_x}{\partial y} = (-1+x)x(SzB_1 + S_1)$, $\frac{\partial F_x}{\partial z} = S(-1+x)xyB_1$. $\frac{\partial F_y}{\partial x} = -((-1+y)y(SzB_1 + S_1))$, $\frac{\partial F_y}{\partial y} = -((-1+2y)(SxzB_1 - C_M + xS_1))$, $\frac{\partial F_y}{\partial z} = -Sx(-1+y)yB_1$. $\frac{\partial F_z}{\partial x} = 0$, $\frac{\partial F_z}{\partial y} = 0$, $\frac{\partial F_z}{\partial z} = (-1+2z)(B_1 - \epsilon B_2)$.

By solving the eigenvalue of the Jacobian matrix of the above 10 equilibrium points, the asymptotic stability of the equilibrium points can be judged. The results are shown in Table 3. Among them, ESS represents the Evolutionarily Stable Stragegy, that is, the stable point.

**Table 3.** Equilibrium Points and Eigenvalues of the System

| Equilibrium point | Eigenvalue $\lambda_1$ | $\lambda_2$ | $\lambda_3$ | Stable condition | Stability |
|---|---|---|---|---|---|
| $E_1(0,0,0)$ | $G + F\epsilon$ | $-C_M$ | $-B_1 + \epsilon B_2$ | - | - |
| $E_2(0,0,1)$ | $G + F\epsilon$ | $-C_M$ | $B_1 - \epsilon B_2$ | - | - |
| $E_3(0,1,0)$ | $G + F\epsilon - S_1$ | $C_M$ | $-B_1 + \epsilon B_2$ | - | - |
| $E_4(0,1,1)$ | $G + F\epsilon - SB_1 - S_1$ | $C_M$ | $B_1 - \epsilon B_2$ | - | - |
| $E_5(1,0,0)$ | $-G - F\epsilon$ | $-C_M + S_1$ | $-B_1 + \epsilon B_2$ | $S_1 < C_M$<br>$\epsilon B_2 < B_1$ | ESS |
| $E_6(1,0,1)$ | $-G - F\epsilon$ | $SB_1 - C_M + S_1$ | $B_1 - \epsilon B_2$ | $SB_1 + S_1 < C_M$<br>$B_1 < \epsilon B_2$ | ESS |
| $E_7(1,1,0)$ | $-G - F\epsilon + S_1$ | $C_M - S_1$ | $-B_1 + \epsilon B_2$ | $S_1 < F\epsilon$<br>$C_M < S_1$<br>$\epsilon B_2 < B_1$ | ESS |

| | | | | | |
|---|---|---|---|---|---|
| $E_8(1,1,1)$ | $-G-F\epsilon+SB_1+S_1$ | $-SB_1+C_M-S_1$ | $B_1-\epsilon B_2$ | $SB_1+S_1<F\epsilon$<br>$C_M<S_1+SB_1$<br>$B_1<\epsilon B_2$ | ESS |
| $E_9(\frac{C_M}{S_1},\frac{F\epsilon}{S_1},0)$ | 0 | 0 | $-B_1+\epsilon B_2$ | - | - |
| $E_{10}(\frac{C_M}{SB_1+S_1},\frac{F\epsilon}{SB_1+S_1},1)$ | 0 | $-((-1+\frac{2F\epsilon}{SB_1+S_1})(-C_M+\frac{SB_1C_M}{SB_1+S_1}+\frac{C_MS_1}{SB_1+S_1}))$ | $B_1-\epsilon B_2$ | - | - |

It can be known from Table 3 that there are four asymptotically stable points: $E_5(1, 0, 0)$, $E_6(1, 0, 1)$, $E_7(1, 1, 0)$, and $E_8(1, 1, 1)$.

When the conditions $S_1 < C_M$ and $\epsilon B_2 < B_1$ are satisfied, that is, when the publicity cost of the insurance company is greater than the fixed subsidy of the government, and the expected value of compensation ($\epsilon B_2$) of the insurance company for the unit using insurance is less than the insurance purchase cost, the evolutionary result of the three parties is $E_5(1, 0, 0)$. In this case, although the government intervenes, the insurance company does not publicize the insurance and the user units do not purchase the insurance.

When $SB_1 + S_1 < C_M$ and $B_1 < \epsilon B_2$, that is, when the fixed subsidy and unit subsidy of the government are less than the publicity cost of the insurance company, and the expected compensation value ($\epsilon B_2$) of the insurance company for the use of unit insurance is greater than the insurance purchase cost, the evolutionary result of the three parties is $E_6(1, 0, 1)$. Compared with the $E_5$ situation, the government still intervenes, the expected compensation value becomes larger, the using unit is willing to purchase insurance, but the insurance company still does not publicize insurance.

When $S_1 < G + F\epsilon$, $C_M < S_1$, and $\epsilon B_2 < B_1$, that is, when the government's expected fine income ($F\epsilon$) is greater than the fixed subsidy, the fixed subsidy is greater than the publicity cost of the insurance company, and the expected compensation value ($\epsilon B_2$) of the insurance company for the unit using insurance is less than the insurance purchase cost, the evolutionary result of the three parties is $E_7(1, 1, 0)$. In this case, the government chooses to intervene, the insurance company chooses to promote, but the user unit is unwilling to purchase insurance.

When $SB_1 + S_1 < G + F\epsilon$, $C_M < S_1 + SB_1$, and $B_1 < \epsilon B_2$, that is, when the government's expected fine income ($F\epsilon$) is greater than the total amount of all subsidies, the total amount of subsidies is greater than the publicity cost of the insurance company, and the expected compensation value ($\epsilon B_2$) of the insurance company for the insurance of the using unit is greater than the insurance purchase cost, the evolutionary result of the three parties is $E_8(1, 1, 1)$. In this case, the government, the insurance company and the using unit respectively choose "intervention, publicity and purchase", and the elevator insurance can be well promoted and implemented.

# 4 Numerical Analysis

To verify the conclusion of the article and present the evolution path of the system and the influence of parameters on the evolution equilibrium more intuitively, this article conducts a numerical analysis of the evolutionary game model by using MATLAB. Referring to previous literature and actual research situations, parameter assignment is carried out.

## 4.1 Dynamic Evolution of Elevator Insurance Promotion in the Initial Stage

In the initial stage, the government implements intervention of punishment and subsidy. According to the practical significance and size relationship of each parameter, the values of relevant parameters are as follows: The parameter assignment is $= 5, \mathrm{F} = 15,\ \epsilon = 0.06,\ \mathrm{S} = 0.1,\ \mathrm{S}_1 = 2, \mathrm{B}_1 = 6, \mathrm{C}_\mathrm{M} = 3, \mathrm{B}_2 = 80$. The initial proportion of the choices of "intervention, publicity, and purchase" by the government, insurance companies, and elevator user units is (0.5, 0.5, 0.5), and the resulting evolution path is shown in Figure 1 at this time (The horizontal axis t represents the number of games, and the unit is 10 games).

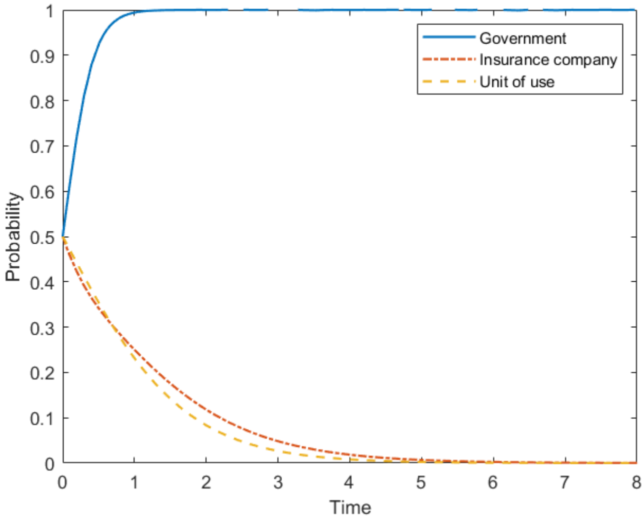


**Fig. 1.** The evolution path of the stable point $E_5$ (1, 0, 0) in the initial stage of elevator insurance promotion

As time goes by, the government will gradually and stably choose the intervention strategy because of the considerable social benefits and income from penalty , and the relatively small amount of subsidies. Although insurance companies receive a small amount of subsidies from the government, they will gradually and stably choose not to promote due to the high publicity cost. The elevator user units will tend not to purchase insurance because the probability of accidents and compensation amounts are much smaller than the insurance purchase cost.

### 4.2 Dynamic Evolution of the Initial Development Stage of Elevator Insurance Promotion

To study the evolutionary stable state of the three main bodies in the initial development stage of elevator insurance promotion after the government has increased subsidy policies. Set the values of relevant parameters as follows: $G = 5, F = 15, \epsilon = 0.06, S = 0.1, S_1 = 4, B_1 = 6, C_M = 3, B_2 = 80$. The initial proportion is (0.5, 0.5, 0.5), and the following evolutionary path is obtained at this time as shown in Figure 2.

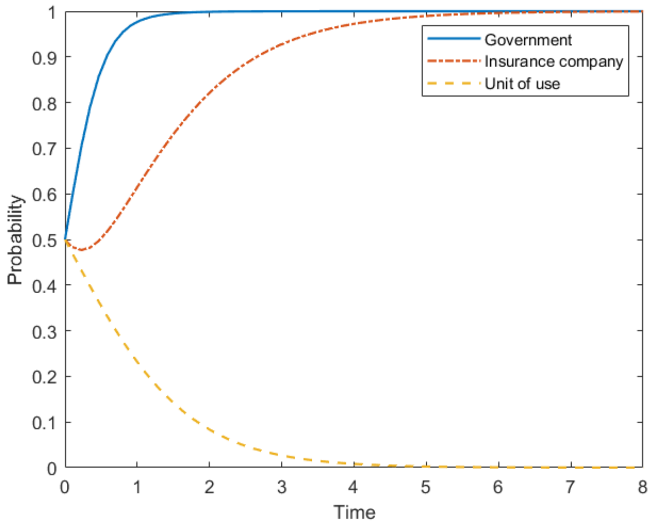


**Fig. 2.** The evolution path of the stable point $E_7(1, 1, 0)$ in the initial development stage of elevator insurance promotion

At this stage, compared with the previous stage, the government has increased the fixed subsidy intensity to promote insurance companies to actively carry out publicity. After weighing the subsidy and publicity costs, insurance companies will stably choose the publicity strategy. The government stably chooses to intervene because the social benefits and penalty income are still greater than the subsidy expenditure. For the user units, because the probability of accidents and the amount of compensation have not changed and are much smaller than the insurance purchase cost, they tend not to purchase insurance.

### 4.3 Dynamic Evolution in the Mid-Term Development Stage of Elevator Insurance Promotion

At this stage, enterprises actively promote and increase the insurance compensation amount to attract user units to purchase insurance. However, the government gradually reduces the fixed subsidy and implements unit subsidies. The relevant parameter values are as follows: $= 5, F = 15, \epsilon = 0.06, S = 0.1, S_1 = 1, B_1 = 6, C_M = 3, B_2 = 120$. The initial proportion is (0.5, 0.5, 0.5), and the resulting evolution path is shown in Figure 3 at this time.

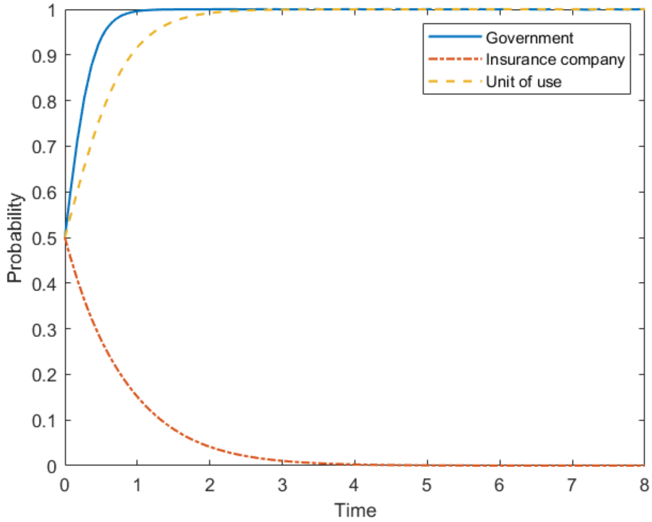


**Fig. 3.** The evolution path of the stable point $E_6(1, 0, 1)$ in the middle development stage of elevator insurance promotion

At this stage, different from the previous two stages, insurance companies can successfully attract elevator user units to stably purchase insurance by reducing the insurance purchase cost $B_1$ or increasing the insurance compensation amount $B_2$, so they tend not to purchase insurance. Because of the increase in insurance purchases, in addition to the fixed subsidy, although the insurance company receives the unit subsidy from the government additionally, it is still insufficient to cope with the large publicity cost due to the reduction of the fixed subsidy, so it will gradually and stably choose not to publicize. While the government, due to the penalty income being greater than the total subsidy expenditure, will gradually and stably choose the intervention strategy.

### 4.4 Dynamic Evolution in the Later Stage of Elevator Insurance Promotion

At this stage, the government increases the unit subsidy to promote the sustainable and sound development of the elevator insurance market. The values of relevant parameters are as follows: $G = 5, F = 15, \epsilon = 0.06, S = 0.5, S_1 = 1, B_1 = 6, C_M = 3, B_2 = 120$. The initial proportion is (0.5, 0.5, 0.5), and the resulting evolution path is shown in Figure 4 at this time.

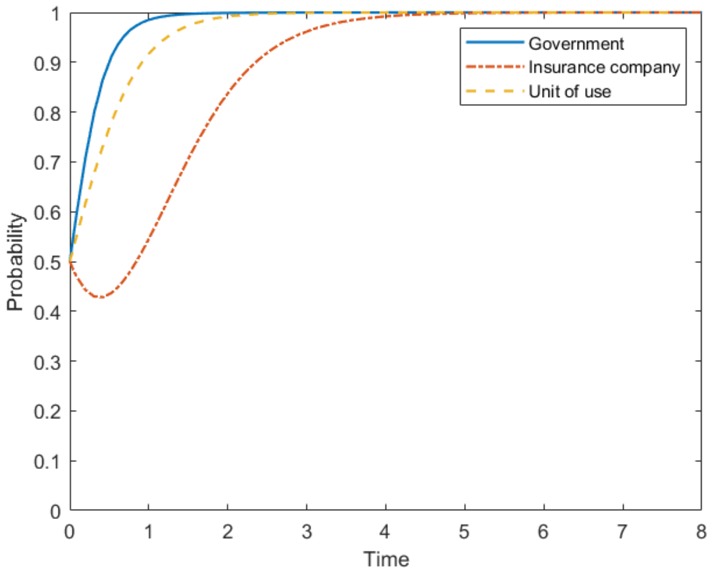


**Fig. 4.** The evolution path of the stable point $E_8$ (1, 1, 1) in the later development stage of elevator insurance promotion

As shown in Figure 4, due to the gradual increase in insurance purchase situations in the insurance market, the government increases the unit subsidy intensity to promote insurance companies to actively carry out publicity. After obtaining more unit subsidies and fixed subsidies that are greater than the publicity cost, insurance companies will stably choose the publicity strategy. Since the social benefits and penalty income of the government are still greater than the total subsidy expenditure, it will stably choose intervention. For users, compared with the previous stage, since the probability of accidents and the amount of compensation have not changed and are already greater than the insurance purchase cost, they will tend to purchase insurance. The promotion of elevator insurance is gradually moving towards sustainable development.

## 5 The Impact of Parameter Changes on the Evolution of the Main Body's Strategy

Taking the initial development stage of elevator insurance promotion as an example, the influence of various factors on the strategy evolution of the government, insurance companies, and elevator user units is visually displayed to provide a decision-making basis for the government to accelerate the promotion and development of elevator insurance. The sensitivity analysis of parameters such as $G$, $\epsilon$ and $C_M$ is carried out through numerical simulation below.

### 5.1 Impact on Social Benefits *G*

Under the initial strategy (x = 0.3, y = 0.3, z = 0.3), with $\epsilon$ and $C_M$ being constant, only by changing the value of G, the system evolution results of three different degrees (low, medium, and high) of social benefits G are shown in Figure 5.

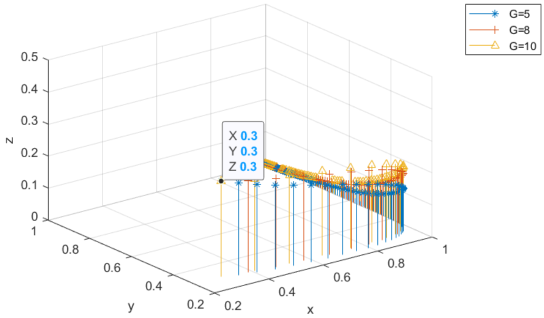


**Fig. 5.** The influence of social benefit G on the strategy evolution of the three parties

It can be known from Figure 5 that when the value of social benefit G gradually increases, the government will evolve to the intervention policy more quickly, the insurance company will evolve to promoting insurance more quickly, and the user unit will increase to a stronger willingness to purchase elevator insurance, but eventually still evolves to not purchasing insurance.

### 5.2 The Influence of Accident Occurrence Rate $\epsilon$

In terms of the accident occurrence rate $\epsilon$, likewise, when G and $C_M$ are fixed and only the value of $\epsilon$ is changed, the system evolution results corresponding to three (low, medium, and high) different degrees of accident occurrence rates are shown in Figure 6 as follows.

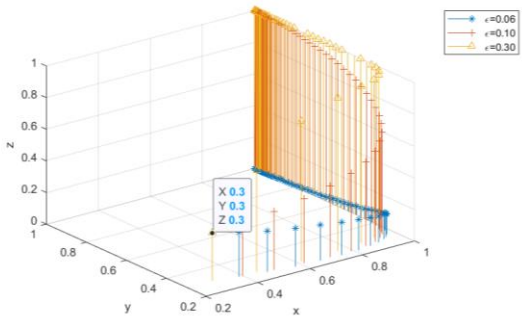


**Fig. 6.** The influence of accident occurrence rate $\epsilon$ on the strategy evolution of the three parties

It can be known from Figure 6 that the accident occurrence rate affects the insurance purchase decision of elevator user units. When the accident occurrence rate is small ($\epsilon$=0.06), the system evolves to (1, 1, 0). However, when the accident occurrence rate is large, the system evolves to (1, 1, 1), and as the accident occurrence rate increases, the evolution speed of the user units to make the decision of purchasing insurance becomes faster.

### 5.3 The Influence of Publicity Costs $C_M$

In terms of the publicity cost $C_M$, when G and $\epsilon$ remain unchanged and only the value of $C_M$ is changed, the system evolution results corresponding to the three different degrees of psychological effects are shown in Figure 7.

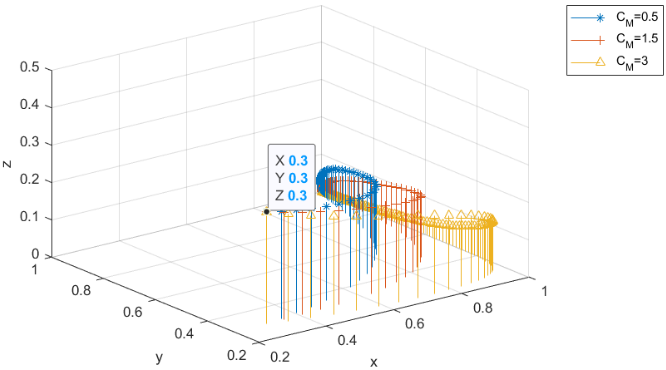


**Fig. 7.** The influence of the promotion cost $C_M$ on the strategy evolution of the three parties

As shown in Figure 7, the system evolution trend does not change with $C_M$ and remains (1, 1, 0). However, as the promotion cost $C_M$ gradually increases, the evolution speed of the using unit towards not purchasing insurance accelerates, and the evolution speed of the insurance company towards promoting insurance slows down.

## 6 Conclusion and Prospect

### 6.1 Research Conclusion

In this paper, an evolutionary game model is constructed to explore the interactive behaviors and policy optimization issues of the government, insurance companies and elevator user units in the elevator insurance market. Through theoretical analysis and numerical simulation, the following main conclusions are drawn:

(1) The importance of government intervention: The research shows that the government's subsidy and penalty policies play a key role in promoting the development of the elevator insurance market. High subsidies can motivate insurance companies to actively promote elevator insurance, thereby increasing the willingness of elevator

user units to take out insurance. At the same time, appropriate penalty measures can prompt elevator user units to increase insurance coverage.

(2) Strategy choice of insurance companies: Insurance companies will choose whether to carry out promotion when facing different subsidies and publicity costs. When the government provides sufficient subsidies to offset the publicity costs, insurance companies are more inclined to choose the promotion strategy, thereby promoting the popularization of insurance.

(3) Purchase decision of elevator user units: The insurance purchase decision of elevator user units is mainly influenced by the insurance premium and the accident occurrence rate. When the insurance company offers a high compensation amount and the insurance premium is reasonable, elevator user units are more willing to purchase insurance to reduce potential risks.

(4) Policy optimization path: In the initial promotion stage of the elevator insurance market, the government should encourage insurance companies to promote and guide elevator user units to purchase insurance by increasing subsidy intensity and implementing penalty measures. As the market gradually matures, the government can gradually reduce the fixed subsidy and increase the unit subsidy based on the number of insured units to maintain the sustainable development of the market.

## 6.2 Policy Suggestions

Based on the research conclusions, this article puts forward the following policy suggestions to promote the healthy development of the elevator insurance market and improve the level of public safety:

(1) Increase government intervention: In the initial development stage of the elevator insurance market, the government should increase subsidy efforts and implement appropriate penalty measures to encourage insurance companies to actively promote and guide elevator-using units to purchase insurance.

(2) Optimize the subsidy mechanism: As the market gradually matures, the government can gradually reduce the fixed subsidy and increase the unit subsidy linked to the number of insured policies to stimulate the long-term enthusiasm of insurance companies and elevator-using units and promote the sustainable development of the market.

(3) Strengthen supervision and cooperation: The government should strengthen the supervision of the elevator insurance market to ensure that insurance companies provide high-quality insurance services. At the same time, encourage insurance companies to cooperate with elevator maintenance units to improve the quality of elevator maintenance, reduce the accident rate, and enhance the public's sense of security.

(4) Enhance public awareness: Through publicity and education, raise the public's awareness of elevator insurance, enhance the risk awareness and willingness to purchase insurance of elevator-using units, and promote the healthy development of the elevator insurance market.

Future research can be carried out from the following aspects: (a) Introducing more variables: Considering factors such as differences in policies in different regions, heterogeneity of market participants, and technological progress, expand and optimize the model to improve the applicability of the research. (b) Field investigation and data analysis: Through field investigation and data collection, further verify and adjust the model parameters to ensure the scientificity and reliability of the research results. (c) Long-term dynamic research: Explore the impact of changes in the external environment on the long-term evolution of the elevator insurance market, analyze the long-term effects of different policy combinations, and provide more scientific decision-making basis for the government.

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