Evolution of Online Public Opinion and Government Response in Public Emergencies Under Emotional Factors: A Tripartite Evolutionary Game Perspective (Postprint)

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Abstract

Purpose/Significance A tripartite game model involving netizens, online media, and the government is constructed to analyze the evolution of online public opinion regarding public emergencies under the influence of emotional factors and government response strategies, with simulation analysis of its evolutionary trends. Method/Process By introducing Rank-Dependent Expected Utility (RDEU) theory, a tripartite evolutionary game model is established to analyze the influence of emotional factors on agents' behavioral decisions and the development trends of online public opinion under different emotional states among the three parties, as well as to examine the impact of emotional states on agents' decision-making. Results/Conclusion The research demonstrates that emotions affect agents' behavioral decisions, and different emotional types and intensities among agents lead to different evolutionary trends in online public opinion. States where the three parties are emotionless, or where netizens and online media maintain optimistic emotions while the government holds pessimistic emotions, are more conducive to the rational evolution of online public opinion. Additionally, compared with netizens and online media, the government' s emotional state exerts a greater influence on the outcomes of the online public opinion evolution game; when the government is in a pessimistic emotional state, it is more inclined to adopt proactive regulatory measures to govern online public opinion.

Full Text

Preamble

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Emotion Factors Influencing the Evolution of Online Public Opinion in Sudden Public Events and Government Response: A Study Based on a Tripartite Evolutionary Game Perspective

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Abstract:

[**Purpose/Significance**] This study addresses the evolution of online public opinion regarding sudden public events under the influence of emotional factors and government response strategies by constructing a tripartite game model involving netizens, online media, and the government, with simulation analysis of its evolutionary trends.

[**Method/Process**] Introducing Rank-Dependent Expected Utility (RDEU) theory, we establish a tripartite evolutionary game model to analyze how emotional factors influence the behavioral decision-making of agents and the development trends of public opinion under different emotional states, while also examining the impact of emotional states on decision-making.

[**Results/Conclusions**] The research demonstrates that emotions affect agents' behavioral decisions, and different emotional types and intensities among agents lead to different evolutionary trends in online public opinion. Scenarios where all three parties are emotionless, or where netizens and online media hold optimistic emotions while the government holds pessimistic emotions, are more conducive to rational evolution of online public opinion. Moreover, compared to netizens and online media, the government' s emotional state has a greater impact on the evolutionary game outcomes; when the government is in a pessimistic state, it tends to adopt more proactive measures to supervise and govern online public opinion.

Keywords: online public opinion; Rank-Dependent Expected Utility theory; emotion; tripartite evolutionary game

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1. Related Research

Sudden public events such as production accidents and extreme weather occur frequently in today' s omnimedia era, almost invariably accompanied by simultaneous network public opinion incidents. Examples include the March 21, 2022 China Eastern Airlines plane crash and the February 22, 2024 collision that broke the Lixinsha Bridge in Nansha District, Guangzhou—both of which quickly triggered intense online public opinion due to their massive radiating impact. However, given the complexity of online communities, different groups exhibit various conflicting emotions when facing emergencies, which become cross-infectious during communication, further transforming online platforms into arenas for intense emotional conflicts and increasing the difficulty of trend judgment and control.

For instance, on December 18, 2023, a 6.2-magnitude earthquake struck Jishishan County, Linxia Hui Autonomous Prefecture, Gansu Province, affecting neighboring Qinghai Province. By December 22, the earthquake had caused 117 deaths in Gansu and 31 deaths with 198 injuries in Haidong City, Qinghai, immediately drawing nationwide attention. While information spread rapidly online, a large amount of false content and negative emotions about the earthquake proliferated across the internet during this solemn moment of national concern, causing public panic, affecting rational judgment and analysis, and seriously disrupting social order. As early as 2018, the General Office of the State Council issued the "Opinions on Promoting the Healthy and Orderly Development of Government New Media," emphasizing that the government must strengthen supervision and guidance of new media platforms to create a clear and bright online environment.

Scientific research shows that paying attention to the evolution of netizens' emotions and analyzing the evolution of sudden public event network public opinion under emotional influence is of great significance for building an ecological governance mechanism for cyberspace and establishing trust between the public and the government. Existing literature reveals that scholars increasingly emphasize the emotional factors of network public opinion subjects. Emotions significantly

impact the interpretation of ambiguous information, judgment of probabilities and consequences, selection of risky options, and causal reasoning in decision-making processes. Moreover, emotional experiences directly influence attitudes and behaviors toward matters.

Through literature review, we find that scholars continuously improve network public opinion propagation and evolution models using various methods including machine learning and deep learning. Some foreign scholars proposed the DK epidemic model for rumor propagation and improved upon the SIR model by incorporating time delays and forgetting mechanisms. Domestic scholars have also considered the dynamic nature of network public opinion propagation, constructing differential game models and complex network-based dual-network information interaction propagation models. As information explodes and complex networks evolve, scholars increasingly adopt evolutionary game theory to study the complex interaction mechanisms among rumor manufacturers, online media, and government, providing more scientifically valuable policy recommendations for government public opinion management in the current network environment.

2.1 Rank-Dependent Expected Utility Theory

Rank-Dependent Expected Utility (RDEU) theory is a utility theory that incorporates individual psychological preferences and emotions, accounting for human bounded rationality. The theoretical core represents individual preferences for strategies using a real-valued function V defined by a utility function U(x) and a decision weight function π(x). For a strategy set X = {x_i} where x_1 > x_2 > ···> x_n and P{X = x_i} = p_i, the probability distribution function is RP_i = P{X > x_i} = p_{i+1} + ···+ p_n. Strategies are ranked according to U(x), and the utility rank of strategy x_i is defined as RP_i. The decision weight function is constructed as:

$$\pi(p_i) = w\left(\sum_{k=1}^{i} p_k\right) - w\left(\sum_{k=1}^{i-1} p_k\right)$$

where w($\cdot$) is a monotonically increasing function satisfying w(0) = 0 and w(1) = 1. This utility theory introduces an emotional function into the strategy's rank distribution, where w($\cdot$) serves as the emotional function. The combination of the utility function and emotional function forms cumulative nonlinear decision weights, which can characterize the influence of emotional states and intensities on public opinion subjects under uncertainty.

2.2 Definition of Three Participating Agents in Network Public Opinion Evolution

Netizens: In this study, netizens refer to network users who utilize online platforms to gather public opinion information and express their views and

emotions.
Online Media: This refers to news websites, social media platforms, and other network-based social media.
Government: This refers to relevant government agencies that intervene and implement control over network public opinion.

2.3 Basic Assumptions of the Game

Netizen Behavioral Strategy Assumptions: When netizens choose to participate in network public opinion, they must invest time and energy costs but gain psychological satisfaction and a sense of identity. When they choose not to participate, they incur no costs but lose the benefits of participation. Under government regulation, participation yields benefits from social stability measures, but netizens may suffer losses from criticism or cyber violence due to erroneous statements. The probability of netizen participation is x, and non-participation is 1-x.

Online Media Behavioral Strategy Assumptions: When online media choose to disseminate public opinion events, they incur costs for information collection, follow-up, and marketing while gaining high attention and traffic benefits. If the government intervenes and regulates, media suffer losses from regulatory pressure. If they choose not to disseminate, they incur no costs but lose traffic from netizen participation. The probability of media dissemination is y, and non-dissemination is 1-y.

Government Behavioral Strategy Assumptions: When the government chooses to regulate, it incurs costs for information collection, manpower, and material resources for supervision while gaining monitoring benefits and enhanced public trust. Choosing not to regulate leads to declining credibility and damaged image. The probability of government regulation is z, and non-regulation is 1-z.

Based on these behavioral strategy assumptions, the netizen decision tree in the network public opinion evolution process is shown in [Figure 1: see original paper], with eight possible behavioral decision combinations among netizens, online media, and government.

2.4 Model Parameter Settings

The costs, benefits, and losses for each participating agent vary under different strategy combinations. The main parameters and their meanings are shown in , and the income matrix for netizens, online media, and government in the network public opinion evolution process is shown in .

2.4.1 Replication Dynamic Equation for Netizen Participation in Network Public Opinion Events

Let U1 be the expected payoff for netizens choosing to participate in network public opinion strategy, U2 be the expected payoff for non-participation, and U be the average expected payoff. The emotional utility payoff for netizens is:

$$U_1 = yr_2zr_3(R_{11}+R_{12}-C_1-L_{12})+(1-yr_2)zr_3(R_{11}+R_{12}-C_1-L_{12})+yr_2(1-zr_3)(R_{11}-C_1-L_{11})+(1-yr_2)(1-zr$$

Applying RDEU theory:

$$U_1 = (R_{11} + R_{12} - C_1 - L_{12})w(xz) + (R_{11} - C_1 - L_{11})w(x)$$

where w(x) = (x)^{r_1}, w(xz) = (xz)^{r_1}, and r_1 is the emotion function.

The replication dynamic equation, which describes the evolution of netizens' strategy adjustment under emotional influence given their learning capabilities, is:

$$F(x) = \frac{dx}{dt} = xr_1(U_1-U) = xr_1[R_{11}+L_{11}-L_{12}zr_3-(R_{11}+R_{12}-C_1-L_{12})(xz)^{r_1}-(R_{11}-C_1-L_{12})]$$

The income, probability, rank, and weight of each netizen strategy are shown in .

2.4.2 Replication Dynamic Equation for Online Media Dissemination of Network Public Opinion Events

Based on , the replication dynamic equation for online media choosing to disseminate public opinion is:

$$F(y) = \frac{dy}{dt} = yr_2\{(R_2+C_2-L_{12})zr_3-(yz)^{r_1}+(R_2-C_2)[RCL+...]-L_{22}[(x+y-xy)+yr_2]\}$$

2.4.3 Replication Dynamic Equation for Government Regulation of Network Public Opinion Events

Based on , the replication dynamic equation for government regulation strategy is:

$$F(z) = \frac{dz}{dt} = zr_2\{(R_3+C_3-L_3)xr_1-xr_1yr_2+yr_2-(xz+yz-xyz)-C_3[(1-xr_1)(1-yr_2)]-zr_3-(xz+yz-xyz)^{r_3}+$$

3. Solution and Analysis of the Game Model

To find the Nash equilibrium solutions, we set F(x) = 0, F(y) = 0, and F(z) = 0, obtaining nine stable equilibrium points: E1(0,0,0), E2(0,0,1), E3(0,1,0), E4(0,1,1), E5(1,0,0), E6(1,0,1), E7(1,1,0), E8(1,1,1), and E9(x, *y*, z*). The stability of these points is analyzed using the Jacobian matrix J.

3.1 All Three Parties in Emotionless State

When r1 = r2 = r3 = 1 (all parties emotionless), the evolutionary stability is shown in . In this scenario, netizens tend to participate in network public opinion with probability fluctuating between 0.18 and 0.3, online media' s dissemination probability stabilizes around 0.38, and government' s regulation probability remains near 0.32. With sufficient information and rational emotions, all three parties make decisions through logical thinking, tending toward conservative behavioral strategies. This rational state helps avoid extreme group phenomena in network public opinion.

3.2 Government in Emotional State

When the government is in an optimistic emotional state (r1 = 1, r2 = 1, r3 = 0.3), as shown in [Figure 3: see original paper], netizens do not clearly tend toward any stable strategy. Online media' s dissemination probability stabilizes around 0.48-0.5, while government' s regulation probability approaches 0. Influenced by the government' s non-regulation strategy, online media adjusts its strategy based on its own benefits, choosing to disseminate with nearly 50% probability to reduce losses from potential government monitoring.

When the government holds a pessimistic emotional state (r1 = 1, r2 = 1, r3 = 1.7), as shown in [Figure 4: see original paper], netizens'participation probability floats around 0.2, while government's regulation probability exceeds 0.57. Under pessimistic emotions, the government becomes more tense about emergencies, anticipating worsening situations, and thus chooses high-attention regulation strategies.

3.3 Online Media in Emotional State

When online media holds optimistic emotions (r1 = 1, r2 = 0.3, r3 = 1), as shown in [Figure 5: see original paper], netizens' participation probability concentrates around 0.18, government' s regulation probability is about 0.26, while online media' s dissemination probability reaches 0.63. With complete information, netizens easily satisfy their need for truth and mostly choose non-participation. However, online media, lacking information and in an optimistic emotional state, may make impulsive, radical decisions to disseminate public opinion.

When online media holds pessimistic emotions (r1 = 1, r2 = 1.7, r3 = 1), as shown in [Figure 6: see original paper], netizens' participation probability is 0, online media' s dissemination probability is about 0.39, and government' s

regulation probability stabilizes near 0.38. Under pessimistic influence and with rational netizens and government, online media almost never disseminates, while the government adopts relaxed regulation, allowing public opinion to self-digest and creating a relatively stable network environment.

3.4 Netizens in Emotional State

When netizens hold optimistic emotions (r1 = 0.3, r2 = 1, r3 = 1), as shown in [Figure 7: see original paper], netizens' participation probability concentrates around 0.24, government' s regulation probability is about 0.41, and online media' s dissemination probability approaches 0. With rational decision-making from all parties, optimistic netizens gradually evolve toward non-participation, while online media almost never disseminates and the government maintains a relatively relaxed regulatory stance, resulting in a relatively healthy network environment.

When netizens hold pessimistic emotions (r1 = 1.7, r2 = 1, r3 = 1), as shown in [Figure 8: see original paper], netizens develop pessimistic psychology about emergencies without forming a unified evolutionary stable strategy. Lacking effective information, netizens easily fall into passive positions under group discussion pressure, producing blind, emotionally-driven herd behavior.

4. Simulation Analysis

Based on the above assumptions, model parameter values are set as: R11 = 2, R12 = 4, C1 = -1.5, L11 = -0.5, L12 = -1, R2 = 5, C2 = -2, L22 = -4, R3 = 5, C3 = -3, L3 = -5. Fifty simulation runs analyze evolutionary situations under different emotional states and strategy combinations.

When all three parties are emotionless, each party adopts conservative strategies through rational judgment. When the government is emotional, its emotional state most significantly impacts the evolutionary game results. Compared to netizens and online media, the government' s emotions have a greater influence on public opinion evolution. When the government is pessimistic, it tends to adopt proactive supervision measures. When online media is emotional, its dissemination behavior becomes more volatile. When netizens are emotional, their participation decisions become unstable, particularly under pessimistic emotions where they fail to form stable strategies.

5. Conclusion

This study introduces Rank-Dependent Expected Utility theory, which incorporates individual psychological preferences and emotions, to construct a tripartite evolutionary game model of netizens, online media, and government involved in network public opinion. The analysis reveals that emotional factors influence each agent's behavioral decisions, and different emotional states lead to different evolutionary trends in network public opinion.

Key findings show that when all three parties are emotionless (rational), or when netizens and online media are optimistic while the government is pessimistic, network public opinion evolves more rationally. The government' s emotional state has the most significant impact on evolutionary outcomes. When the government is pessimistic, it tends toward active regulation, which effectively governs network public opinion.

Based on these conclusions, we propose the following government strategies:

1. **Monitor and Guide Netizen Emotions:** The government should establish an effective netizen emotion monitoring and response mechanism to track emotional dynamics in real-time, helping assess development trends. When negative emotions emerge, timely guidance and communication are essential to prevent social instability.
2. **Strengthen Online Media Supervision:** The government should enhance supervision of online media, ensuring comprehensive and objective reporting while preventing false information dissemination. Media management should ensure reports remain objective and neutral, avoiding excessive exaggeration that triggers negative emotions.
3. **Maintain Comprehensive Information and Rational Decision-Making:** When emergencies occur, the government must quickly and comprehensively grasp relevant information to provide a basis for situation assessment. Decision-making should fully consider the nature of emergencies and accurately analyze current public opinion situations, avoiding judgments based solely on past experience or subjective assumptions. The government should maintain calm and rational decision-making states, improving emergency response capabilities while avoiding excessive optimism or pessimism.

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Note: Figure translations are in progress. See original paper for figures.