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RDEU Game Model Analysis of Prevention and Control Behavior in Public Health Emergencies under Different Emotional States

Yining Mao*, Jiangxiao Hou

School of Economics and Management, Yanshan University, Qinhuangdao, Hebei, China
maoyining@stumail.ysu.edu.cn
**Corresponding author*

Abstract: *Analyzing the role of public and government emotions in their prevention and control behavior in public health emergencies will help the government better control the development trend of the event, reduce social losses, and enhance the public's awareness of taking corresponding measures. This article is based on the theory of expected utility of hierarchy and constructs an RDEU game model for strategy selection when the public and government face public health emergencies. It explores the existence of Nash equilibrium under different emotional states and analyzes the evolutionary mechanism of public and government emergency prevention and control. The results indicate that the strategy choices of decision-makers vary due to different emotional states, and their evolution process, evolution speed, and the other party's strategy choices will also change accordingly. The impact of negative emotions is more significant.*

Keywords: *Public health emergency; Emergency prevention and control; RDEU game model; Negative emotions; Positive emotions*

1. Introduction

Public health emergencies can cause significant adverse consequences, including social, economic, and health issues, and even result in many deaths in a short period of time. They can be defined as "the occurrence or imminent threat of a disease or health condition that poses a significant risk of causing a large number of deaths, injuries, or permanent or long-term disabilities."[1] Major public health emergencies often face governance challenges such as suddenness, urgency, high uncertainty, information asymmetry, social consequences, and abnormal management.[2] The COVID-19 that broke out in 2020 has had a profound impact on the world, involving public health, economy, social politics and other aspects, and is an unprecedented global challenge. Although the COVID-19 epidemic has passed, the emerging public health events of different scales are still a problem that puzzles the government and society. How to effectively control the spread and dissemination of such public health emergencies, and maximize the protection of people's lives, health, and social security has become a focus of attention for scholars in recent years.

Public protective behavior is a gradual transformation from exploratory to standardized, from irrational avoidance to rational protection. Responding to public health emergencies not only requires strong collective action at the local, national, and international levels, but also the establishment of a capable system to prepare, plan, and manage these events.[3] It's also necessary to unleash the broad mobilization capacity of society, mobilize the public's enthusiasm for protection, prevent the spread of the situation and greater potential threats. Ning Liangwen et al. evaluated the characteristic importance of the influencing factors of high compliance behavior among the public under the background of normalized management of public health emergencies using a random forest model [4]. Wei Jiuchang proposed a protective behavior strategy based on behavioral science to enhance public participation, cooperation, and support in self health management. [5] Dai et al. proposed an information perception action mediation model to explain protective behavior during pandemics, indicating that government systemic intervention programs need to be combined with individual factors to achieve effective prevention and control of public health emergencies [6]. In addition, in recent years, residents have significantly increased their crisis awareness, and their sense of urgency, initiative, and cooperation have gradually improved [7], but still show certain group differences [8]. Scholars have studied the influencing factors of the public's adoption of protective emergency measures and pointed out that risk perception is

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an important factor affecting individual decision-making [9]. Attitudes, subjective norms, and perceived behavioral control can affect individuals' willingness to self-isolate [10]. The group with higher awareness of the severity of public health emergencies tends to adopt isolation measures [11]. At the same time, there is a significant relationship between the anxiety of the public during home isolation and their level of awareness of protective knowledge, beliefs and attitudes, and behavioral compliance [12]. The provision of accurate information can increase risk avoidance and health protection behaviors, reduce public panic and anxiety [13].

The authors found that few scholars in existing research have slowed down and blocked the spread of public health emergencies from the perspective of participants themselves by enhancing their awareness of taking measures, and have not reflected the dynamic process of participant behavior changes. The research paradigm of evolutionary game models can model human behavior as an interactive decision-making process with certain selection and learning abilities, and then explore the inherent mechanism of event evolution over time. In crisis situations, decision-makers often intervene in decision-making outcomes by influencing their perception of events [14]. The Ranked Dependent Expected Utility Theory (RDEU theory) proposed by Quiggin includes the utility of individual psychological preferences and emotions, effectively characterizing the impact of participants' emotional states and intensity under uncertain conditions [15].

In view of this, this article combines RDEU theory with evolutionary game models, introduces an emotion function that reflects the psychological activities of participants in the game structure of public health emergency prevention and control behavior, constructs an RDEU game model, explores the specific impact of emotions on their strategy choices, reflects the evolutionary mechanism of participant behavior in the process of public health emergency prevention and control, and enhances the public's awareness of taking measures, providing a theoretical basis for macroeconomic regulation.

2. Basic theories and assumptions

2.1. Basic Theory of Game Theory

The Ranked Dependent Expected Utility Theory (RDEU theory) is a utility theory that encompasses individual psychological preferences and emotions, taking into account human imperfect rationality, its core is to use the utility function U(x) and the decision weight function π(x) defined by the real value function V to represent an individual's preference for the strategy, namely:

$$V(x, u, \pi) = \sum_{i=1}^{n} \pi(x_i) U(x_i) \tag{1}$$

Among them, for the policy set $X = \{x_i; i = 1,2, \dots, n\}$, the probability of X taking x_i is $P\{X = x_i\} = p_i$. For the policy x_i, it is sorted according to $U(x)$ and $x_1 > x_2 > \cdots > x_n$ is defined. The utility level of policy x_i is defined as RP_i, and the probability distribution function of the policy is $RP_i = P\{X \le x_i\} = p_i + p_{i+1}$. At this point,

$$\pi(x_i) = \omega(p_i + 1 - RP_i) - \omega(1 - RP_i) \tag{2}$$

$\omega(\cdot)$is an emotion function, which is a monotonically increasing function that satisfies $\omega(0) = 0$, $\omega(1) = 1$. The strategy level distribution function and emotion function introduced by the utility theory constitute cumulative nonlinear decision weights, and this nonlinear decision probability can characterize the impact of the public and government's emotional state and emotional intensity under uncertain conditions.

2.2. Basic assumptions of the game

Assumption 1: Both the public and the government are in a state of incomplete information, with the goal of maximizing their own interests in the game. In the process of preventing and controlling public health emergencies, the public chooses active and passive protective behavior strategies, and the government adopts mandatory and flexible prevention and control strategies based on the development trend of the event.

Assumption 2: Assuming different strategy combinations, the returns of both parties are shown in Table 1. When the public adopts proactive protective strategies, they will gain psychological benefits, but they will need to pay protective costs. If the government adopts mandatory prevention and control strategies, the public may be punished or cause greater losses; If the public adopts a passive protection strategy, although the benefits are less, the costs will also be lower. Therefore, for the public: $b > d >$

$c > a$. As an important entity in the management and decision-making of public health emergencies, the government's effective control can greatly benefit from improving credibility, but it requires human and material costs. If the government adopts flexible prevention and control strategies, it may bear losses higher than costs, such as consumer panic, price gouging, social instability, and market disorder. Therefore, there is $e > 0 > f$. When the public adopts a passive protection strategy, the government cannot obtain the benefits brought by the public's active protection, so there is $g < h < e$. Therefore, for the government: $e > h > g > f$.

Assumption 3: In the game, the probability of the public choosing to adopt active protection strategies is p, and the probability of the government choosing to adopt mandatory prevention and control strategies is q. Introducing emotional functions for both parties, $\omega(p) = p^{r_1}$, $\omega(q) = q^{r_2}$, where r_1 and r_2 are the emotional indices of the public and the government, respectively, and meet the conditions of $r_1 > 0$ and $r_2 > 0$. When $r_1 = r_2 = 1$, it indicates that both parties are not affected by emotions.

Table 1: Matrix of Game Benefits for Both Parties

		Government	
		Mandatory prevention and control q	Flexible prevention and control $(1-q)$
Public	Proactive protection p	a, e	b, f
	Passive protection $(1-p)$	c, g	d, h

3. Construction and Solution of RDEU Game Model

3.1. Construction of Evolutionary Game Model

Firstly, based on the above conditions, the strategy benefits, strategy probabilities, utility levels, and weights for both the public and the government can be obtained, as shown in Tables 2 and 3.

Table 2: Benefits, probabilities, levels, and weights of various public strategies

Public strategic benefits x_i	Probability p_i	Grade Rp_i	Decision weight π_i
b	$p(1-q)$	1	$\omega(p-pq)$
d	$(1-p)(1-q)$	$1-p+pq$	$\omega(1-q)-\omega(p-pq)$
c	$q(1-p)$	q	$\omega(1-pq)-\omega(1-q)$
a	pq	pq	$1-\omega(1-pq)$

Table 3: Benefits, probabilities, levels, and weights of various government strategies

Government's strategic benefits y_i	Probability p_i	Grade Rp_i	Decision weight π_i
e	pq	1	$\omega(pq)$
h	$(1-p)(1-q)$	$1-pq$	$\omega(1-p-q+2pq)-\omega(pq)$
g	$q(1-p)$	$p+q-2pq$	$\omega(1-p+pq)-\omega(1-p-q+2pq)$
f	$p(1-q)$	$p(1-q)$	$1-\omega(1-p+pq)$

From Tables 2 and 3, the expected utility and average expected utility of the public and government when making different strategy choices can be obtained. The utility of encouraging the public to adopt proactive protective strategies is U_p, and the expected utility level is denoted as EU_p; The effectiveness of the government's mandatory prevention and control strategy is U_q, and the expected level of effectiveness is recorded as EU_q. The utility levels of emotions included in the RDEU theory for the public and government are:

$$U_p = a \cdot q^{r_2} + b \cdot (1-q^{r_2}) = b + (a-b) \cdot q^{r_2} \tag{3}$$

$$EU_p = b \cdot \omega(p-pq) + d \cdot [\omega(1-q) - \omega(p-pq)] + c \cdot [\omega(1-pq) - \omega(1-q)] + a \cdot [1-\omega(1-pq)] = (b-d) \cdot (p-pq)^{r_1} + (d-c) \cdot (1-q)^{r_1} + (c-a) \cdot (1-pq)^{r_1} + a \tag{4}$$

$$U_q = e \cdot p^{r_1} + g \cdot (1-p^{r_1}) = g + (e-g) \cdot q^{r_1} \tag{5}$$

$$EU_q = e \cdot \omega(pq) + h \cdot [\omega(1-p-q+2pq) - \omega(pq)] + g \cdot [\omega(1-p+pq) - \omega(1-p-q+$$

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$$2pq)] + f \cdot [1 - \omega(1 - p + pq)] = (e - h) \cdot (pq)^{r_2} + (h - g) \cdot (1 - p - q + 2pq)^{r_2} + (g - f) \cdot (1 - p + pq)^{r_2} + f \quad (6)$$

On this basis, by replicating dynamic equations in evolutionary game theory to describe the learning, imitation, and ultimately stable evolution process of strategies under emotional influence, the replication dynamic equations of public proactive protection strategies and government mandatory prevention and control strategies can be obtained:

$$\frac{dp}{dt} = p^{r_1}(U_p - EU_p) = p^{r_1}[(b - a) \cdot (1 - q^{r_2}) - (b - d) \cdot (p - pq)^{r_1} - (d - c) \cdot (1 - q)^{r_1} - (c - a) \cdot (1 - pq)^{r_1}] \quad (7)$$

$$\frac{dq}{dt} = q^{r_2}(U_q - EU_q) = q^{r_2}\{(g - f) \cdot [1 - (1 - p + pq)^{r_2}] + (e - g) \cdot p^{r_1} - (e - h) \cdot (pq)^{r_2} - (h - g) \cdot (1 - p - q + 2pq)^{r_2}\} \quad (8)$$

3.2. Analysis of Solving Game Models

This game model adopts a mixed strategy, and the Nash equilibrium solution and its existence can be solved through its utility function. If $V_p = U_p - EU_p$, $V_q = U_q - EU_q$, then:

$$\begin{cases} V_p = (b - a) \cdot (1 - q^{r_2}) - (b - d) \cdot (p - pq)^{r_1} - (d - c) \cdot (1 - q)^{r_1} \\ \qquad -(c - a) \cdot (1 - pq)^{r_1} = 0 \\ V_q = (g - f) \cdot [1 - (1 - p + pq)^{r_2}] + (e - g) \cdot p^{r_1} - (e - h) \cdot (pq)^{r_2} \\ \qquad -(h - g) \cdot (1 - p - q + 2pq)^{r_2} = 0 \end{cases} \quad (9)$$

By solving the replication dynamic equation system, five equilibrium points for the evolution of the game system can be obtained: $E_1(0,0)$, $E_2(0,1)$, $E_3(1,0)$, $E_4(1,1)$, $E_5(p^*, q^*)$. According to evolutionary game theory, the stability of the five evolutionary equilibrium points can be determined by the conditions of $Det(J) > 0$ and $Tr(J) < 0$ in the Jacobian matrix, and the final evolutionary stability strategy of the game model under emotional influence can be determined. So, let $F(p) = \frac{dp}{dt}$, $F(q) = \frac{dq}{dt}$. Take the derivative of $F(p)$ and $F(q)$ with respect to p and q respectively, and obtain the Jacobian matrix J:

$$J = \begin{bmatrix} \frac{dF(p)}{dp} & \frac{dF(p)}{dq} \\ \frac{dF(q)}{dp} & \frac{dF(q)}{dq} \end{bmatrix}$$

It can be observed that the equilibrium solution and evolutionary stability of each point in the game model depend on the profit parameters and sentiment index in the model. According to the RDEU theory, this article divides the emotional states that the public and government may have into three dimensions: positive emotions, emotionless emotions, and negative emotions. Positive (r<1), rational (r=1), and negative (r>1) are used to characterize the emotional states of both parties, and the value of their emotional index represents the intensity of their emotions. Considering the different situations of prevention and control behaviors in public health emergencies, the situations when the public and the government hold different emotions will be discussed.

3.2.1. Situations where both the public and the government are in a rational state

This situation indicates that the strategic choices of the public and government are not influenced by emotions, i.e. $r_1 = 1$, $r_2 = 1$. By substituting this into equation (9), the Nash equilibrium solution can be obtained: $(p^*, q^*) = \left(\frac{h-g}{e-f+h-g}, \frac{d-b}{a-b+d-c}\right)$. Therefore, when both parties are in a state of ruthlessness, the public chooses proactive protection strategies with a probability of $\frac{h-g}{e-f+h-g}$, and the government chooses mandatory prevention and control strategies with a probability of $\frac{d-b}{a-b+d-c}$. At this point, the equilibrium point of the mixed strategy is $E_5(p^*, q^*)$. However, in reality, it is difficult to find a situation where both the public and the government are in a rational state. Therefore, situations where both parties are in a rational state will not be discussed.

3.2.2. Rational government and emotional state of the public

In this situation, the government is in a rational state, while the public is subject to emotional intervention when making strategic choices. Due to incomplete information obtained by the public, the understanding of the prevention and control of public health emergencies may have a certain degree of subjectivity, so this type of situation generally exists in the process of public protection. In this case, where $r_1 \neq 1$ and $r_2 = 1$, $p^* = p^*(r_1)$, $q^* = q^*(r_1)$, $p^*(r_1)$, $q^*(r_1)$ are the solutions of the replicated dynamic equation system (9). The mixed strategy Nash equilibrium point of this game model is$(p^*(r_1), q^*(r_1))$, and the evolutionary stability of each point can be calculated in Table 4.

As shown in Table 4, equilibrium points E_2 and E_3 do not meet the conditions for evolutionary equilibrium points, and the determinant and trace of E_1 are both zero, making it a saddle point in the evolutionary process. When the equilibrium point E_4 is $r_1 > 1$, $Det(J) > 0$, $Tr(J) < 0$, it is an evolutionarily stable equilibrium point, while when $r_1 < 1$, it is an unstable fixed point. This means that when the public is in an emotional state, the game will form an evolutionary stability strategy (proactive protection, mandatory prevention and control).

Table 4: Evolution of Government Rationality and Public Emotions

Equilibrium	$\frac{dF(p)}{dp}$	$\frac{dF(p)}{dq}$	$\frac{dF(q)}{dp}$	$\frac{dF(q)}{dq}$	Det(J)	Tr(J)	Stability
$E_1(0,0)$	0	0	0	$g-h$	0	0	Saddle point
$E_2(0,1)$	0	0	$g-e$	$h-g$	0	−	Instability
$E_3(1,0)$	$r_1(d-b)$	$(a-b)\cdot(1-r_1)$	0	$e-f$	−	Indeterminacy	Instability
$E_4(1,1)$	0	$a-b$	$(e-g)\cdot(r_1-1)$	$f-e$	+/−	−	Stabilize / Instability
$E_5(p^*(r_1), q^*(r_1))$, The Nash equilibrium solution and stability depend on the return value and the emotional intensity of the public.							

3.2.3. Public rationality and emotional state of government

This situation indicates that the government will be influenced by emotions when adopting prevention and control strategies, while the public will maintain a rational state, that is, $r_1 = 1$, $r_2 \neq 1$. In this case, $p = p^*(r_2)$, $q = q^*(r_2)$, $p, q \in (0,1)$, the mixed strategy Nash equilibrium is $(p^*(r_2), q^*(r_2))$, and the evolution of each equilibrium point is shown in Table 5.

As shown in Table 5, when the government holds an emotional state, the Jacobian matrices corresponding to equilibrium points E_2, E_4 do not meet the conditions of evolutionary stability and are not evolutionary stable strategies. And the $Tr(J) = 0$ at points E_1, E_3 belongs to the saddle point. It can be seen that the public is rational and the government does not tend to adopt pure strategies when holding emotions. For the mixed strategy Nash equilibrium point E_5, its emotional index r_2 and return value are uncertain, and different variable values will lead to different results.

Table 5: Evolution of Public Rationality and Government Emotions

Equilibrium	$\frac{dF(p)}{dp}$	$\frac{dF(p)}{dq}$	$\frac{dF(q)}{dp}$	$\frac{dF(q)}{dq}$	Det(J)	Tr(J)	Stability
$E_1(0,0)$	$b-d$	0	0	0	0	0	Saddle point
$E_2(0,1)$	$a-c$	0	$e-g$	0	0	−	Instability
$E_3(1,0)$	$b-d$	$b-a$	0	0	0	0	Saddle point
$E_4(1,1)$	$c-a$	$(b-a)\cdot(1-r_2)$	$(h-g)\cdot(1-r_2)$	$r_2(f-e)$	−	Indeterminacy	Instability
$E_5(p^*(r_2), q^*(r_2))$, The Nash equilibrium solution and stability depend on the value of returns and the emotional intensity of the government							

3.2.4. Situations where both the public and the government are in an emotional state

In this situation, both the public and the government are in an emotional state, which is a combination of positive and negative emotions. At this point, $r_1 \neq 1$, $r_2 \neq 1$, there exists $p = p^*(r_2, q)$, $q = q^*(r_1, p)$, $p, q \in (0,1)$, which makes equation (9) hold. And when both parties are in an extreme state of emotions, namely $r_1 \to 0$, $r_2 \to 0$, or $r_1 \to +\infty$, $r_2 \to +\infty$, the Nash equilibrium solution does not exist. Therefore, when considering the emotional factors of both parties, the probability of the public choosing proactive protective strategies in the Nash equilibrium solution is $p^*(r_2, q)$, and the probability of the government choosing mandatory prevention and control strategies is $q^*(r_1, p)$. The evolutionary stability of each point is shown in Table 6.

As shown in Table 6, when both parties hold emotions, their emotions will influence each other, making it difficult for the public and government to predict each other's behavior and make favorable choices. However, regardless of the emotions held by both parties, if the government has stronger emotions of the same type, that is, $r_2 > r_1$, the game model will adopt an evolutionary stability strategy (proactive protection, mandatory prevention and control). Although E_1, E_2 and E_3 do not satisfy the stability condition, they all belong to the saddle point. This means that for the Nash equilibrium point of the mixed strategy, E_5, under the interaction of the emotions of both parties, the mixed strategy may become a pure strategy, becoming a stable evolutionary state.

Table 6: Evolution of Emotional State in Both the Public and Government

Equilibrium	$\frac{dF(p)}{dp}$	$\frac{dF(p)}{dq}$	$\frac{dF(q)}{dp}$	$\frac{dF(q)}{dq}$	Det(J)	Tr(J)	Stability
$E_1(0,0)$	0	0	0	0	0	0	Saddle point
$E_2(0,1)$	0	0	0	0	0	0	Saddle point
$E_3(1,0)$	$r_1(d-b)$	$r_1(b-a)$	0	0	0	0	Saddle point
$E_4(1,1)$	0	$r_2(a-b)$	$(e-g)(r_1-r_2)$	$r_2(f-e)$	+/−	−	Stability / instability
$E_5(p^*(r_2,q), q^*(r_1,p))$, Nash equilibrium solution and stability depend on the emotional intensity of both parties							

4. Numerical simulation and analysis

Next, the impact of emotions on evolutionary stability strategies through specific numerical simulations will be described, while verifying the properties of the model and its applicability in the actual prevention and control of public health emergencies. Based on the previous profit relationship and the stability results of replicating the dynamic equation, assign values and observe the optimal path of the system. Assuming $a=-3, b=3, c=0.5, d=1, e=1, f=-4, g=-3, h=0$, and simulate with initial probabilities of $p=0.5, q=0.5$ to analyze the evolution trend under different emotional states and emotional indicators.

4.1. The impact of public emotions on evolution

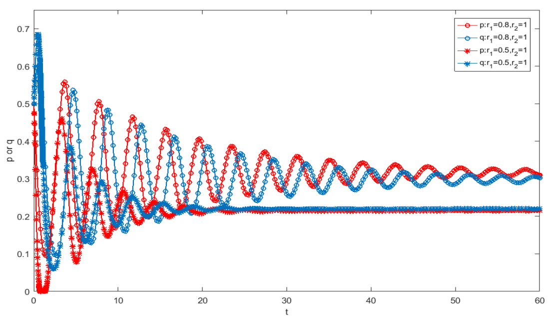

Figure 1: Evolution process under positive public emotions

As shown in Figure 1, when the public is in a positive emotional state ($r_1 = 0.8$), the probability of the public choosing proactive protective strategies and the probability of the government choosing mandatory prevention and control strategies remain stable between 0.3 and 0.4. If the positive sentiment index of the public is increased ($r_1 = 0.5$), the probability of the public choosing proactive protective strategies and the probability of the government choosing mandatory prevention and control strategies will remain stable between 0.2 and 0.3. It can be seen that the more positive the public's attitude towards the prevention and control of public health emergencies is, the more conducive it is to the formation of stable strategies {passive protection, flexible prevention and control}. This indicates that in the process of prevention and control, if the public views issues with a positive attitude, they will be able to quickly and easily understand the relevant information of the event, and can take timely and correct personal emergency measures, thereby reducing the spread of false information and the occurrence of panic behavior. At the same time, while maintaining a rational state, the government is more likely to control

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the overall development situation of the situation, and can make relevant decisions in a timely and smooth manner. By adopting a flexible prevention and control strategy, the government will also better pay attention to public needs and meet the interests of the general public as much as possible.

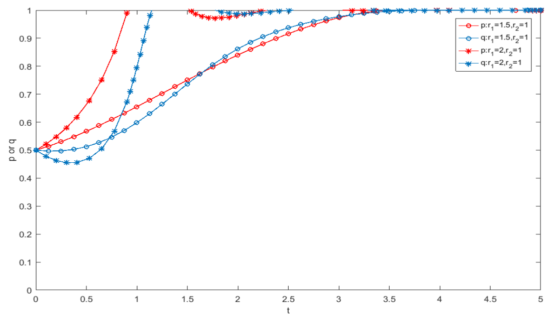

Figure 2: Evolution process under negative public emotions

As shown in Figure 2, when the public is in a negative emotional state ($r_1 = 1.5$), the probability of the public choosing proactive protection strategies and the probability of the government choosing mandatory prevention and control strategies are both close to 1, that is, (proactive protection, mandatory prevention and control). If the negative sentiment index of the public is increased ($r_1 = 2$), the strategic choices of the public and the government remain unchanged, but both sides converge to a stable state at a faster rate. This indicates that the occurrence and spread of public health emergencies are likely to cause the public to engage in emotional behavior, create social chaos, and lead to blind conformity, spreading and spreading rumors. Meanwhile, the generation of negative emotions can affect the public's perception of themselves and events, leading to irrational choices. At this time, the government quickly analyzes the situation, stabilizes the negative psychology and emotions of the public, and in order to avoid the expansion of the scope and impact of the spread, it is necessary to adopt mandatory prevention and control strategies in a timely manner, implement control measures for the public's erroneous behavior, and promote the formation of stable strategies (proactive protection, mandatory prevention and control). In addition, positive emotions have a slower impact on the public and can change their behavior and cognition as events progress slowly. Negative emotions are more likely to drive the public to quickly reach a consensus, accelerate panic behavior and social chaos, which may lead to the government not being able to respond in time, resulting in a serious situation.

4.2. The Impact of Government Emotions on Evolution

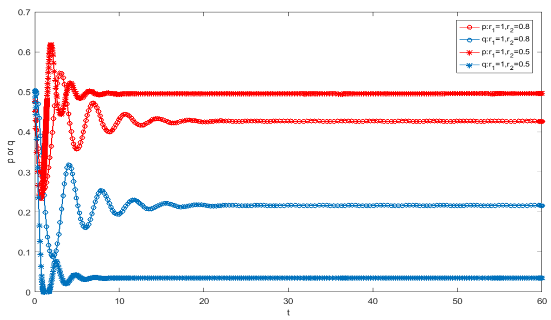

Figure 3: Evolution process under positive government sentiment

As shown in Figure 3, when the government is in a positive emotional state ($r_2 = 0.8$), the probability of the public choosing proactive protective strategies will remain stable between 0.4-0.5, and the probability of the government choosing mandatory prevention and control strategies will remain stable between 0.2-0.3. That is to say, when the government's positive emotional index is low, the public is more inclined to choose passive protective strategies. If the government's positive sentiment index is increased ($r_2 = 0.5$), the probability of the public choosing proactive protective strategies will stabilize at around 0.5, and the probability of the government choosing mandatory prevention and control strategies will decrease to between 0-0.1. This indicates that the more positive the government's emotions are, the more rational the public will choose strategies that are more favorable to themselves, and ultimately approach the evolutionary stability strategies with the worst government returns (proactive protection, flexible prevention and control). At the same time, the government's overly positive emotions

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may reveal negative signals of shirking responsibility and neglecting control, which may bring negative emotions to the public and create a tense situation where the public takes the initiative while the government's control strategies have little effect.

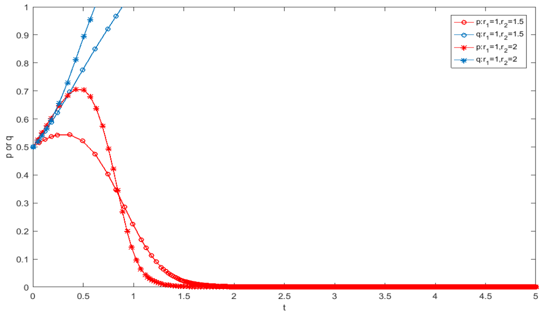

Figure 4: Evolution process under negative government sentiment

As shown in Figure 4, when the government is in a negative state ($r_2 = 1.5$), the probability of the public choosing proactive protection strategies gradually approaches 0, and the probability of the government choosing mandatory prevention and control strategies gradually approaches 1. Moreover, the government will take control measures at a faster speed to achieve evolutionary stability strategies (passive protection, mandatory prevention and control). If the government's negative sentiment index is increased ($r_2 = 2$), the evolution speed of both sides will be faster. This indicates that public health emergencies can trigger negative emotions such as tension and anxiety in the government, leading to cognitive biases when making situational judgments. They believe that the prevention and control measures are severe, prompting them to make prevention and control decisions with a more cautious attitude, and to quell the incident as quickly as possible. The public tends to take proactive protective strategies in the early stages, but rational individuals will eventually adopt passive protective strategies when they perceive the government's negative emotions and understand its proactive governance attitude.

4.3. The impact of public and government emotions on evolution

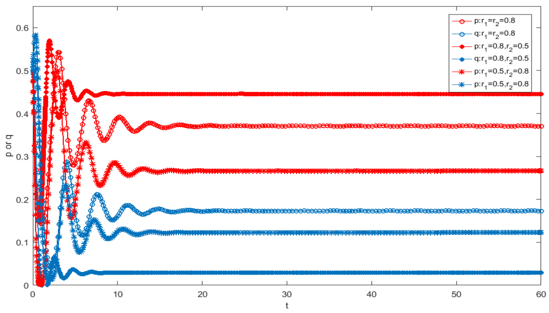

Figure 5: Evolution process of both parties in positive emotions

As shown in Figure 5, when both the public and the government are in a positive emotional state, no evolutionary stability strategy has been formed. No matter how high the positive sentiment index of the public and the government is, after a certain period of evolution, the probability of both choosing strategies will stabilize in a certain range. But this situation is different from the situation where the public is in a positive emotional state and the government is in a rational state. In this situation, the probability of the public choosing proactive protection strategies is higher than that of the government choosing mandatory prevention and control strategies. Although the positive emotional state of both parties has contributed to a relatively harmonious situation between the public and the government, not all the public choose proactive protection, and there is still a situation of dissatisfaction among some groups. Moreover, due to the many uncertain factors of unexpected events, there may be certain risks if the government does not take action, which may cause dissatisfaction among some groups.

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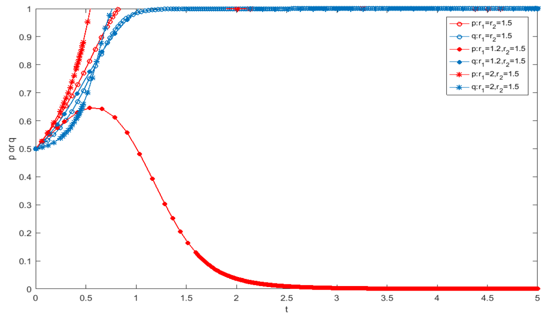

Figure 6: Evolution process of both parties under negative emotions

As shown in Figure 6, when both the public and the government are in a negative emotional state, two evolutionary stability strategies are formed. When the negative emotion index of both parties is high ($r_1 = r_2 = 1.5$), the probability of the public choosing proactive protection strategies and the government choosing mandatory prevention and control strategies gradually approaches 1, ultimately reaching an evolutionary stable strategy (proactive protection, mandatory prevention and control). When the public's negative emotion index is low ($r_1 = 1.2$), the probability of the public choosing proactive protective strategies gradually approaches 0, and the probability of the government choosing mandatory prevention and control strategies gradually approaches 1, reaching an evolutionary stable strategy (passive protection, mandatory prevention and control). In the process of prevention and control, the slight negative emotions of the public did not completely lose their rationality. In the face of strong negative emotions from the government, the public believed that the government would control it in a timely manner, thus restraining their own behavior. But this situation is not stable, and once the negative sentiment index of the public rises ($r_1 = 2$), there will be a situation of opposition between the public and the government. Due to the public's emotional agitation and subjective media coverage, it is easy for them to generate strong negative emotions. After sensing the government's negative emotions, the public still hopes to receive timely response from the government and is willing to bear the consequences of government control.

5. Conclusion

This article uses the RDEU theory to depict the impact of the emotional state and intensity of the public and government on their strategy choices under uncertain conditions, reflecting the dynamic evolution process of the public and government's behavior in preventing and controlling public health emergencies. Through numerical simulation analysis, the impact of different emotional states on the strategy choices of both parties in the game is analyzed. The research results indicate that: (1) Emotions can affect decision-makers' strategy choices. Regardless of which player is in negative emotions, they tend to make more autonomous decisions (proactive protection or mandatory control), and the higher the negative emotion index, the greater the probability of choosing proactive strategies; When they are in a positive emotional state, they are more likely to choose passive strategies (passive protection or flexible prevention and control), and the higher the positive emotional index, the greater the probability of choosing passive strategies. (2) Compared to the public, the emotional state and intensity of the government have a greater impact on its strategic choices, and negative emotions have a greater impact than positive emotions. (3) When both parties are in a positive emotional state, the evolution process is relatively long, and both parties converge to a stable state at a slow speed; when both parties are in a negative emotional state, the evolution process will be significantly shortened, and both parties will converge to a stable state at a faster rate.

The research results help the government understand the changes in the public's emotional state, intervene and guide the public's negative emotions in a timely manner, and to some extent, avoid the occurrence of intensified public behavior. In addition, during the prevention and control of public health emergencies, the government should maintain a rational decision-making state, timely obtain comprehensive information, and control the development trend of the situation; Fully consider the needs and wishes of the people, improve the mechanism for expressing interest demands and public participation in decision-making, weaken cognitive biases caused by information asymmetry, and alleviate the possibility of the situation expanding.

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