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Game Analysis of Government's Response to Network Public Opinion

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Abstract: The network public opinion has brought certain challenges to the authority of the government and the control of social order. Based on the evolutionary game theory, this paper establishes the network public opinion game model of government, netizens, Internet celebrity, network media, and uses the replication dynamic equation to analyze the game process of participants. Finally, according to the evolutionary stabilization strategy, put forward relevant countermeasures to the government in dealing with network public opinion of emergencies.

Keywords: Network Public Opinion; Quartet Game; Replication Dynamics; Evolutionary Stability Strategy; Government

1. INTRODUCTION

The network public opinion, that is, the public's attention to an event has produced a certain impact and personal tendencies of views and statements. The uncontrolled network public opinion easily leads to emergencies, at the same time, emergencies affect network public sentiment[1]. As the scale of netizens is growing, the power of their speech can't be ignored. Once some negative phenomena or topic-sensitive incidents occur, they will spread rapidly on the Internet and have a negative impact.

For the government, how to improve handling capacity of network public opinion is crucial to avoid the deterioration of public opinion and secondary events. But the development of network public opinion is formed by multi-participants. Different participants choose different strategies and adjust them according to their own interests. This paper studies the game process between the government, netizens, network Internet celebrity, network media from the perspective of four participants of network public opinion, and uses the replication dynamic equation in the evolutionary game to analyze the game strategy choice of the main players of network public opinion, so as to provide effective strategic suggestions for the government to the network public opinion.

2. LITERATURE REVIEW

Generally speaking, many scholars at home and abroad have study the dissemination and development of public opinion and proposed a number of social network models. Public opinion plays a key role in many fields, such as theoretical side[2], marking [3], social governance[4] , policy-making[5] , etc. Wu[6] presented a public opinion model based on Shannon entropy and used the Holme-Kim network to stimulate, this model help understand the dynamics of opinion entropy, and control the public opinion. Li[7] proposed an improved KH model based on BA model, it considered the intimacy and personality of agents as well as environmental factor to support for the guidance of the public opinion.

In recent years, public opinion can be put forward in a more plentiful definition with the rapid development of the Internet, as we called network public opinion. But,research on public network opinion is still in the preliminary stage. Suo[8] proposed a simple model to analyze the dynamics of four kinds of networks, its simulations result represent that regular communities establish not only local consensus, but also global

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diversity in public opinions. Zhu[9] proposed the SIRS model of network public opinion dissemination, which comprehensively measured the characteristics of network public opinion dissemination on micro-blog platform. Fang[10] used cellular automata to construct a network public opinion dissemination model in theory, and used computer simulation technology to verify the feasibility of the model. Liu[11] established Stackelberg multi-stage game model, pointed out that the possibility of government opportunism is based on the evolution of netizens' group strategy. Wei[12] established an improved Brookes knowledge equation to identify the conditions for the dissemination of network public opinion. Zhang[13] constructed an evolutionary game model of rumor spreading among individuals, and carried out agent-based simulation experiments.

3. ANALYSIS ON THE DEFINITON OF PARTICIPANTS IN NETWORK PUBLIC OPINOIN GAME

3.1 Government

The government refers to the administrative agency that guides in the development process of the network public opinion. As a manager , the government can deal with network public opinion in a controlled or unregulated manner, and different coping strategies will lead to different public opinion development. If the government adopts an unregulated attitude, conceal the truth or deceive the public, it will lead to serious consequences such as reduced trust, public sentiment, and public opinion crisis.

3.2 Netizen

Netizens are the main carriers in the process of network public opinion communication. They can freely publish personalized opinions on the network platform and spread them through the network. They can express their opinions anytime and anywhere, and can also communicate and exchange opinions with others. However, freedom of speech has also led to many netizens posting many false speeches and messages, which has caused the network public opinion to have a bad influence in the process of dissemination.

3.3 Internet celebrity

Internet celebrity is usually a network public figure, they are certified on the web platform, have a large number of fans, and have a wide range of personal influence. The comments they posted on the Internet often have the role of guiding netizens. As the "opinion leaders" on the Internet, they are the main representative power of the network voice. They can influence the network public opinion environment, whether it is to publish positive or negative speech opinions, it will have a certain impact of public opinion.

3.4 Network media

With the development of Internet technology, network media has a greater impact on our lives than traditional media. Most network media rely on network platforms to disseminate information. According to the purpose of the services, we can divide them into four categories: government news websites, business news websites, news media websites and representative local websites. However, the online media referred to in this paper refers to commercial network platforms such as Sina, NetEase and Tencent.

4. CONSTRUCTION OF QUADRIPARTITE GAME MODEL OF NETWORK PUBLIC OPINION

Based on the existing research[14][15], this paper improves the game model of network public opinion. In addition to the government, netizens and network media, this paper also considers the role of Internet celebrity in the process of network public opinion game, and considers different income and cost parameters in the process of game. Previous studies are mostly based on traditional game theory, assuming that participants are completely rational. However, according to the actual situation, the participants of network public opinion are not completely rational, and have the characteristics of "group character", "slow learning speed" and "repeated

game", so this paper uses the replication dynamics of evolutionary game to analyze.

4.1 Model hypothesis

- Participants: government, netizens, Internet celebrity, network media
- Strategies set of participants: government {control, not control}; netizens {participate, not participate}; Internet celebrity {positive, negative}; network media {report, not report}.
- The parameters in the game are set as shown in Table 1.

Table 1. Main parameters and their implications

Participants	Parameter	Parameter implication	Participants	Parameter	Parameter implication
Government	α	Probability of Government Regulation	Internet celebrity	β	Positive Publication of Speech Probability
	G_1	Benefits from social order stability		V_1	Benefits from social order stability
	G_2	Fines (Internet celebrity or Network Media)		V_2	Netizens' Response Benefits
	G_3	Government Control Cost		V_3	marketing cost
	G_4	The cost of social disorder		V_4	Government fines
Participants	Parameter	Parameter implication	Participants	Parameter	Parameter implication
Netizens	γ	Participation probability	Network media	θ	Reporting probability
	N_1	Benefits from social order stability		M_1	Traffic click revenue
	N_2	Information Leading Benefits		M_2	Advertising revenue
	N_3	Access to additional information costs		M_3	Reporting cost
	N_4	Loss of information lag		M_4	Government fines

4.2 Combination of game strategies and revenue

According to the above hypothesis, each participant has two opposing strategic combinations, totaling 16 kinds. Then the revenue matrix of the government-netizen-Internet celebrity-network media quadripartite game constructed in this paper is shown in Table 2.

Table 2. Government-Netizens-Internet celebrity-Network Media Revenue Matrix

Game strategy	Income
(control,participate,positive,report)	$(G_1+G_2-G_3, N_1+N_2, V_1+V_2-V_3, M_1+M_2-M_3-M_4)$
(control,participate,positive,not report)	$(G_1-G_3, N_1+N_2-N_3, V_1+V_2-V_3, 0)$
(control,participate,negative,report)	$(G_1+2G_2-G_3, N_1+N_2, V_1+V_2-V_3-V_4, M_1+M_2-M_3-M_4)$
(control,participate,negative,not report)	$(G_1+G_2-G_3, N_1+N_2-N_3, V_1+V_2-V_3-V_4, 0)$
(control,not participate,positive,report)	$(G_1+G_2-G_3, N_1-N_4, V_1-V_3, M_1+M_2-M_3-M_4)$
(control,not participate,positive,not report)	$(G_1-G_3, N_1-N_4, V_1-V_3, 0)$
(control,not participate,negative,report)	$(G_1+2G_2-G_3, N_1-N_4, V_1-V_3-V_4, M_1+M_2-M_3-M_4)$
(control,not participate,negative,not report)	$(G_1+G_2-G_3, N_1-N_4, V_1-V_3-V_4, 0)$
(not control,participate,positive,report)	$(G_2-G_4, N_2, V_2-V_3, M_1+M_2-M_3-M_4)$
(not control,participate,positive,not report)	$(-G_4, N_2-N_3, V_2-V_3, 0)$

Game strategy	Income
(not control,participate,negative,report)	$(2G_2 - G_4, N_2, V_2 - V_3 - V_4, M_1 + M_2 - M_3 - M_4)$
(not control,participate,negative,not report)	$(G_2 - G_4, N_2 - N_3, V_2 - V_3 - V_4, 0)$
(not control,not participate,positive,report)	$(G_2 - G_4, -N_4, -V_3, M_1 + M_2 - M_3 - M_4)$
(not control,not participate,positive,not report)	$(-G_4, -N_4, -V_3, 0)$
(not control,not participate,negative,report)	$(2G_2 - G_4, -N_4, -V_3 - V_4, M_1 + M_2 - M_3 - M_4)$
(not control,not participate,negative,not report)	$(G_2 - G_4, -N_4, -V_3 - V_4, 0)$

4.3 Model solution

4.3.1 Duplication dynamic equation of government

The benefits of governments' regulatory response strategies are $U_1(control)$,the benefits of setting up governments to adopt regardless response strategies are $U_1(\text{not control})$.The expected revenue of the government is U_1,the calculation formulas are as follows:

$$U_1(\text{control}) = G_1 + (\theta - \beta + 1)G_2 - G_3 \quad U_1(\text{not control}) = (\theta - \beta + 1)G_2 - G_4 \tag{1}$$

$$U_1 = \alpha[G_1 + (\theta - \beta + 1)G_2 - G_3] + (1 - \alpha)[(\theta - \beta + 1)G_2 - G_4] \tag{2}$$

Therefore, the government adopts control strategy to cope with the replication dynamic equation of network public opinion as follows: $f(\alpha) = \frac{d\alpha}{dt} = \alpha(U_1(\text{control}) - U_1) = \alpha(1 - \alpha)(G_1 - G_3 + G_4)$

- If $G_1 - G_3 + G_4 = 0$, so $f(\alpha) = \frac{d\alpha}{dt} \equiv 0$, so when α takes any value, it is stable.
- If $G_1 - G_3 + G_4 > 0$, make $f(\alpha) = \frac{d\alpha}{dt} \equiv 0$, when $\alpha = 0$ or $\alpha = 1$, it is stable. $\frac{df(\alpha)}{dt}|_{\alpha=1} < 0, \frac{df(\alpha)}{dt}|_{\alpha=0} > 0$, so $\alpha = 1$ is the equilibrium point. Therefore, the government should adopt the control strategy to deal with the network public opinion is an evolutionary and stable strategy.
- If $G_1 - G_3 + G_4 < 0$, make $f(\alpha) = \frac{d\alpha}{dt} \equiv 0$, when $\alpha = 0$ or $\alpha = 1$, it is stable. $\frac{df(\alpha)}{dt}|_{\alpha=1} > 0, \frac{df(\alpha)}{dt}|_{\alpha=0} < 0$, so $\alpha = 0$ is the equilibrium point. Therefore, the government should adopt the not control strategy to deal with the network public opinion is an evolutionary and stable strategy.

4.3.2 Duplication dynamic equation of netizen

The benefits of netizens' participation strategy are as follows：$U_2(\text{participate})$，the benefits of netizens' non-participation strategy are as follows: $U_2(\text{not participate})$.The expected income of netizens is U_2，the calculation formulas are as follows:

$$U_2(\text{participate}) = \alpha N_1 + N_2 + (\theta - 1) N_3 \quad U_2(\text{not participate}) = \alpha N_1 - N_4 \tag{3}$$

$$U_2 = \gamma[\alpha N_1 + N_2 + (\theta - 1) N_3] + (1 - \gamma)(\alpha N_1 - N_4) \tag{4}$$

Therefore, the replication dynamic equation of netizens' participation in network public opinion is as follows： $f(\gamma) = \frac{d\gamma}{dt} = \gamma(U_2(\text{participate}) - U_2) = \gamma(1 - \gamma)[N_2 + (\theta - 1) N_3 + N_4]$

- If $\theta = 1 - \frac{N_2 + N_4}{N_3}$, so $f(\gamma) = \frac{d\gamma}{dt} \equiv 0$，so when γ takes any value, it is stable.
- If $\theta > 1 - \frac{N_2 + N_4}{N_3}$, make $f(\gamma) = \frac{d\gamma}{dt} \equiv 0$, when $\gamma = 0$ or $\gamma = 1$, it is stable. $\frac{df(\gamma)}{dt}|_{\gamma=1} < 0, \frac{df(\gamma)}{dt}|_{\gamma=0} > 0$，so $\gamma = 1$ is the equilibrium point. Therefore, netizens should adopt participatory strategies to cope with the network public opinion, which is an evolutionary and stable strategy.

- If $\theta < 1 - \frac{N_2+N_4}{N_3}$, make $f(\gamma) = \frac{d\gamma}{dt} \equiv 0$, when $\gamma = 0$ or

$\gamma = 1$, it is stable. $\frac{df(\gamma)}{dt}|_{\gamma=1} > 0, \frac{df(\gamma)}{dt}|_{\gamma=0} < 0$， so $\gamma = 0$ is the equilibrium point. Therefore, netizens should adopt non-participatory strategies to cope with the network public opinion, which is an evolutionary and stable strategy.

4.3.3 Duplication dynamic equation of internet celebrity

Setting up Internet celebrity to adopt positive strategies benefits as follows:$U_3(\text{positive})$， the Internet celebrity takes the negative strategy the benefit is as follows: $U_3(\text{negative})$， expected revenue of Internet celebrity is U_3， the calculation formulas are as follows:

$$U_3(\text{positive}) = \alpha V_1 + \gamma V_2 - V_3 \quad U_3(\text{negative}) = \alpha V_1 + \gamma V_2 - V_3 - V_4 \tag{5}$$

$$U_3 = \beta(\alpha V_1 + \gamma V_2 - V_3) + (1-\beta)(\alpha V_1 + \gamma V_2 - V_3 - V_4) \tag{6}$$

Therefore, the dynamic equation of the Internet celebrity actively responding to the network public opinion is:$f(\beta) = \frac{d\beta}{dt} = \beta(U_3(\text{positive}) - U_3) = \beta(1-\beta)V_4$

- If $V_4 = 0$, so $f(\beta) = \frac{d\beta}{dt} \equiv 0$, so when β takes any value, it is stable.

- If $V_4 > 0$,make $f(\beta) = \frac{d\beta}{dt} \equiv 0$,when $\beta = 0$ or $\beta = 1$, it is stable. $\frac{df(\beta)}{dt}|_{\beta=1} < 0, \frac{df(\beta)}{dt}|_{\beta=0} > 0$， so $\beta = 1$ is the equilibrium point. Therefore, the network V should adopt a positive strategy to deal with the network public opinion is an evolutionary stability strategy.

- If $V_4 < 0$,make $f(\beta) = \frac{d\beta}{dt} \equiv 0$,when $\beta = 0$ or $\beta = 1$, it is stable. $\frac{df(\beta)}{dt}|_{\beta=1} > 0, \frac{df(\beta)}{dt}|_{\beta=0} < 0$， so $\beta = 0$ is the equilibrium point. Therefore, the network V should adopt a negative strategy to deal with the network public opinion is an evolutionary stability strategy.

4.3.4 Duplication dynamic equation of network media

The benefits of adopting the reporting strategy in the network media are as follows:$U_4(\text{report})$， The benefits of online media's non-reporting strategy are as follows:$U_4(\text{not report})$.The expected revenue of network media is as follows:U_4， the calculation formulas are as follows:

$$U_4(\text{report}) = M_1 + M_2 - M_3 - M_4 \quad U_4(\text{not report}) = 0 \tag{7}$$

$$U_4 = \theta(M_1 + M_2 - M_3 - M_4) \tag{8}$$

So the replication dynamic equation of network media reporting network public opinion is as follows: $f(\theta) = \frac{d\theta}{dt} = \theta(U_4(\text{report}) - U_4) = \theta(1-\theta)[M_1 + M_2 - M_3 - M_4]$

- If $M_1 + M_2 - M_3 - M_4 = 0$,so $f(\theta) = \frac{d\theta}{dt} \equiv 0$,so when θ takes any value, it is stable.

- If $M_1 + M_2 - M_3 - M_4 > 0$,make $f(\theta) = \frac{d\theta}{dt} \equiv 0$,when $\theta = 0$ or $\theta = 1$, it is stable. $\frac{df(\theta)}{dt}|_{\theta=1} < 0, \frac{df(\theta)}{dt}|_{\theta=0} > 0$， so $\theta = 1$ is the equilibrium point. Therefore, the network media should adopt the reporting strategy to deal with the network public opinion is an evolutionary and stable strategy.

- If $M_1 + M_2 - M_3 - M_4 < 0$,make $f(\theta) = \frac{d\theta}{dt} \equiv 0$,when $\theta = 0$ or $\theta = 1$, it is stable. $\frac{df(\theta)}{dt}|_{\theta=1} >$

$0, \frac{df(\theta)}{dt}|_{\theta=0} < 0$， so $\theta = 0$ is the equilibrium point. Therefore, the network media should not adopt the reporting strategy to deal with the network public opinion is an evolutionary and stable strategy.

5. STRAREGIC SUGGESTIONS ON GOVERNMENTS

In the process of the development of network public opinion, the strategic choice of the four participants has an important impact on it. The government should take into account the three main participants, in order to maximize its own benefits, and then make strategic choices. According to the results of the game model above, this paper proposes the following suggestions:

- We should standardize netizens' online access mechanism and adopt a real-name system. From the above game analysis results, it can be seen that the participation or non-participation strategies of netizens mainly depend on the profit of leading information N_2, loss of lagging information N_4.If the government adopts the real-name network system, netizens will weigh the relationship between their N_2 and their cost when they express their opinions on the network public opinion.
- Effective management of Internet celebrity. From the analysis of the above game results, it can be seen that the positive or negative attitude of the Internet celebrity to deal with the network public opinion mainly depends on the government's fine V_4. If the government takes certain punishment measures for its bad speech, then Internet celebrity will actively respond to the network public opinion and express its own objective views to guide ordinary netizens.
- Improve the network media channels to ensure the correct and effective transmission of public opinion information. From the game analysis results, we can also see that the network media is weighing the positive and negative value of its revenue to decide whether to report or not. The government can regulate the behavior of the network media by increasing the click-through revenue M_1 and advertising revenue M_2 and reducing the fines M_4 when the government controls the network public opinion.

6. CONCLUSION

This paper uses evolutionary game theory which is different from traditional game theory to analyze the quadripartite network public opinion model of government, netizens, Internet celebrity and network media. At the same time, we use replication dynamic equation to analyze evolutionary stability strategy to make suggestions for the government in dealing with network public opinion. The disadvantage of this paper is that it puts forward relatively simple parameters and simplifies the actual network public opinion model. In the future research, we should consider more relevant factors in this model.

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