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The Game Model with Emotional Factors of Public and Media in Public Emergencies Management Engineering

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Abstract

The current researches on the game behavior between the media and the public in emergency management engineering are limited to the traditional expected utility theory, the theory suppose the both sides are rational people, so the theory researches often do not match the reality. This paper introduces emotional factors and makes a new study on the game model. At first, according to the analysis of the relations between the public and the media in emergencies, we begin to study the impacts of emotions on the game behavior, and then set up the RDEU game model Based on emotional function; At last, it takes a Nash Equilibrium dynamic evolution modeling analysis by numerical example.

Keywords: Emergency Management Engineering; Emotional Function; Game Model; Nash Equilibrium.

1. Introduction

The public emergencies management is the key of the emergency management engineering. Public emergencies happen suddenly, it is likely to cause significant casualties, property losses, ecological environmental damages and serious social problems, finally endanger public safety [1]. In recent years, the worldwide public emergencies occur frequently; these incidents threat the public's life and property safety directly, and they become the important factors, influencing Chinese social stability and modernization. Media is the main channel for general public to receive information, their reports of these incidents will directly influence the general public's behavior and response attitudes, so it is a very meaningful work to research the decision-making behavior of media and public in public emergencies engineering.

In the modern society, the domestic and foreign researches on the emergency management engineering are increasing .In the study of public emergency management engineering, JingYang, Jianming Chen (2005)[2] thought that it's suitable to suppose that the whole respond process to emergencies is a dynamic gambling process between two players of "decision maker" and "emergency" itself. And they put forward a set of thoughts and methods to classify the emergency incidents dynamically from the viewpoint of system. In the application of game theory, based on a single step, normal form game model and the Nash equilibrium, Nagarajan, Rang Nathan (2007)[3] proposed a emergency management system; Darin Goldstein (2008)[4] used the method of game theory to study the

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emergency vehicle path model, and confirmed the new Nash equilibrium was the best through the simulation.

In the applications of game theory in emergency management engineering , Yaping Si (2008)[5] used the game theory to analyze the government's different behaviors and attitudes to the relevant individuals, organizations and other interested groups involved in the process of public crisis management. DeHai Liu (2010)[6] built a game equilibrium evolutionary model considering the mental models that reflect cognition structure different among grass-roots, higher-lever government and social vulnerable group in the emergency management engineering.

At present, there are few studies about the participants in the public emergency management engineering, and the existing literatures do not take emotional factors into account. They lack of in-depth analysis of each player's risk preferences and the actions they taken. This paper introduces emotional factors and makes a new study on the game model. At first, according to the relations between the public and the media in emergencies, we study the impacts of emotions on the game behavior, and then set up the RDEU game model based on emotional function.

2. The research of game relations between media and public in public emergency management engineering

2.1. Stakeholders involved in public emergency management engineering

Public emergency management is a game process, which involves two or more player's interaction. In recent years, the domestic and foreign researches on various stakeholders involved in public emergency management are relatively rare, and they lacks of in-depth study and system discussion. We take emergency management as the title, search the CNKI database carefully, finally found 144 journal articles related participation body. And among them, the type and the number of participation body referred are different. So we use the method of literature metrology and system engineering to statistics the involved participation body in emergency management. Next, we select the ones whose proportion of number is more than 50% as the main stakeholders. They are: the public, government, non-governmental organizations, and mass media.

Table1. The literature number in each year

year	Literature number
2011	22
2010	42
2009	27
2008	26
2007and before	27

Table 2 .The proportion of each participant

	Literature number	The proportion
The public	121	84%
government	140	97.2%
non-governmental organizations	70	50%
Profit organizations	22	15.3%
Mass media	96	66.7%

2.2. Game relations between the media and public in public emergency management engineering

The public emergencies has enormous destructive, so it is bound to harm the people's lives and property, and bring people a considerable impact and pressure and make most people are in strong impulse. Therefore, the public need to receive a variety of information. Media and Public need to go all out to make the society return to normal and avoid the spread of negative emotions. But sometimes, in order to convert the news' value to the interests, some reports of the media may hide some information according to government's needs, which may help us to reduce the spread of the panic, but may also cause rumors. The media will sometimes deviate from the true conditions or over-reported, which would aggravate the panic among people. When the mass media can't satisfy the strong information needs of people, various other forms of non-mass media may be step on, thus aggravating the spread of false news and creating social panic. This creates a game between media and ordinary people.

3. The study of game model with emotion function between the media and the public

3.1. Emotion function description

Based on the important influence of the emotions, this article defines the emotional function through the introduction of emotional factors. Here, we divide the emotion into two categories: optimism and pessimism.

Definition1: if participants' preferences to the two random events X1, X2 meet: $X_1 \geq X_2 \Leftrightarrow V(X_1;u;w) \geq V(X_2;u;w)$

.We claims that participants satisfy the RDEU decision-making model. $V(X_1;u;w) = \sum_{i=1}^{n} u(x_i)W_i(p)$

Here $W_i(p) = w(\sum_{j=1}^{i} p_j) - w(\sum_{j=1}^{i-1} p_j)$ is decision weight function, $u(x_i)$ is the utility function; p_j is the occurrence probability of x_i. By the definition we can see that $w(\cdot)$ is the emotion function and the function curve is the reaction of participants' optimistic or pessimistic mood to the probability, it meets the interval [0, 1]and $w(0)=0, w(1)=1$.The distribution function is the corresponding cumulative probability. And $w(\sum_{j=1}^{i} p_j) = w(P\{X_1 \geq X_2\})$

In RDEU decision model, $\forall p \in [0,1]$ if $w(p)<p$ we think the decision-maker is pessimist; if $w(p)>p$ the decision-maker is optimist; if $w(p)=p$, it suggests that person has not been affected by the emotion, we claim the decision-maker is rational people in traditional theory, and he is risk-neutral.

3.2. The research on RDEU game model between public and media in emergency *management*

3.2.1. The basic description and analysis of game model

During the whole process of public emergency, the message to mass media and the public is non-reciprocal, thus forms the game between them.

(1) First, we chose the mass media and the public as a group of players, and corresponding different emotions they have different risk preference, here we introduce complex emotional function $w(p)$, $w(p)$ is the function of probability p, and $w(p)=p^{\Gamma}$.

(2) Suppose both of the participants understand the benefits and behavior of each other and they take action at the same time. The strategies for public are: underestimate risk and overestimate risk. The strategies for media are: completely report and selective report. Their strategies space and the specific payment are shown in table 3:

Table 3.The game between public and media

The public / media	Overestimate risk	Underestimate risk
Fully report	a , a'	c , c'
Selective report	b , b'	d , d'

3.2.2. The result of the game model and analysis of Nash equilibrium

Let's analysis the matrix game above: when $a>b$ 、$c>d$ or $a<b$ 、$c<d$, the media have strict dominant strategy ;When $a' > c'$、$b' > d'$ or $a' < c'$、$b' < d'$, the public has strict dominant strategy, in such situation, we can get Nash equilibrium by using the repeat eliminates method, if $a=b$ 、$c=d$ and $a' = b'$、$c' = d'$, Then for two participants: the media and the public, the two strategies are no difference and the earnings are the same with any mixed strategies. Now we assume that the strict dominant strategy does not exist, so we introduce emotional factors under RDEU theory, and calculate the mixed Nash equilibrium of the matrix game .First of all,

The utility function for media is:

$$U_1(p,q,w)=\left(p^r,1-p^r\right)\begin{pmatrix}a & c\\ b & d\end{pmatrix}\begin{pmatrix}q^e\\ 1-q^e\end{pmatrix} \tag{1}$$

The utility function for the public is:

$$U_2(p,q,w)=\left(p^r,1-p^r\right)\begin{pmatrix}a' & c'\\ b' & d'\end{pmatrix}\begin{pmatrix}q^e\\ 1-q^e\end{pmatrix} \tag{2}$$

Among them, P is the probability for media to chose the completely report strategy, q is the probability for the public to chose the overestimate strategy, r is the emotional factors for media, e is the emotional factors for the public; w is the probability Weight function, and $w(p)=p^r$.

Arrange (1), we get $$U_1(p,q,w)=p^r[q^e(a-b)+(1-q^e)(c-d)]+bq^e+(1-q^e)d \tag{3}$$

The formula (3) derivation of P, we get

$$\frac{\partial U(p,q,w)}{\partial p}=rp^{(r-1)}[q^e(a-b)+(1-q^e)(c-d)] \tag{4}$$

In order To make the player A's expected utility maximization, let (4) equal to 0, then

$$rp^{(r-1)}[q^e(a-b)+(1-q^e)(c-d)]=0 \tag{5}$$

Because $rp^{(r-1)}\neq 0$, so $q^e(a-b)+(1-q^e)(c-d)=0$ then $q^e=\dfrac{d-c}{a-b+d-c}$ (6)

We can get $$q^*=\left(\frac{d-c}{a-b+d-c}\right)^{\frac{1}{e}} \tag{7}$$

In the same way, we can get: $$p^*=\left(\frac{d'-b'}{a'-c'+d'-b'}\right)^{\frac{1}{r}} \tag{8}$$

So you can get the mixed strategy Nash equilibrium of RDEU game model for the media and public

$$\left(\begin{pmatrix}\left(\frac{d'-b'}{a'-c'+d'-b'}\right)^{\frac{1}{r}}\\ 1-\left(\frac{d'-b'}{a'-c'+d'-b'}\right)^{\frac{1}{r}}\end{pmatrix},\begin{pmatrix}\left(\frac{d-c}{a-b+d-c}\right)^{\frac{1}{e}}\\ 1-\left(\frac{d-c}{a-b+d-c}\right)^{\frac{1}{e}}\end{pmatrix}\right) \tag{9}$$

We can see that it's a function related to the player' emotion, and affected by the player' risk preferences.

3.2.3. The analysis of emotional factors in RDEM game model

The payoff matrix values of the game model can be determined as two sets of sure figures, as shown in table 4.

Table4. The media and the public payoff matrix

Public / Mass media	Overestimate risk	Underestimate risk	Public / Mass media	Overestimate risk	Underestimate risk
Completely report	（4，-5)	(-6，0)	Completely report	（3，-4)	(-2，0)
Selective report	(0，3)	(0，0)	Selective report	(0，1)	(0，0)

We can get two equilibriums from the analysis above, they are:

$$(p^*,q^*)=\left(\begin{pmatrix}0.375^{\frac{1}{r}}\\1-0.375^{\frac{1}{r}}\end{pmatrix},\begin{pmatrix}0.6^{\frac{1}{e}}\\1-0.6^{\frac{1}{e}}\end{pmatrix}\right)\qquad(p^*,q^*)=\left(\begin{pmatrix}0.2^{\frac{1}{r}}\\1-0.2^{\frac{1}{r}}\end{pmatrix},\begin{pmatrix}0.4^{\frac{1}{e}}\\1-0.4^{\frac{1}{e}}\end{pmatrix}\right)$$

According to the equilibrium solution, we can get the diagrams of $p^*$and r, $q^*$and e, as shown in fig1 and fig 2. In order to simplify the description, we determine:

$$\frac{d'-b'}{a'-c'+d'-b'}=S,\quad 1-\left(\frac{d'-b'}{a'-c'+d'-b'}\right)^{\frac{1}{r}}=s,\quad \frac{d-c}{a-b+d-c}=D,\quad 1-\left(\frac{d-c}{a-b+d-c}\right)^{\frac{1}{e}}=d$$

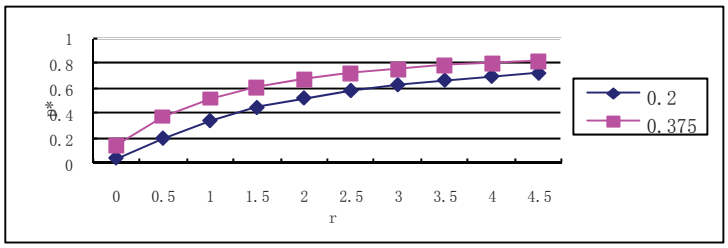

Fig1. Relation between p*and r (r<1)

When S' value unchanged and the media's emotional factor value is more than 1, the curve is up-convex, now, $s>S$, that is $p^{r*}< p^*$, it suggests that ,under the rational thinking ,the probability of full report is larger to media, after the analysis of pessimistic psychological, the value of p reduces. The larger the publics' emotional factor, the lager the value of s. that is to say, the larger the emotional factors, the lower the media's estimate of the probability of completely report, and the media will be more pessimism.

Conversely, when the value of emotional factor is less than 1, the curve at this point is concave. According to the analysis, $s<S$, that is $p^{r*}> p^*$, s will become smaller as emotional factor of the media is smaller. In other words, the smaller the emotional factors, the higher the estimate of the probability of full report to the media and they will become more optimistic.

For example, at the beginning of 5.12 Wenchuan earthquake, various communications facilities were damaged, the communication channel between outside and disaster areas has lost, because the situation cannot be estimated, so people become more despair when aftershocks occurred again and again, in order to avoid social panic, the media only make selective report under the severe stress. Now their emotional factors are larger. As the recovery of the communications, people has further understanding on specific situation and they do their best to provide assistance to disaster area people in various forms, we unite as one, this spirit stimulate the media, enhance their seismic confidence and lessen their emotional factors, then push them to make the full report about this earthquake .

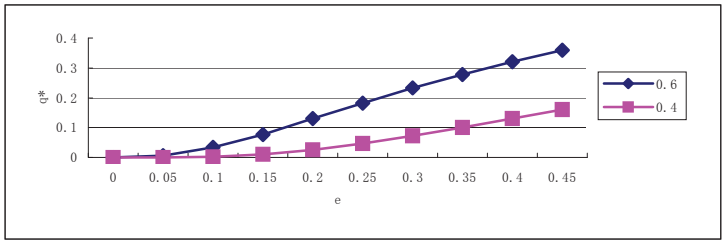

Fig2. Relation between q*and e (e<1)

On the condition of unchanging D's value, when the public's emotional factor value is less than 1, the curve is concave, according to the analysis, $d<D$, that is $q^{e*}>q^*$, public's optimism would improve the estimates of actual probability. The smaller the public's emotional factors, the smaller the d's value, that is, the smaller the emotional

factors, the lower the estimate of the probability to overestimate the risk of public, and the public will be more optimistic.

And when the public's emotion factor value is greater than 1, the curve is convex, $d>D$, that is $q^{e*}<q*$, shows that under the rational thinking, the probability of overestimate the risk to the public is greater. The greater the public's emotion factors, the greater the d's value, in other words, the greater the emotional factors, the lower the estimate of the probability of overestimate the risk, and this illustrates that the public is more pessimistic.

For example: in 2011 Japan's nuclear leakage period, various of rumors on nuclear radiation affect the general people's life , due to lacking of information about specific situation, people will enlarge the disaster depending on subjective assume and imagination , it makes them living in the panic, in other words, it increases their emotional factors, and cause the boom of purchasing salt in various regions. When the government come forward to clarify on this thing, people get more real information, these information calm people's impatient mood, and lower their emotional factors. People start to restore optimism with their mental state is improving continuously.

Through the above analysis, we know the emotional factors can influence the player's strategy, and reflect their emotions in emergency management engineering, this agrees with the analysis of emotional function in the preceding text. When $0<r<1$, the player is optimism. While when $r>1$, the player is pessimism; when $r=1$, it returns to the game model under the theory of traditional expected utility. The analysis above shows that different emotions between players produces different risk preferences, this behavior directly affects the decision-making results of emergency management body, and then makes the theoretical analysis more close to the player's behavior in reality.

4. Conclusions

At present, the research on the game behavior between media and public in emergency management engineering are restricted to the theory of expected utility, these articles suppose that both sides are rational people, in fact their decisions will be affected by many other uncertainties factors, such as the level of knowledge, awareness and emotion. So this article introduces emotional factors to the process, studies the effects of them and establishes the RDEU emotional game model based on the emotional function. By analyzing the balance results, it's obvious that ,in the public emergency management engineering, emotions directly affect the behavior of the media and the public: When the emotional factor is large, media will make selective report, and the public will be pessimistic and overestimate their own risks; when the emotional factor is low, the media will select full report, public will be optimistic and underestimate their risks. Therefore, in order to achieve the better management effect of public emergencies, we should pay more attention to emotion's effects in public emergency management engineering.

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