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# Quantitative Research on the Evolution Stages of We-media Network Public Opinion based on a Logistic Equation

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**Abstract:** We-media network public opinion is a new force in the current social public opinion field that has an important impact on the guidance of social public opinion and social stability. Studying the periodic law of we-media network public opinion dissemination and constructing a quantitative model of we-media network public opinion dissemination stages provide the basis for guiding social public opinion and governing we-media network public opinion dissemination. Based on this, this paper explores the life cycle of we-media network public opinion evolution, analyzes the characteristics and connotations of each evolution stage, and determines the dominant indicators of we-media network public opinion evolution stages; in addition, this paper constructs a logistic quantitative model and its stage refinement model for the evolution and development of we-media network public opinion and uses MATLAB software to simulate the event of the academic fraud of the Chinese actor Zhai. This paper studies the four key points on the logistic curve of we-media network public opinion evolution and the five key intervals, analyzes the connotation of the quantified stage of each interval, and puts forward the governance strategy of we-media network public opinion events, through the simulation of initial values, growth rates and upper limits.

**Keywords:** dissemination stage; logistic model; network public opinion; refinement model; we-media

## 1 INTRODUCTION (INTRODUCTORY REMARKS)

According to information released by the Ministry of Industry and Information Technology of China, by the end of 2019, China had become the country with the largest number of netizens in the world, with 914 million people and a 65.7% Internet penetration rate, ranking at the forefront of the world. Moreover, Chinese netizens are still growing by a large margin every year, and an increasing number of Chinese netizens have begun to use mobile Internet devices or smart phones for online activities [1]. Mobile Internet devices not only facilitate people's contact with each other but also help netizens express their thoughts and opinions on the Internet anytime and anywhere, greatly promoting the development of public opinion on mobile social networks, that is, the development of so-called we-media network public opinion. We-media network public opinion is a very important part of the public opinion system, and people express their attention to popular social issues or public focus events through the mobile Internet platform, which is diverse, fast and interactive [2]. At present, the influence of we-media network public opinion is increasing, and it has become an important force in the social public opinion field, which has an important impact on social stability and people's lives. Some hot network events which have been widely publicized on the Chinese internet have aroused great concern of Chinese we-media netizens, produced great repercussions in the society and also brought some unstable factors to the social stability, such as "the incident of Shaanxi Mercedes-Benz female owner's rights protection" in 2019, "the case of a young man who stopped rape being detained for 14 days", "Murder of a 10-year-old girl by a 13-year-old boy in Dalian", the "Beijing woman drove a Mercedes into the Forbidden City" in 2020, "the Luckin self-disclosed fake transaction case", "the case of fake milk powder's leading to big head babies in Hunan" and so on. If it is not guided and regulated, it is likely to affect social stability and even cause public security incidents. Therefore, it is necessary to explore the development law of we-media network public opinion evolution, quantify the stages of evolution and development of we-media network public opinion, and formulate targeted governance strategies for its development stages, as this has an important role and great significance for social stability.

With the continuous popularity of social platforms such as Bebo in the UK, Facebook, Twitter and WeChat in the US, and Chinese WeChat, Weibo, Douyin and QQ, we-media networks have gradually come to play the role of social and information communication bridges in the daily life of netizens. At the same time, with the development of mobile Internet technology, social information dissemination has become more convenient and smooth, and we-media network public opinion has gradually taken on the core role of mass social communication and information dissemination, which affects the dissemination and evolution of social public opinion and has made research on we-media network public opinion the focus of scholars. For example, Rapoport et al. (1952) first used the infectious disease model in research on information dissemination, which provided a new direction for research on we-media network public opinion dissemination [3]. Leskovec et al. (2007) used the susceptible-infected-susceptible (SIS) model to simulate the propagation of network public opinion; Chen Bo et al. (2011) proposed a network public opinion propagation control model in a ubiquitous media environment based on the susceptible-exposed-infected-recovered (SEIR) model [4]. With the development of complex networks, scholars have found that random networks, scale-free networks and small-world networks can be used to simulate real social networks. Therefore, it has become a new research hotspot to explore the propagation law of we-media network public opinion by comprehensively using infectious disease models and complex networks. Yang et al. (2018) used the susceptible-infected-recovered (SIR) model to study the propagation of we-media network public opinion and analyzed the propagation threshold in a small-world network [5]. Wei Jing et al. (2019) proposed an improved SIR model, used a directed scale-free network to simulate a microblog network, and analyzed the factors affecting the spread of public opinion on a microblog network [6].

In the research on we-media network user behavior analysis, Gundottir (2016) studied the effect of cultural

factors on the motivation of users to publish and share information on we-media networks and measured the influence of cultural factors on self-decision-making from a personal perspective [7]; Aiello et al. (2018) carried out machine calculations on the user behavior characteristics of we-media networks, and the research goal was to apply the algorithm of we-media networks to predict user preferences and analyze the information relationships of users of we-media networks after identifying their preferences [8]; Sayyadi et al. (2019) incorporated the hedonic, social and utilitarian characteristics of the we-media network environment and studied the continuous use behavior tendency of we-media network users through the technology reception model [9]; Clarke et al. (2019) discussed the influence of we-media network service social media and the user's social knowledge value perception on word-of-mouth dissemination of corporate social media [10]; and Zhang Jie et al. (2020) studied the security and privacy of user information on we-media networks, specifically using an empirical case to prove the importance of perception factors in the information sharing behavior of netizens in we-media networks [11].

Scholars have studied the division of the stages of we-media network public opinion dissemination from different perspectives. From the perspective of government information management, Zhou Wei (2018) divides the process of we-media public opinion dissemination into three stages: crisis incubation, crisis outbreak and crisis recovery [12]; According to the harm caused to society by the continuous development and evolution of we-media public opinion, Zhang Jie et al (2020) divides it into three stages: the stage of possible harm and threat generation, the stage of actual harm occurring, and the stage of harm's gradually weakening and recovering. Generally, it can be divided into four stages: early warning period, outbreak period, remission period and later period [13]. Huang Su-fen et al (2021) sums up the evolution stages of we-media public opinion as incubation, emergence, evolution, remission and disappearance [14]. Although there are differences in the division of specific stages of we-media network public opinion evolution, they have one thing in common, that is, they regard the dissemination process of we-media public opinion as a life cycle, which covers four stages: incubation, outbreak continuation period and recovery. Generally speaking, although scholars have divided the stages of we-media network public opinion dissemination, there are still two problems in previous research: on the one hand, the division and perspective of we-media network public opinion dissemination stages are not the same, which leads to the different evolution patterns of its life cycle with time; on the other hand, the division of we-media network public opinion dissemination stages is relatively rough, and it fails to make a more precise division in terms of quantity, so that it is impossible to identify and govern we-media network public opinion events by stages.

In summary, scholars have performed much research on we-media network public opinion, especially on traditional Internet public opinion, and have achieved fruitful results. However, the research on we-media network public opinion based on mobile Internet technology needs to be further expanded; in particular, the research on the evolution of we-media network public opinion needs to be further refined. Based on this, from the perspective of the evolution and development of we-media network public opinion, this paper studies the internal characteristics of its development stages and reveals the development law of each stage through empirical simulation. Then, governance strategies are proposed.

The structure of this paper is as follows: The first part is the introduction, which briefly introduces the influence of we-media network public opinion on society and reviews the related research on we-media network public opinion. The second part is the theoretical basis, which discusses the life cycle and evolution stage indicators of we-media network public opinion. The third part is model construction, which constructs a logistic quantitative model of the evolution stage of we-media network public opinion and a refined model of the communication stage. The fourth part is the simulation analysis, taking the event of the academic fraud of the Chinese actor Zhai as the research object; using the statistical data of the official website of Sina Weibo, this paper simulates and analyzes the quantitative problem of the evolution stage of we-media network public opinion. The fifth part presents countermeasures and suggestions. Based on the simulation analysis, we propose a governance strategy for we-media network public opinion.

## 2 THEORETICAL BASIS

### 2.1 The Life Cycle of We-media Network Public Opinion Evolution

The growth law of we-media network public opinion conforms to a logistic curve. According to the change in the growth rate of the logistic curve, the life cycle of we-media network public opinion can be divided into the incubation period, prediffusion period, postdiffusion period and extinction period [15, 16]. According to agenda setting theory, we-media network information updates rapidly, and only a small number of topics are activated from the incubation period to the diffusion period [17]. Most topics are diluted in the incubation period (the mechanism is shown in Fig. 1). Therefore, it is particularly important to find public opinion topics with diffusion potential in poor data environments during the public opinion incubation period. In this paper, we simplify the evolution of we-media network public opinion into the incubation period and diffusion period. From the perspective of event types and public opinion characteristics, we comprehensively consider the main characteristic factors that affect the development of public opinion in each stage and construct a classification indicator system.

We-media network public opinion has different characteristics in each development stage, which helps us better understand and grasp the development law of network public opinion. Specifically, the characteristics of the development stages of we-media network public opinion are as follows:

(1) Incubation period. In this period, we-media network public opinion begins to form; the public opinion triggered by public events is still in the embryonic stage and is in the breeding period of newly trending public opinion. The incubation period of we-media network public opinion depends mainly on popular public events,

such as violent demolitions, environmental pollution, traffic jams, official corruption and other social issues closely related to the vital interests of netizens. After these events appear on the Internet, they will cause great concern for netizens. Some netizens will freely discuss and evaluate the events in cyberspace, and with the spread and development of the event, its influence may exceed a certain range, leading to the transition of we-media network public opinion from the incubation period to the growth period.

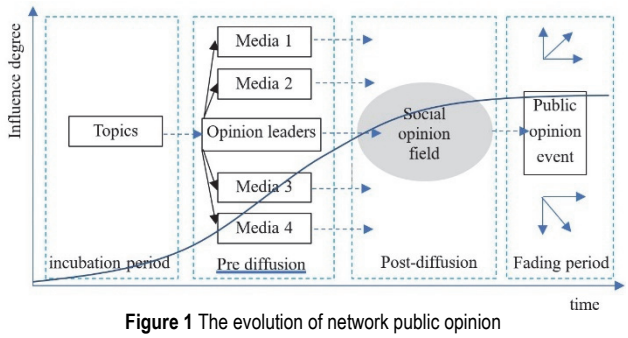


**Figure 1** The evolution of network public opinion

(2) Growth period. The growth period is an important stage in the evolution and development of we-media network public opinion that indicates that the corresponding network events have attracted a large number of netizens. In this process, different netizens conduct in-depth exchanges and discussions, gradually integrating several representative views from the original "contention of a hundred schools of thought", and are likely to produce a unified group opinion of netizens to promote the development of we-media network public opinion in a certain direction. At this time, personal opinions that do not conform to the mainstream opinions will disappear, and the different views of related events will gradually develop into the collective views of platform consistency. In the growth period, social hotspots attract different netizens on the mobile Internet platform. Through collective discussion and communication, netizens expand the power of group public opinion, and individual consciousness gives way to collective consciousness.

(3) Mature period. In this period, we-media network public opinion gradually attains social influence, and along with social influence, gains the ability to guide public opinion, which causes the mainstream media to pay attention to popular social issues and leads increasing media resources to join in the dissemination of we-media network public opinion. With the addition of various media and network resources, the integration of netizens' opinions is further improved, the tendentious characteristics of popular social public opinion begin to appear, and then dominant and unified public opinion appears. With the continuous participation, interaction and promotion of netizens and the help of other media, we-media network public opinion reaches extreme intensity and becomes the leading force in the field of public opinion, having an important impact on public opinion; at this time, we-media network public opinion forms the mainstream public opinion, and public opinion reaches the "peak" of evolution and development.

(4) Recession period. At the late stage of the mature period, for various reasons, we-media network public opinion slowly enters the recession period; the popular topics of concern gradually fade from people's view, and are replaced by new public events and popular topics. After a period of time, the we-media network public opinion event will no longer cause discussion but will exist only in the memory of some netizens. In essence, the decline of we-media network public opinion does not mean the end of the network event itself but that the attention of netizens has been attracted by other network events. The mainstream media no longer pay attention to the previous network events, updated social hotspots replace them, and netizens' attention shifts to new popular events.

Therefore, the evolution and development of we-media network public opinion has the characteristics of a life cycle, which is reflected in two respects. One is that no network event happens suddenly; from a macro-level perspective, they all go through four processes, generation, establishment, development and decline, which constitute the complete cycle of we-media network events. The other is that the life cycle of we-media network public opinion in real life is mainly manifested in four periods, the incubation period, growth period, maturity period and recession period, which constitute the complete cycle of the evolution and development of we-media network public opinion. Overall, the life cycle of the evolution and development of we-media network public opinion is shown in Fig. 2.

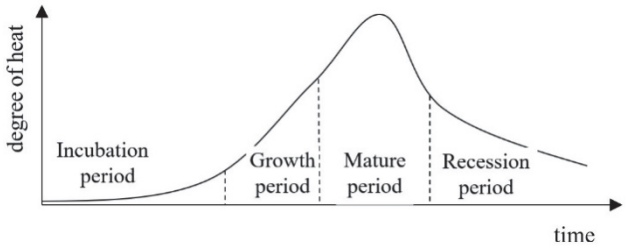


**Figure 2** The life cycle of the evolution and development of we-media network public opinion

## 2.2 Indicators of the Evolution Stage of We-media Network Public Opinion

The dominant indicators of we-media network public opinion measure the behavior or event that plays a key role in the generation, promotion and development of we-media network public opinion. Through the analysis of the behavior of the subject of we-media network public opinion in different stages, it is determined that the attention degree of we-media network public opinion in each stage is the first dominant indicator that we should pay attention to; at the same time, different stages depend on different indicators. Specifically, this is summarized as follows:

(1) The dominant indicators of the incubation period. The dominant indicators of this period include the activities of the event parties, the influence of netizens, the speed of the government's collection of information related to the event, the attitude to its response, and the prestige of the media. At the same time, they include the IP address of the event publisher, the industry of the publisher, the social platform of the event publisher, and the IP address of the event receiver. Based on the above situation, the influence of different we-media platforms varies, and there will be

more popular public opinions on influential platforms. By analyzing the IP address of the receiver, we can effectively determine the scope and region of public opinion. According to the receiver's industry situation, we can determine the receiver's attitude toward the same public opinion in different industries and then determine the development of public opinion through the statistical analysis of the indicators.

(2) The dominant indicators of the growth period. The dominant indicators of this period include the interactivity and emotional inclination of netizens, the activity of the media, the responsiveness and credibility of the government, the transparency of information, and the speed of public opinion dissemination. Government responsiveness includes the response attitude to public events, response speed, response management level and dynamic response behavior. These indicators mainly reflect the management of social platforms and the response to media. The transmission speed of we-media network public opinion involves the scope of diffusion, which reflects the speed of public opinion propagation and the possibility of the next development of public opinion.

(3) The dominant indicators of the mature stage. The dominant indicators of this period include the total number of similar public opinion subjects, click frequencies and times, forwarding and comment times, the number and influence of fans of publishers, the number and influence of fans of receivers, the number of second forwardings of topics, etc. Focusing on the total number of similar topics, the number of topics related to we-media network public opinion can be determined, which is conducive to the control of related hotspots and public opinion; the purpose of paying attention to the click frequency and times is mainly to understand the degree of attention to the events related by the theme in a certain period of time; paying attention to the number of reposts and comments can facilitate understanding of the public's attitude and attention to public opinion; the number and influence of fans of the publisher are mainly reflected in their friends and fans, especially for those with many friends and fans, which have a great influence on public opinion; and the number and influence of fans of the receiver can directly affect the secondary dissemination of public opinion. Therefore, we need to focus on netizens with more friends and fans, especially netizens with more influence on the social platform. The number of secondary forwardings of topics refers to the reforwarding of forwarded topics; the more forwards there are, the larger the audience, the wider the scope of influence, and the greater the possibility of becoming a popular public opinion.

(4) The dominant indicators of the recession period. The recession period generally indicates that the popularity of we-media network public opinion is greatly reduced and that it is at the end stage of its evolution and development. With the emergence of other popular events, we-media network public opinion on this event will withdraw from the public opinion field in a short time. Therefore, the dominant indicators that should be considered in this period are mainly reflected in the continuous attention of netizens, the duration of netizens' participation, the frequency of other media interaction, the speed of government information survey collection and the attitude to the response. These indicators are mainly used to evaluate the decline of we-media network public opinion popularity.

## 3 MODEL CONSTRUCTION

### 3.1 Quantitative Model of We-media Network Public Opinion Evolution Stages

Based on the meaning of we-media network public opinion [18, 19], we-media network public opinion is the sum of the information exchange regarding a popular social event through a mobile Internet platform. Therefore, mobile Internet technology is the loading platform and material basis of we-media network public opinion, and the amount of relevant platform information is the source of its development and evolution. The total value of the information quantity of the mobile Internet platform will change with the evolution of we-media network public opinion; this change is in line with statistical laws (that is, statistical data can yield the total value of a variable by accumulation, and the total value of a variable can yield statistical data by subtraction [20]), and over time, it changes according to a monotonically increasing function [21]. Generally, the total value of the information quantity is a discrete variable; therefore, by simulating the cumulative value of statistical data, we can treat the evolution and propagation of we-media network public opinion as a continuous monotonically increasing function of time. The equation is as follows:

$$x = x(t) \ (t \geq 0) \tag{1}$$

In Eq. (1), $x(t)$ can be regarded as the difference function of $\Delta x_k$, where $k = 0, 1, 2, ..., n - 1$. In the statistical data fitting calculation, $x = x(t)$ can be derived as follows:

$$x' = x(t)' \ \ (t \geq 0) \tag{2}$$

If $x(t)$ represents the total value of the information quantity of we-media network public opinion and $x(0) = x_0$, the upper limit of $x(t)$ is $K$. Since $x(t)$ is a monotonically increasing function, the total value of the information quantity per unit time of the we-media network public opinion platform will change with the relative change rate $r$. Then, the following result will be obtained:

$$\frac{\mathrm{d}x}{x\mathrm{d}t} = r \tag{3}$$

Generally, the change in the total value of the information quantity in the evolution of we-media network public opinion is mainly limited by the growth rate $r$, which is a function of $x$. The equation is as follows:

$$\frac{\mathrm{d}x}{x\mathrm{d}t} = r(x) \tag{4}$$

The complete differential equation is:

$$\begin{cases} \dfrac{\mathrm{d}x}{\mathrm{d}t} = xr(x) \\ x(0) = x_0 \end{cases} \tag{5}$$

As seen from the above equations, the growth rate function $r(x)$ is a core function concerning the evolution of we-media network public opinion, but the growth of its information is affected by the $K$ value and determines the "remaining space" of we-media network public opinion information $(1 - x/K)$. In this case, the equation is as follows:

$$r(x) = r\left(1 - \frac{x}{K}\right) \tag{6}$$

Therefore, the quantitative model of the evolution and development of we-media network public opinion can be constructed as follows:

$$\begin{cases} \dfrac{\mathrm{d}x}{\mathrm{d}t} = xr\left(1 - \dfrac{x}{K}\right) \\ x(0) = x_0 \end{cases} \tag{7}$$

Eq. (7) is a logistic equation, which has three key parameters: the initial value $x_0$, inherent growth rate $r$ and upper limit $K$. If the differential equation is used to solve the problem, the equation is as follows:

$$x(t) = \frac{K}{1 + \left(\dfrac{K}{x_0} - 1\right)\mathrm{e}^{-rt}} \tag{8}$$

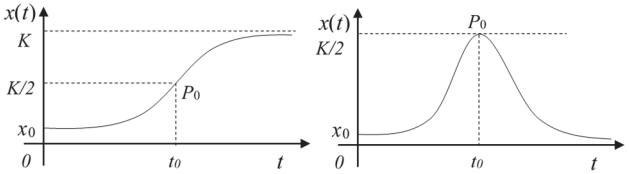


**Figure 3** Comparison between the function image and derivative function image of the logistic model

Therefore, the quantitative model of we-media network public opinion evolution stages is a logistic model, and the function image and derivative function image are as shown in Fig. 3. In Fig. 3, $P_0$ is the inflection point of the function curve and the node of the evolution and development of we-media network public opinion. The logistic model curve has an "s" shape on the whole, which reveals the internal law of the evolution and development of we-media network public opinion [17].

### 3.2 Refined Model of We-media Network Public Opinion Dissemination Stages

According to principles of calculus, the third and fourth derivatives of the function in Eq. (7) are determined, and the results are as follows:

$$\begin{cases} x''' = r^2 x'\left(1 + \dfrac{6x^2}{K^2} - \dfrac{6x}{K}\right) \\ x^{(4)} = r^3 x'\left(1 - \dfrac{2x}{K}\right)\left(1 + \dfrac{12x^2}{K^2} - \dfrac{12x}{K}\right) \end{cases} \tag{9}$$

Let $x''' = 0$. The coordinates of two key points of we-media network public opinion dissemination are determined as follows:

$$P_2\left(t_2, \frac{3-\sqrt{3}}{6}K\right),\ P_2\left(t_2, \frac{3-\sqrt{3}}{6}K\right),$$

$$\text{where: } \begin{cases} t_2 = \dfrac{1}{r}\left[\ln\left(2-\sqrt{3}\right) + \ln\left(\dfrac{K}{x_0} - 1\right)\right] \\ t_3 = \dfrac{1}{r}\left[\ln\left(2+\sqrt{3}\right) + \ln\left(\dfrac{K}{x_0} - 1\right)\right] \end{cases} \tag{10}$$

Let $x^{(4)} = 0$; the coordinates of the other two key points of we-media network public opinion dissemination are determined as follows:

$$P_1\left(\mathrm{t}_1, \frac{3-\sqrt{6}}{6}\mathrm{K}\right), P_4\left(t_4, \frac{3+\sqrt{6}}{6}K\right),$$

$$\text{where: } \begin{cases} t_1 = \dfrac{1}{r}\left[\ln\left(5-2\sqrt{6}\right) + \ln\left(\dfrac{K}{x_0} - 1\right)\right] \\ t_4 = \dfrac{1}{r}\left[\ln\left(5+2\sqrt{6}\right) + \ln\left(\dfrac{K}{x_0} - 1\right)\right] \end{cases} \tag{11}$$

By calculating the four key points $P_1$, $P_2$, $P_3$ and $P_4$ of the logistic model, the curve can be divided into five parts, which correspond to the five key intervals $[0,t_1]$, $[t_1,t_2]$, $[t_2,t_3]$, $[t_3,t_4]$ and $[t_4,+\infty)$ of we-media network public opinion dissemination. In turn, the increment of the cumulative information volume in each of the 5 intervals of we-media network public opinion is calculated as follows:

Part one, $(-\infty,t_1]$:

$$f(t)\Big|_{-\infty}^{t_1} = \frac{K}{6+2\sqrt{6}} - 0 \approx 0.0918K$$

Part two, $[t_1,t_2]$:

$$f(t)\Big|_{t_1}^{t_2} = \frac{K}{3+\sqrt{3}} - \frac{K}{6+2\sqrt{6}} \approx 0.1196K$$

Part three, $[t_2,t_3]$:

$$f(t)\Big|_{t_1}^{t_2} = \frac{K}{3-\sqrt{3}} - \frac{K}{3+\sqrt{3}} \approx 0.5774K$$

Part four, $[t_3,t_4]$:

$$f(t)\Big|_{t_3}^{t_4} = \frac{K}{6-2\sqrt{6}} - \frac{K}{3-\sqrt{3}} \approx 0.1196K$$

Part five, $[t_4,+\infty)$:

$$f(t)\Big|_{t_4}^{+\infty} = K - \frac{K}{6-2\sqrt{6}} \approx 0.0918K$$

In addition, the lengths of $[t_1,t_2]$, $[t_2,t_3]$ and $[t_3,t_4]$

can be calculated accurately:

$$\text{Part two } [t_1,t_2]: \ t_2-t_1=\frac{1}{r}\ln\frac{2-\sqrt{3}}{5-2\sqrt{6}}\approx\frac{0.9755}{r}$$

$$\text{Part three } [t_2,t_3]: \ t_3-t_2=\frac{1}{r}\ln\frac{2+\sqrt{3}}{2-\sqrt{3}}\approx\frac{2.6339}{r}$$

$$\text{Part four } [t_3,t_4]: \ t_4-t_3=\frac{1}{r}\ln\frac{3+2\sqrt{6}}{2+\sqrt{3}}\approx\frac{0.9755}{r}$$

Based on the above, it is found that the increment of the cumulative information volume in the five intervals of we-media network public opinion is related only to the upper limit $K$ and has nothing to do with the growth rate $r$ or the initial value $x_0$; the lengths of the three key intervals are related only to the growth rate $r$ but have nothing to do with the initial value $x_0$ or the upper limit $K$.

To deeply study the propagation law of we-media network public opinion dissemination and enhance the degree of fine research, this paper defines the five intervals $[0,t_1]$, $[t_1,t_2]$, $[t_2,t_3]$, $[t_3,t_4]$ and $[t_4,+\infty)$ of we-media network public opinion dissemination as the budding period, incubation period, outbreak period, remission period and saturation period. The key quantitative information of each stage is shown in Tab. 1.

From Tab. 1, it is easy to obtain the characteristics of the network public opinion dissemination stages:

(1) Budding period: In this period, the information increment of we-media network public opinion is the smallest, the attention of netizens is low, and the intensity of network public opinion is low. It is appropriate to carry out network public opinion data prediction, determine the dissemination stage in advance and implement trend warnings in a timely manner. At the same time, the budding period is determined by $t_1$, which is inversely proportional to the initial value. In other words, the larger the initial value is, the shorter the budding period is. In particular, when the initial value is large enough, $t_1$ will be negative, that is, the germination period will be 0.

**Table 1** Key quantitative information of we-media network public opinion dissemination stages

| Dissemination stage | Budding period | Incubation period | Outbreak period | Remission period | Saturation period |
|---|---|---|---|---|---|
| Starting point of the stage | 0 | $t_1$ | $t_2$ | $t_3$ | $t_4$ |
| Ending point of the stage | $t_1$ | $t_2$ | $t_3$ | $t_4$ | - |
| Length of the stage | $t_1$ | 0.9755/$r$ | 2.6339/$r$ | 0.9755/$r$ | - |
| Increment of the stage | 0.0918$K$ | 0.1196$K$ | 0.5774$K$ | 0.1196$K$ | 0.0918$K$ |

(2) Incubation period: In this period, the information increment of we-media network public opinion increases, the attention of netizens increases, opinion leaders appear, and the popularity of network public opinion increases. Due to the addition of new data, the accuracy of we-media network public opinion trend warnings will be greatly improved.

(3) Outbreak period: In this period, the amount of we-media network public opinion information increases rapidly in a short period of time, and the increment is the largest among the five stages. In this stage, netizens pay the most attention, the network opinion is the hottest, a large amount of real information, speculative information and gossip collide, and it is very easy to generate network gossip or even network rumors. It is necessary to closely monitor the abnormal forwarding information change rate and total amount.

(4) Remission period: In this period, the growth of we-media network public opinion information slows, and the popularity of network public opinion decreases. However, at this time, it is very easy to generate a derivative public opinion. Therefore, it is necessary to carry out dynamic prediction and monitor derivative public opinion closely according to the data of the first three stages.

(5) Saturation period: In this period, the growth of we-media network public opinion information tends to be saturated and nears the upper limit $K$. In response to emergencies, the saturation period may last for a long time. Therefore, a long tail effect will appear when drawing the statistical data (cumulative) curve of network public opinion. At the same time, as in the remission period, it is still necessary to monitor anomalies through data forecasting and quickly warn of the development trend of we-media network public opinion.

## 4 SIMULATION ANALYSIS

### 4.1 Data Sources

Since the end of the Chinese Spring Festival in 2019, news about the academic fraud of Zhai, a famous Chinese actor, has been a hot topic on China's major Internet platforms. The academic misconduct of the actor Zhai started on January 31, 2019. After Zhai posted his postdoctoral admission notice from Peking University on his microblog, he received widespread attention from society. Then, in a live interaction in early February 2019, in the face of netizens' questions, Zhai claimed that he did not know what China National Knowledge Infrastructure (CNKI) was. For a person who was going to study as a postdoctoral student, it was odd that he did not recognize CNKI. This incident led to heated discussion among Chinese netizens. Netizens seriously questioned the authenticity of his doctoral degree. Later, the incident that Zhai did not know what CNKI was developed quickly, public opinion gradually intensified, and the influence of this topic gradually expanded. On February 11, 2019, People's Daily, an authoritative Chinese newspaper, made a statement on the incident that Zhai did not know what CNKI was. On February 14, 2019, the Beijing Film Academy, where Dr.Zhai studied, officially began to investigate the incident. On the afternoon of February 14, 2019, Zhai issued an apology letter through his microblog account. As of February 20, 2019, "Zhai did not know what CNKI was", "Zhai's doctoral degree is fake", "Zhai's image as a straight A student collapsed", "Zhai is suspected of

academic misconduct" and other related topics have been read as much as 270.514 million times, and the number of discussions on this topic is 396 million. According to the official website of Sina Weibo, more than 43.7 million pieces of information have been posted and forwarded on the topic of "the academic fraud of actor Zhai". From the beginning of Zhai's academic fraud incident to the time at which Peking University released the processing results, the trend chart of this we-media network public opinion dissemination in days is shown in Fig. 4.

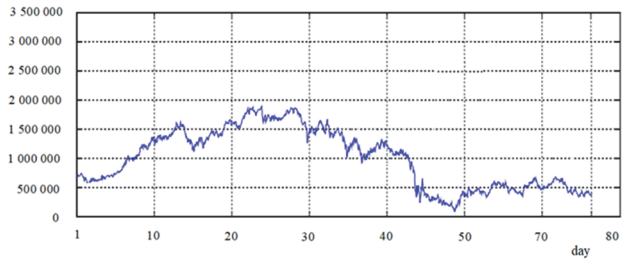


**Figure 4** Statistics of Sina Weibo about the academic fraud of Zhai

## 4.2 Initial Value Simulation

The event of the academic fraud of the actor Zhai spread wildly on the we-media network. The propagation of the event conforms to the characteristics and performance of the logistic model. Because the three parameters of the logistic model (the initial value, growth rate and upper limit) play an important role in the propagation of public opinion, this paper describes in detail the influence of these three parameters on the propagation of we-media network public opinion through a MATLAB data simulation. To unify the standard, the logistic model parameters and their fluctuation range for the event are specified, as shown in Tab. 2.

To quantify the characteristics of the we-media network public opinion propagation stages of the "academic fraud of the actor Zhai" event, we need to fix the growth rate $r$ and upper limit $K$ of the model and study the law of we-media network public opinion propagation and the change in propagation stages through the fluctuation of the initial value $x_0$.

Letting the initial values $x_0$ be 1% $K$, 2% $K$, 4% $K$, 8% $K$, 10% $K$, 20% $K$, 30% $K$, 40% $K$, 50% $K$, 60% $K$, 70% $K$ and 80% $K$, we draw the corresponding logistic curve, as shown in Fig. 5; we calculate the corresponding key time points and study the changes in the key propagation stages of the curve under different initial values, as shown in Tab. 3.

**Table 2** Type parameters and their fluctuation ranges

| Parameter | Initial agreement | Fluctuation range | Overall length of time |
|---|---|---|---|
| Initial value $x_0$ | 1% $K$ | 0 ~ $K$ | 80 |
| Growth rate $r$ | 0.2 | 0.1-1 | |
| Upper limit $K$ | 500000 | 50% ~ 200% $K$ | |

**Table 3** Initial value simulation data table

| Initial value | $t_1$ | $t_2$ | $t_3$ | $t_4$ | Period | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Budding | Incubation | Outbreak | Remission | Saturation |
| 1% $K$ | 9.36 | 12.74 | 35.11 | 38.90 | — | — | — | — | — |
| 2% $K$ | 7.41 | 10.08 | 21.62 | 25.81 | Shortening | In advance | In advance | In advance | In advance, lengthening |
| 4% $K$ | 4.29 | 7.35 | 17.32 | 18.52 | Shortening | In advance | In advance | In advance | In advance, lengthening |
| 8% $K$ | 2.77 | 5.10 | 12.75 | 15.64 | Shortening | In advance | In advance | In advance | In advance, lengthening |
| 10% $K$ | 0.66 | 2.38 | 6.29 | 8.75 | Shortening | In advance | In advance, shortening | In advance | In advance, lengthening |
| 20% $K$ | −0.40 | 1.12 | 3.16 | 5.13 | Shortening | In advance | In advance, shortening | In advance | In advance, lengthening |
| 30% $K$ | −4.55 | 0.37 | 2.05 | 3.47 | Disappearance | Disappearance | In advance, shortening | In advance | In advance, lengthening |
| 40% $K$ | −6.70 | −2.70 | 0.27 | 2.87 | Disappearance | Disappearance | In advance, shortening | In advance | In advance, lengthening |
| 50% $K$ | −8.29 | −5.29 | −2.21 | 1.22 | Disappearance | Disappearance | In advance, shortening | In advance | In advance, lengthening |

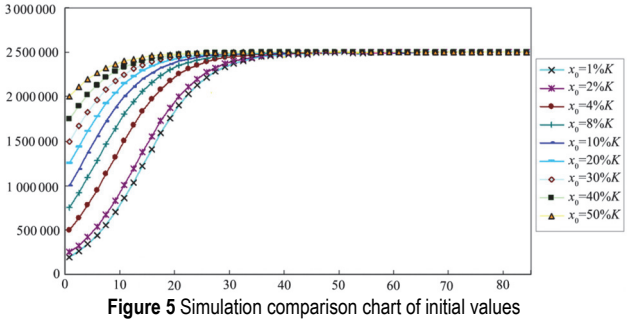


**Figure 5** Simulation comparison chart of initial values

From Fig. 5 and Tab. 3, we find that with the increase in the initial value, the four key time points gradually decrease, and some even have negative values, leading to a shorter budding period. The other four dissemination stages advance; some of them have the same length, some of them decrease and some of them disappear. To accurately describe the relationship between the initial value and the disappearance of the we-media network public opinion dissemination stage of the "academic fraud of the actor Zhai" event, the maximum increment ratio is defined, that is, the ratio of the initial value to the upper limit, as shown in Eq. (12):

$$H_{\max} = \frac{x_0}{K} \tag{12}$$

The maximum increment ratio at the critical state is calculated by the equations of $t_1$, $t_2$, $t_3$ and $t_4$.

$$t_1 = 0 : H_{\max} = \frac{3-\sqrt{6}}{6} \approx 0.0918 = 9.18\%$$

$$t_2 = 0 : H_{\max} = \frac{3-\sqrt{3}}{6} \approx 0.2113 = 21.13\%$$

$$t_3 = 0 : H_{\max} = \frac{3+\sqrt{3}}{6} \approx 0.7887 = 78.87\%$$

$$t_4 = 0 : H_{\max} = \frac{3+\sqrt{6}}{6} \approx 0.9082 = 90.82\%$$

Therefore, the lower limit of the maximum increment ratio of the budding period, incubation period, outbreak period and remission period is 9.18%, 21.13%, 78.87% and 90.82%, respectively, which has nothing to do with the growth rate $r$. Based on this, a ratio similar to the maximum increment ratio can be constructed:

$$H = \frac{x_0}{K'} \tag{13}$$

In Eq. (13), $K'$ is the accumulated information volume of current network public opinion obtained by monitoring, and the research on network public opinion prediction is carried out based on its dynamic changes.

### 4.3 Growth Rate Simulation

On the basis of the fixed initial value $x_0$ and upper limit $K$, through the fluctuation of the growth rate $r$, this paper studies the propagation law and the change in the propagation stages of we-media network public opinion. Letting the initial value $r$ be 0.1, 0.2, 0.3, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9, we draw the logistic curve again, as shown in Fig. 6. We calculate the corresponding key time points and study the changes in the key propagation stages, as shown in Tab. 4.

From Fig. 6 and Tab. 4, we find that with the increase in the growth rate, the four key time points gradually decrease, resulting in a shorter budding period. The other four transmission stages occur sooner, and the latency, outbreak and remission stages become shorter, and the duration of the saturation period becomes longer.

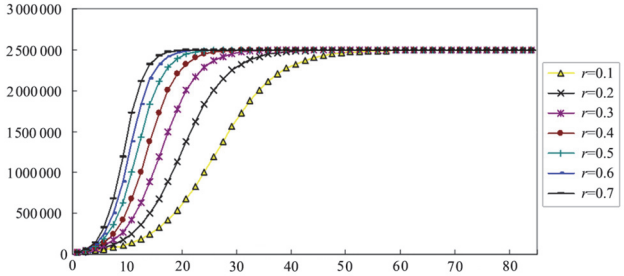


**Figure 6** Growth rate simulation comparison chart

In general, the growth rate $r$ is between 0 and 1, which is the normal rule for we-media network public opinion spreading on the Internet. However, in the actual process of we-media network public opinion dissemination of an event, it is easy for it to be affected by netizens' interests, emotions and other factors, and even by the influence of online pushers, online supporters and so on, which may cause the event's public opinion dissemination to deviate from the normal law; that is, the growth rate may exceed 1. For this reason, the simulation curve for a growth rate $r \geq 1$ is drawn, as shown in Fig. 7.

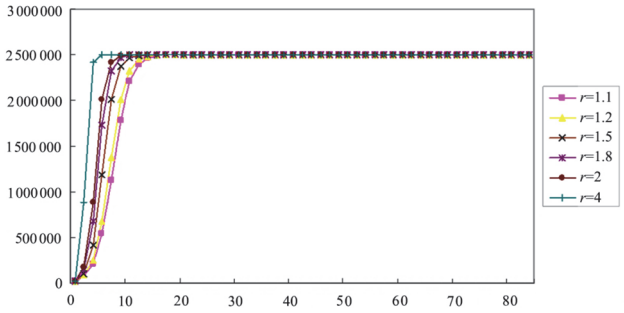


**Figure 7** Simulation image with a growth rate greater than 1

The amount of public opinion information in the event's we-media network quickly reaches saturation within 10 units of time. The rapid increase in information in a short time can easily lead to the cumulative information volume exceeding the upper limit $K$ of the model, so there will be a "multipeak phenomenon" in the statistical data of network public opinion.

**Table 4** Initial value simulation data table

| Initial value | $t_1$ | $t_2$ | $t_3$ | $t_4$ | Period | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Budding | Incubation | Outbreak | Remission | Saturation |
| $r = 0.1$ | 35.27 | 47.68 | 71.60 | 75.83 | — | — | — | — | — |
| $r = 0.2$ | 18.14 | 23.05 | 33.82 | 36.49 | Shortening | In advance, shortening | In advance, shortening | In advance, shortening | In advance, lengthening |
| $r = 0.3$ | 12.76 | 15.32 | 23.05 | 27.10 | Shortening | In advance, shortening | In advance, shortening | In advance, shortening | In advance, lengthening |
| $r = 0.4$ | 10.95 | 13.08 | 16.19 | 19.38 | Shortening | In advance, shortening | In advance, shortening | In advance, shortening | In advance, lengthening |
| $r = 0.5$ | 8.32 | 11.29 | 13.20 | 17.54 | Shortening | In advance, shortening | In advance, shortening | In advance, shortening | In advance, lengthening |
| $r = 0.6$ | 6.10 | 9.46 | 11.89 | 14.39 | Shortening | In advance, shortening | In advance, shortening | In advance, shortening | In advance, lengthening |
| $r = 0.7$ | 4.29 | 7.20 | 9.27 | 12.17 | Shortening | In advance, shortening | In advance, shortening | In advance, shortening | In advance, lengthening |

The corresponding dissemination stages of Fig. 5 and Fig. 6 show the phenomenon of “left compression”, which inevitably leads to the peak point of the statistical data of the we-media network public opinion on the event "moving

to the left", that is, reaching the climax of network public opinion ahead of the expected time. If the amount of information of we-media network public opinion exceeds the theoretical upper limit, multiple peak points will appear from left to right, and then the growth rate will change. Inferring the position of a series of "peaks" through the change in the growth rate has become an important problem in trend prediction of network public opinion. By referring to the method of [22], we know that the inflection point of the logistic curve is the peak point (the point at $K/2$) of the statistical data of we-media network public opinion on the event, and the corresponding time is:

$$t_0 = \frac{1}{r}\ln\frac{K - x_0}{x_0} \tag{14}$$

The peak time is inversely proportional to the growth rate. More generally, the peak time can be regarded as a function of $r$ and $K$, i.e.,

$$t_0(r, K) = \frac{1}{r}\ln\frac{K - x_0}{x_0} \tag{15}$$

The time corresponding to the peak point can be inferred from the change in $r$ and $K$.

### 4.4 Upper Bound Simulation

Based on the inherent growth rate $r$ and the initial value $x_0$, the fluctuation of the upper limit $K$ is used to study the changes in an event with the public opinion propagation law and the transmission stage of the media network. The upper limit $K$ is set to 50% $K$, 60% $K$, 70% $K$, 80% $K$, 90% $K$, $K$, 120% $K$, 150% $K$, 180% $K$, 200% $K$, 300% $K$ and 500% $K$, and a logistic curve is drawn, as shown in Fig. 8. The corresponding key time points are calculated, and the changes in the key propagation stages are studied, as shown in Tab. 5.

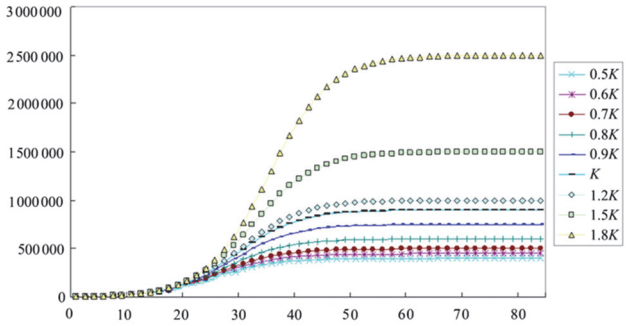


**Figure 8** Upper limit simulation comparison chart

Through Fig. 8 and Tab. 5, it is found that with the increase in the upper limit, the four key time points gradually increase, leading to a longer budding period and the delay of the other four propagation stages. However, the durations of the incubation period, outbreak period and remission period are affected only by the growth rate, so the durations of their propagation periods remain unchanged and the duration of the saturation period becomes shorter. The logistic curve shows the phenomenon of "right compression", which leads to the peak value of the statistical data of we-media network public opinion moving to the right.

**Table 5** Upper limit simulation data table

| Initial value | $t_1$ | $t_2$ | $t_3$ | $t_4$ | Period | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Budding | Incubation | Outbreak | Remission | Saturation |
| 0.5 $K$ | 6.84 | 14.35 | 26.17 | 35.84 | — | — | — | — | — |
| 0.6 $K$ | 7.18 | 16.23 | 28.40 | 37.19 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| 0.7 $K$ | 8.02 | 17.59 | 30.16 | 38.45 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| 0.8 $K$ | 9.54 | 19.07 | 32.55 | 39.93 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| 09 $K$ | 10.07 | 21.24 | 33.57 | 40.18 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| $K$ | 11.65 | 23.79 | 35.03 | 42.89 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| 1.2 $K$ | 12.75 | 25.38 | 36.88 | 43.70 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| 1.5 $K$ | 13.86 | 27.60 | 38.81 | 44.21 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |
| 1.8 $K$ | 14.33 | 29.17 | 40.62 | 45.83 | Lengthening | Delayed | Delayed | Delayed | Delayed, shortening |

### 4.5 Analysis of the Simulation Results

From the above simulation results, the cumulative data line graph of we-media network public opinion on the event shows a logistic curve structure, and the curve can be divided into eight parts, as shown in Fig. 9. If we study each part separately, we can obtain thegrowth rate and upper limit of each part. The results are shown in Fig. 10 and Tab. 6.

From Tab. 6, we can find that the original broken line of the cumulative data is divided into eight parts. Corresponding to the eight broken-line curves in Fig. 8, we find tha tthe inconsistency coefficients of these curves are less than 0.1, indicating that the fitting effect of the eight curves formed by the eight separate parts of the original curve is also good. It can also be found from Fig. 9 and Tab. 6 that there are obvious differences in the growth rates of the 8 curves, with upper and lower limits of 0.79 and 0.08, respectively. The overall growth rate of the logistic model simulation curve is 0.23, which shows that the growth rate of the eight parts of the simulation presents a "multipeak" phenomenon, which is consistent with the development law of the evolutionary stages of public opinion dissemination for the event.

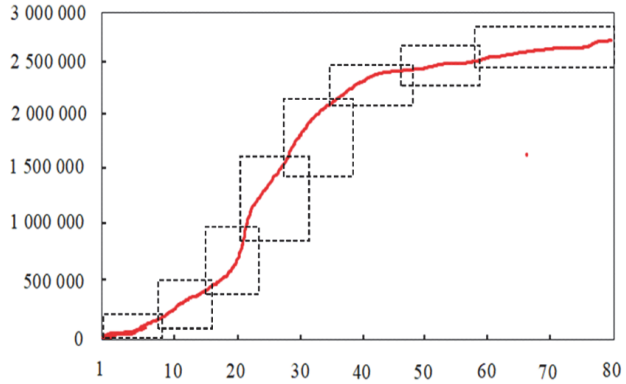


**Figure 9** Cumulative data line chart of we-media network public opinion for the event of "academic fraud of actor Zhai"

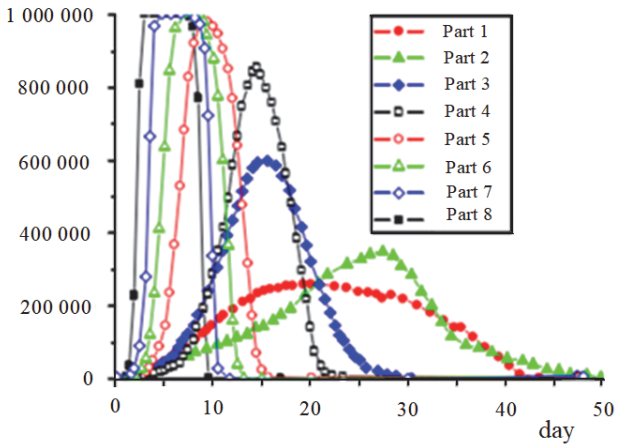


**Figure 10** Line chart corresponding to 8 segments of the data

**Table 6** Modeling parameter table of 8 segments of the data

| Parameter | Model initial value | Growth rate | Upper limit | Coefficient of inconsistency |
|---|---|---|---|---|
| Part 1 | 4279 | 0.63 | 4279 | 0.07 |
| Part 2 | 1350 | 0.74 | 10582 | 0.08 |
| Part 3 | 286 | 0.79 | 45907 | 0.02 |
| Part 4 | 219581 | 0.41 | 325096 | 0.05 |
| Part 5 | 790244 | 0.35 | 583240 | 0.08 |
| Part 6 | 38235 | 0.32 | 280745 | 0.03 |
| Part 7 | 2508 | 0.40 | 513904 | 0.06 |
| Part 8 | 11047 | 0.08 | 263112 | 0.09 |
| Global model | 45823 | 0.15 | 2026732 | 0.05 |

## 5 CONCLUSIONS AND SUGGESTIONS

Conclusions

Through the simulation analysis of the "academic fraud of the actor Zhai" event in the Sina Weibo dissemination process, we find that the evolution and development of we-media network public opinion has clear stages and that each stage has an internal development law. This is mainly manifested in the following three aspects:

(1) With the promotion of mobile Internet platform and the popularity of smart phones, the leading force of public opinion is increasingly shifting from institutions, organizations and the upper class to the civilian class. Therefore, we-media netizens will become the leading force of public opinion, and we-media network public opinion events will gradually become the key object of emergency management.

(2) Compared with other emergencies, we-media network public opinion events have its particularity, which leads to its unique life cycle, that is, any specific we-media network public opinion event will die out from its germination. We-media network public opinion events can be divided into several stages, and its evolution has a certain "phased" regularity.

(3) In different life cycle stages, we-media network public opinion events show different characteristics, and the characteristics of each stage determine the coping style of the we-media network public opinion events. Therefore, it is very important for the governance of we-media network public opinion events to find out the way to adapt to the life cycle of we-media network public opinion events.

Suggestions

Through the theoretical research, empirical simulation and conclusion induction of this paper, we can find that the evolution and development of we-media network public opinion has the quantitative characteristics of stages. Accordingly, the governance of we-media network public opinion events can be carried out from the following four aspects:

(1) Incubation period. At this stage, we can collect relevant information on public opinion from the source, track and monitor the development of public opinion to understand the initial views and attitudes of Internet users toward the event, predict the next development direction of public opinion, and formulate effective governance measures at the root. The government public opinion supervision department relies on professional technical means to collect information about the incubation period of public opinion, predict the development trend of we-media network public opinion, and achieve timely control according to the development characteristics of public opinion at this stage.

(2) Growth period. At this stage, it is particularly important to strengthen the dissemination and interaction with we-media netizens. To control the development of public opinion, government departments should establish a news spokesperson system, announce the truth of the incident to netizens in a timely manner, release authoritative and verifiable information through authoritative people, and enhance netizens' trust in information. At the same time, government departments should formulate reasonable dissemination strategies, select and train high-quality news spokespeople, and improve the overall response and dissemination abilities of government personnel. In addition, government departments should set clear rewards and punishments, reward departments or personnel with high dissemination efficiency quickly, and punish departments or personnel with low dissemination efficiency.

(3) Mature period. The mature period is also the outbreak period of we-media network public opinion. At this stage, we-media network public opinion will have an

uncontrollable trend, so this is the most active stage of public opinion and the most difficult stage of governance. At this stage, government departments should effectively carry out overall planning and coordination, establish a multilevel linked public opinion response mechanism, minimize organizational levels, improve the feedback efficiency of governmental public opinion governance, give full play to the advantages of grassroots government departments, actively contact the masses, and ensure that the government's intention can be transmitted to the public promptly; at the same time, government departments should strengthen cooperation with various media platforms, improve the professionalism of the government response and enhance the credibility of the government.

(4) Recession period. At this stage, the influence of we-media network public opinion shows a decreasing trend. Government departments should shift the focus of work in a timely manner to the aftermath of public events, try to recover the losses caused by the events, and reduce the negative social impact. At the same time, the relevant departments should effectively evaluate the development of we-media network public opinion, learn from the experience and lessons of public opinion governance, improve the relevant work system, prevent the growth of secondary hazards of public opinion, and ensure a controllable range for public opinion.

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