

## Opinion Leaders in Social Network Public Opinion: Butterfly Diagram, Identification, and Influence Evaluation (Postprint)

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### Abstract

[Purpose/Significance] In the social media environment, opinion leaders and audience communities have formed a self-operating and self-circulating scoped public opinion system. Effectively identifying opinion leaders and evaluating their influence holds practical significance for strengthening online public opinion governance and control. [Method/Process] By integrating OCA extension theory, intergroup relations theory, public opinion field potential theory, and SIC theory, this study employs system dynamics to analyze the role of opinion leaders, antecedent variables, and their dynamic mechanisms, constructs a general framework for an opinion leader influence evaluation system, proposes an opinion leader identification algorithm based on variable-weight grey relational analysis, and conducts an empirical study using the public opinion topic “The November 3rd Case of a Chinese Female Student Murdered in Japan”. [Result/Conclusion] The “butterfly diagram” structures the causal relationships and feedback loops between the role of opinion leaders and antecedent variables, revealing the internal mechanism of co-evolution between community ecology and the role of opinion leaders within the public opinion system. The theoretical model proposed in this paper features multi-dimensional measurement, scientifically determined weights, and superior algorithmic performance, making it applicable to the dynamic process of opinion leader formation in social networks.

### Full Text

### Preamble

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## Abstract

**[Purpose/Significance]** In the social media environment, opinion leaders and audience communities have formed a self-operating, self-circulating public opinion system. Effectively identifying opinion leaders and evaluating their influence holds practical significance for strengthening online public opinion management and control. **[Method/Process]** Combining OCA extension theory, intergroup relations theory, public opinion field potential theory, and SIC theory, this paper analyzes the roles of opinion leaders, antecedent variables, and their dynamic mechanisms through system dynamics. It constructs a general framework for an opinion leader influence evaluation system, proposes an opinion leader identification algorithm based on variable-weight grey correlation degree, and conducts an empirical study using the public opinion topic “11·3 Murder of a Chinese Female Student in Japan.” **[Result/Conclusion]** The “Butterfly Schema” structures the causal relationships and feedback loops between opinion leader roles and antecedent variables, revealing the internal mechanism of co-evolution between community ecology and opinion leader roles within the public opinion system. The theoretical model proposed in this paper features multi-dimensional measurement, scientific weight sets, and superior algorithm performance, making it suitable for the dynamic process of opinion leader formation in social networks.

## 1 Literature Review

Research on opinion leader identification and influence evaluation primarily addresses two issues: indicator system construction and research model design, as shown in Table 1 and Table 2. Current research faces two main problems: first, a unified indicator system has not yet been formed, requiring problem-specific indicator models; second, while grey correlation analysis currently offers optimal performance, most scholars have overlooked the fact that opinion leader formation is a dynamic process, thus their research methods and algorithm designs still require optimization. To address these gaps, this paper focuses on two aspects: first, constructing a more scientific, comprehensive, and realistic opinion leader influence evaluation system; and second, designing an opinion leader identification algorithm with multi-dimensional measurement, higher algorithmic optimality, and stronger universality.

The remainder of this paper is organized as follows: First, system dynamics is employed to analyze the roles of opinion leaders, antecedent variables, and their dynamic mechanisms, demonstrating the theoretical foundation for indi-

icator system establishment and the basis for evaluation dimension selection. Second, based on the system dynamics analysis and literature review, a general framework for opinion leader influence evaluation is constructed, and an opinion leader identification algorithm based on variable-weight grey correlation degree is proposed. Third, an empirical study is conducted on Sina Weibo, using the hot topic “11·3 Murder of a Chinese Female Student in Japan” (hereinafter referred to as the “Jiang Ge Case”) to verify the robustness of the indicator system and algorithm. Finally, the study is summarized and future research directions are proposed.

## 2 Opinion Leader Roles, Antecedent Variables, and Motivations

Online public opinion, disseminated through social media, represents a collection of information audience attitudes, viewpoints, and emotions. There inevitably exists a difference between the audience group’s “external world” and “mental picture,” and the process of cognizing the world necessarily involves contacting an intermediary role—trusted leaders who interpret mass media information. Opinion leaders publish influential evaluations that are widely forwarded through social media, forming focal opinions that guide community members’ cognition and behavior, thereby establishing a new paradigm of communication theory: “Social Media → Opinion Leaders → Community Audience.” This paper argues that opinion leaders are structural units that cohere social network entities and thereby dominate system behavior. This conceptual framework suggests that such roles are adept at using social media, their tendentious emotional viewpoints can spread rapidly, constituting a public opinion field with certain polarity and intensity, and deriving community opinions that cause audiences within the field source to converge in cognition, emotion, and other tendencies.

Within the opinion flow, audiences reinforce their own viewpoints, group attitudes and emotions become polarized, and the degree of community cognitive convergence continuously strengthens, positively influencing the evolution of online public opinion. The combined effect of “charismatic appeal + concentrated identification” between opinion leaders and audience communities forms a self-operating, self-circulating public opinion system. The model constructed based on the above analysis is shown in Figure 1 [Figure 1: see original paper].

According to the Online Community Attraction Extension Theory, opinion leaders’ public opinion guidance ability stems from their personal charisma, which attracts followers through leadership traits such as personality appeal, appearance and temperament, and past achievements, thereby forming a fan effect. The fan effect juxtaposes audience emotional flow and public opinion information flow, creating a community public opinion production model of emotional generation content. Psychologist Grossberg argues that the fundamental difference between fans and ordinary audiences lies in their emotional sensibility. These ascribed or achieved capitals strengthen the opinion leader’s personal charisma, directly influencing their followers’ cognition and intention activities,

generating organized emotional sensibility that forms common community emotions among members. The stronger this emotional sensibility, the stronger the resulting fan effect, forming a fan community with strong group normativity. This group normativity influences the group's behavior and communication in implicit or explicit ways, maintaining group relations and cohesion for community development, promoting group harmony and identity group attachment, and constituting a psychological connection system with the opinion leader as the interpersonal bond.

According to social identity construction theory, driven by compensation psychology, opinion leaders have strong self-construction needs, generating self-building behaviors—investment activities oriented by self-worth. To maintain brand images or personal identity, opinion leaders invest personal resources or rely on others' promotion, such as through strategies like enhancing popularity, obtaining privileges, and acquiring social recognition to build celebrity brands, thereby achieving social role-seeking.

Existing intergroup relations theory research suggests that opinion leaders generate significant public opinion influence because they are “active performers” with wide social networks who self-express in social situations (deliberate behavior) and are communicators skilled at dominating topic themes and tendencies—information attributes. The more active this public opinion role, the stronger its intergroup contact intensity; the broader its intergroup contact scope and the better its intergroup contact validity, the more it forms a secondary intergroup micro-ecological space derived from public opinion information. Within this space, the optimized intergroup contact scope improves information diffusion effects and reduces familiarity costs, achieving satisfactory information communication results. Simultaneously, the better the role's intergroup contact validity—that is, the more effective the intergroup contact is at improving intergroup attitudes—the more conducive it is to forming implicit cognition and stereotypes within the space. Implicit cognition, the unconscious representation of group bias, strengthens the role's emotional guidance capability, driving the emergence of intergroup isolation tendencies—that is, this cognition ultimately shapes intergroup segregation, activating group schemas in members' cognitive structures, enabling control over intergroup attitudes and public opinion development directions. Stereotypes, expressions of group identity, reduce familiarity costs, enhance information communication capabilities, make leader opinions symbols of intergroup attitudes, and further beautify intergroup identity.

Public opinion field potential theory posits that opinion leaders possess assimilative capacity, generating region-like public opinion fields that evolve into group atmosphere, reputation, and word-of-mouth culture for social networks, leveraging extension to the target of community communication ecological circles, enabling strong control over information resources and interaction resources in online communities, and 被视为一种塑造过程. The better this shaping effect, the stronger the opinion leader's role; simultaneously, the quality of shaping effect also influences their metacognition processes and strategies, motivating, regu-

lating, or transforming their leadership shaping behaviors.

The opinion leader motivation mechanism serves as a path reference for connecting opinion leader role dimension indicators with driving factors, and for conducting opinion leader identification and influence evaluation research, and can also become a beneficial exploration for corresponding theoretical debugging. The dynamic analysis model is shown in Figure 2 [Figure 2: see original paper]. The “Butterfly Schema” depicts antecedent variables—community ecological elements—and outcome variables—opinion leader roles—co-evolving within the public opinion system, effectively encompassing previous public opinion theoretical research findings and serving as the theoretical basis for constructing a general framework for opinion leader evaluation systems.

### 3 Opinion Leader Identification Model

#### 3.1 Indicator System Construction

Based on system dynamics analysis results and support from existing research, this paper proposes a general framework for opinion leader influence evaluation covering four dimensions: popularity index, activity level, assimilative capacity, and shaping behavior (see Figure 3 [Figure 3: see original paper]):

1. **Popularity Index:** Reflects the popularity and appeal of a public opinion role in social media contexts, which can be analyzed through two complementary indicators—popularity magnitude and trend magnitude—to assess current charisma performance and future popularity trends. Fan count and net fan growth constitute the measurement standards: fan count is fundamental data measuring existing popularity scale, while net fan growth is the most direct numerical reflection of popularity trends.
2. **Activity Level:** Reflects the proactivity of opinion leaders’ participation in topics, requiring examination of the total volume or frequency of their one-way participation and two-way interaction behaviors—that is, self-expression frequency and topic interaction intensity. Self-expression frequency can be observed through information posting volume and active visit volume of social media users. Topic interaction intensity requires examination of the total volume of user interaction behaviors, with measurement standards including replies, forwards, and comments.
3. **Assimilative Capacity:** Represents the social skill of opinion leaders to influence audience attitudes to align with information subjects, which can be measured based on non-immune factors such as audience support degree and acceptance tendency. Support degree is a quantitative indicator of users’ semantic attitudes of identification and support toward opinion leaders’ information, requiring collection of basic data such as likes, comments, and retweets, and calculating support rates through text semantic recognition. Acceptance tendency refers to users’ tendentious reactions to opinion leaders’ information, manifested as selection, understanding, and

internalization processes, with measurement standards including friend count, subscription count, and collection count.

4. **Shaping Behavior:** Refers to behavioral characteristics of opinion leaders shaping personal images to gain identification, marked by self-worth-driven investment behaviors, which can be reflected through two indicators: shaping expectation and investment intensity. Shaping expectation is the expected return an individual role can obtain through acquired capital investment behavior, using expected values or expected growth values of click-through rates and mention rates as reference bases. Investment intensity has a significant positive interactive relationship with shaping returns, with measurement standards including live broadcast count, membership level, and privilege activation count.

### 3.2 Identification Algorithm Design

Grey correlation analysis is a multi-factor analysis method used to describe the magnitude, strength, and order of relationships among numerous uncertain factors. For complex systems with long relaxation times and high public opinion steady-state values, factors such as topic content, community needs, audience focus, and evaluation objects are all changing, requiring matching different opinion leader characteristics. Opinion leader indicator weights change with public opinion evolution, making it unsuitable for online public opinion with long dissemination cycles, complex evolution processes, and fluctuating content development. The calculation method is as follows:

$$\zeta_j(k) = \frac{|x_0(t) - x_s(t)| + \rho \max |x_0(t) - x_s(t)|}{|x_0(t) - x_s(t)| + \rho \max |x_0(t) - x_s(t)|}$$

$$w_j \zeta_j(k)$$

where  $x_0 = \{x_0(1), x_0(2), \dots, x_0(n)\}$  and  $x_i = \{x_i(1), x_i(2), \dots, x_i(n)\}$  are sets of discrete time series, called reference sequences and comparison sequences respectively. Formula (2) embodies the weighted average concept, where the weight coefficient of correlation coefficient  $\zeta_j(k)$  at time  $t_k$  is  $w_j$  with  $\sum w_j = 1$ . For a given partition  $p = t_1 < t_2 < \dots < t_n = q$ ,  $w_j$  is fixed and unchanging, meaning the weights of different comparison sequences on the reference sequence are identical at all stages of public opinion evolution, which is clearly unreasonable.

Considering that comparison sequences have different impacts on reference sequences at different times, researching the dynamic formation process of opinion leaders in social media can uncover greater value and make identification results more realistic. Therefore, based on weighted grey correlation algorithms and depth coefficient optimization models, this paper proposes a variable-weight grey correlation degree opinion leader identification model. The calculation method is as follows:

Assume that at time  $t_k$  during public opinion evolution, the total number of users to be evaluated is  $m$ , the number of opinion leader influence evaluation indicators is  $n$ , and the opinion leader influence evaluation set is divided into  $l$  levels. Let the reference sequence (evaluation standard) be  $x_0(t_k) = \{x_{01}(t_k), x_{02}(t_k), \dots, x_{0n}(t_k)\}$ , and the measured values of the  $i$ -th user's indicators constitute the comparison sequence (evaluation object)  $x_i(t_k) = \{x_{i1}(t_k), x_{i2}(t_k), \dots, x_{in}(t_k)\}$ . If  $Y_{sj}$  is the limit value of the  $j$ -th indicator belonging to level  $s$  ( $s = 1, 2, \dots, l$ ), then for indicators where larger values indicate stronger influence and higher levels,  $Y_{sj}$  is the upper limit; conversely, for indicators where smaller values indicate stronger influence and higher levels,  $Y_{sj}$  is the lower limit.

**Step 1: Data Standardization.** Divide opinion leader influence into levels. For data where larger values indicate higher levels, perform standardization transformation:

$$p_{ij} = \begin{cases} 0, & x_{ij} \geq Y_{1j} \\ \frac{Y_{1j} - x_{ij}}{Y_{1j} - Y_{lj}}, & Y_{lj} \leq x_{ij} \leq Y_{1j} \\ 1, & x_{ij} \leq Y_{lj} \end{cases}$$

For data where smaller values indicate higher levels, perform standardization transformation:

$$p_{ij} = \begin{cases} 0, & x_{ij} \leq Y_{lj} \\ \frac{x_{ij} - Y_{lj}}{Y_{1j} - Y_{lj}}, & Y_{lj} \leq x_{ij} \leq Y_{1j} \\ 1, & x_{ij} \geq Y_{1j} \end{cases}$$

Simultaneously, perform dimensionless processing of opinion leader influence indicator measured data.

**Step 2: Define Grey Correlation Coefficient.**

$$\zeta_{ij}(t_k) = \frac{1 - |p_{ij} - q_{sj}|}{1 + |p_{ij} - q_{sj}|}$$

where formula (5) represents the discrete coefficient between the  $j$ -th indicator of the  $i$ -th user's transformed sequence and evaluation level  $s$  at time  $t_k$ .

**Step 3: Determine Variable Weight Coefficient.**

$$w_j(t_k) = \frac{|Y_{1j} - Y_{lj}|}{|Y_{1j} - Y_{lj}| - |Y_{sj} - X_{ij}|}$$

where formula (6) represents the weight coefficient when opinion leader influence reaches evaluation level  $s$  at time  $t_k$ , denoted as fuzzy vector matrix  $w(t_k) = (w_1(t_k), w_2(t_k), \dots, w_n(t_k))$ .

**Step 4: Introduce Penalty Factor  $\sigma$  to Transform Objective Function.**

$$\min F(w_{sj}(t_k), \sigma) = \sum w_{sj}(t_k) \ln w_{sj}(t_k) + \sigma \sum |\max(0, H_u(w_{sj}(t_k)))|$$

subject to  $\sum w_{sj}(t_k) - 1 = 0$ , where  $H_u(w_{sj}(t_k))$  represents function expressions satisfying inequality constraint conditions  $H_u(w_{sj}(t_k)) \geq 0$  in the variable-weight grey correlation model, and  $U$  is the number of all inequality constraint conditions. If the research topic is relatively simple, this step and Steps 5-6 can be omitted.

**Step 5:** Drawing on correlation algorithms for decision indicator weight optimization, iteratively update and solve for the representation vector of optimal weight solutions  $w'_j(t_k) = (w_j(1), w_j(2), \dots, w_j(n))$  in the constraint model.

**Step 6:** Obtain equivalent weights  $W_j = \frac{w'_j(t_k)}{\sum w'_j(t_k)}$  based on the obtained weight coefficients.

**Step 7: Calculate Variable-Weight Grey Correlation Degree.**

$$r(p_i, q_s) = \frac{\sum W_j(t_k) \zeta_{sj}(t_k)}{\sum W_j(t_k)}$$

where formula (8) represents the correlation degree of the  $i$ -th user belonging to level  $s$  influence, denoted as the opinion leader value. The larger the variable-weight grey correlation degree, the better the influence evaluation. Formula (8) is a generalization of formula (2) for variable weight sets in complex systems, while formula (2) is a special case of formula (8) with fixed weight sets within partitions. Therefore, the algorithm in this paper optimizes the weighted absolute grey correlation algorithm.

**Step 8: Establish Correlation Order.** Compare the magnitudes of variable-weight grey correlation degrees  $r(p_i, q_1), r(p_i, q_2), \dots, r(p_i, q_l)$ . If  $r(p_i, q_s) = \max\{r(p_i, q_j)\}$  for  $1 \leq j \leq l$ , then the  $i$ -th topic participant user belongs to level  $s$  influence evaluation, and the evaluation object correlation order is established accordingly to obtain the identified opinion leader set.

## 4 Empirical Study

### 4.1 Indicator System Construction

Social media has broken the limitations of traditional community time and space and the constraints of real social relationships, greatly enhancing the effectiveness of information dissemination and becoming an important carrier for

public opinion topic dissemination. Among these, Sina Weibo's dissemination mechanism is the most diverse and personalized, and has become a measured channel for online public opinion research such as corpus development and public opinion topic mining. This paper selects Sina Weibo as the measurement source, and based on the general framework of opinion leader influence evaluation, considering existing research measurement standards and Sina Weibo's media mechanism, combined with literature review and expert consultation results, constructs an evaluation indicator system including 4 first-level indicators and 15 second-level indicators (see Table 3 ).

## 4.2 Data Collection

This paper selects the hot topic “Jiang Ge Case” as the data source for empirical research on opinion leader identification and influence evaluation. All Weibo posts, forwards, and comments related to this topic were crawled from the entire network, with some data obtained through backend access. Relevant information under each Weibo post on the collected webpages was counted, including comment time and content, reply time and content, etc., and saved into an Access database according to their respective categories.

The selection of the “Jiang Ge Case” as the empirical case is based on its characteristics of high public opinion heat, long cycle, and obvious changes in content attention: (1) High public opinion heat: Searching on the Micro Index platform, as of January 15, 2018, the “Jiang Ge Case” topic had a huge data volume, totaling 1,692,714 Weibo posts, indicating that the “Jiang Ge Case” has become a highly representative public opinion content. (2) Long public opinion cycle: In November 2016, Jiang's mother first posted on Weibo to seek justice for her daughter Jiang Ge, and until the end of 2018, netizens' criticism of Jiang Ge's roommate Liu Xin had not ended. (3) Fluctuating public opinion content: Conducting over a year of tracking research has accumulated a large amount of case and data materials. The development of the “Jiang Ge Case” experienced three stages: public opinion condemnation, moral appeal, and court trial, with a relatively complex public opinion evolution mechanism.

## 4.3 Opinion Leader Identification and Influence Evaluation

According to the algorithm proposed in this paper, opinion leader values were calculated, with weight results shown in Tables 4 and 5. Based on the correlation order of evaluation objects at each stage—that is, the order of opinion leader values—the identified opinion leader set was obtained, with the top 5 users selected as opinion leaders (see Table 6 ).

**4.3.1 First-Level Indicator Evaluation Results Analysis** Based on the first-level indicator weight results in Table 4 , combined with the characteristics and factual basis of opinion leaders in the “Jiang Ge Case” public opinion, evaluation results were analyzed from the perspective of first-level indicators (see Table 7 ).

**4.3.2 Second-Level Indicator Evaluation Results Analysis (1) Popularity Index (Dimension 1):** Synthesizing the evaluation results of each stage and the entire process of the “Jiang Ge Case,” fan count and fan trend magnitude dimensions contribute relatively high, while group member count dimension contributes relatively low. “Weibo Big Vs” possess numerous fans due to their endowments, with significantly higher social attention than unnoticed “grassroots” users, leading to the phenomenon of celebrity prominence and civilian marginalization. Fan trend magnitude reflects the expected popularity accumulation effect of opinion leaders, and the popularity accumulation process precisely corresponds to the opinion leader formation process. However, the “Jiang Ge Case” topic includes many “has-been” celebrity users with high fan counts but many “zombie fans,” making low fan trend magnitude their common characteristic. Group functions gather homogeneous groups that more easily generate common topics and have higher loyalty to opinion leaders, but Sina Weibo adopts a “comment-reply” topic interaction mechanism, making group power relatively weak.

**(2) Activity Level (Dimension 2):** Synthesizing the evaluation results of each stage and the entire process of the “Jiang Ge Case,” posting rate and interaction rate dimensions contribute relatively high, while super-topic update rate and visit volume dimensions contribute relatively low. Opinion leaders posting Weibo content is a prerequisite for generating influence, and their information may be further disseminated by other users, potentially generating cross-media dissemination behavior or even offline action transformation. Interpersonal interaction is the information exchange process among Weibo users, promoting the formation of positive interpersonal relationships between opinion leaders and audience groups. Users such as “Liu Xin 6\_6” and “Bitter Coffee Xia Lian” enable other users to deeply understand the “Jiang Ge Case” details and developments through targeted replies and timely comments, thereby establishing frequent and close interactive relationships that facilitate increased familiarity and intergroup trust perception. The larger the opinion leader’s visit volume, the broader the topic content they can cover, maintaining information acquisition and tracking capabilities. In the “Jiang Ge Case,” opinion leader users continuously browsed, collected, and integrated valuable argument materials, publishing comprehensive blog posts such as “Eight Questions for Liu Xin” (from “Wandering Around 06”), “Ten Questions for Liu Xin” (from “Bitter Coffee Xia Lian”), and “Ten Questions and One Request” (from “Liu Xin 6\_6”), generating opinion leader posts that hit the nail on the head, attracting audience group identification and attention.

**(3) Assimilative Capacity (Dimension 3):** Synthesizing the evaluation results of each stage and the entire process of the “Jiang Ge Case,” support rate and tracked count dimensions contribute relatively high, while friend count dimension contributes relatively low. The focus of debate in the “Jiang Ge Case” lies in the word “humanity,” with fierce ideological confrontations in the opinion flow showing strong exclusive emotional tendencies. The mainstream ideology encounters deconstruction under the impact of law and emotion interaction, and

the role of opinion leaders in the “Jiang Ge Case” is precisely completed through extracting, integrating, reconstructing, and transforming community cognition, thereby gaining community support and achieving discourse monopoly. Therefore, support rate well depicts assimilative capacity and the resulting degree of community cognitive convergence. Weibo users’ subscription, collection, and other tracking behaviors are active and selective actions driven by emotional identification and spiritual internalization. Their self-organizing and implicit emotional interaction enable opinion leaders to reproduce meaning, emotion, and value, enhancing their cluster effect. The more friends an opinion leader has, the better the breadth of their homologous community, and through mutual following with other opinion leaders, they can access more high-level information sources and expand the diffusion scope of their Weibo information influence.

**(4) Shaping Behavior (Dimension 4):** Synthesizing the evaluation results of each stage and the entire process of the “Jiang Ge Case,” account placement count dimension contributes relatively high, while shaping expectation, information flow position, and privilege level dimensions contribute relatively low, and live broadcast count dimension shows large fluctuations. Shaping expectation quantifies the necessity of users’ self-shaping; only with stronger self-shaping necessity can they have better public opinion brand images and stronger public opinion guidance capabilities. Existing decision theory research suggests that decision-makers will sacrifice decision quality and adopt satisfactory strategies to reduce effort in complex decision environments. Social media represented by Weibo is a relatively complex decision environment where users tend to seek balance between effort and emotional resonance—that is, under incomplete information conditions, they screen out alternative opinion leader sets with relative emotional identification. The more headline posts users have, the more likely their generated blog content will be topped and browsed preferentially, making it more possible to enter the opinion leader alternative subset. Higher user privilege levels indicate better public opinion brand images, reducing audience groups’ defense and 禁錮 psychology, helping audiences reduce perceived decision-making effort and improve decision quality, thereby including and narrowing down the opinion leader alternative subset. Sina Weibo’s social topic push adopts a broad and extensive approach, but opinion leaders can purchase precise blog post placement, pushing content to highly matched audience groups, obtaining higher landing page diversion efficiency and quality, reducing audience group topic participation costs, and improving their information acquisition satisfaction, enabling direct entry into the opinion leader alternative set. Different from communication systems primarily using text and images as information carriers, Weibo live broadcasts rely on video images with higher information dissemination efficiency and interaction quality, enabling opinion leaders to achieve “word-of-mouth advantages” in the process of influencing audience groups through live content.

#### 4.4 Model Effectiveness Testing

**4.4.1 Comparative Analysis of Identification Results** To test the scientific validity of the proposed model, social network analysis, grey correlation analysis, and entropy weight coefficient method from relevant literature were selected for comparison, with the topic period defined as the entire Jiang Ge Case process. The results are shown in Table 8 .

The identification results indicate that the overall ranking of the proposed model differs from social network analysis but is similar to other methods. Social network analysis constructs only a single time-section static network, lacking effective revelation of opinion leaders' dynamic formation, with certain deviations from actual conditions. Grey correlation analysis conducts multi-directional measurement calculations but similarly overlooks that the establishment of opinion leaders' discourse status is a gradual accumulation process, with flawed algorithm design in weight sets, leading to identification results that are close but not completely consistent. Both the entropy weight coefficient method and the proposed model can conduct multi-dimensional comprehensive measurement of opinion leaders, with the proposed model additionally considering the dynamic process and mechanism of opinion leader formation, enabling more accurate and comprehensive identification of opinion leaders. This study organized 30 well-known public opinion experts to conduct a "consultation" on the Jiang Ge Case, obtaining expert-determined results through repeated comprehensive diagnosis. The results show that both the entropy weight coefficient method and the proposed model are completely consistent with expert consultation rankings, truly demonstrating opinion leaders.

**4.4.2 Comparative Analysis of Algorithm Performance** To verify the algorithm performance of the proposed model, the following testing method was adopted: The optimal values, worst values, and average values in Table 9 represent the opinion leader optimal values, worst values, and average values from independent operation results of test samples in the Jiang Ge Case optimal alternative set by grey correlation analysis ( $f_1$ ), entropy weight coefficient method ( $f_2$ ), and the proposed model ( $f_3$ ). If each operation result differs from existing results, that operation result is called "successful." The success rate is defined as  $\frac{n_k}{N_k} \times 100\%$ , where  $n_k$  is the number of successful algorithm test runs in the  $k$ -th stage of the Jiang Ge Case ( $k = 1, 2, 3, 4$ ) out of  $N_k$  independent runs. Figures 4 [Figure 4: see original paper] to 7 [Figure 7: see original paper] show the solution process curves of the three algorithms for each stage and the entire process of the Jiang Ge Case.

From the measured curves in Figures 4 to 7 and algorithm operation results in Table 9: (1) **Convergence Speed:** The measured convergence curves for each stage and the entire process of the Jiang Ge Case show that the identification progress of the variable-weight grey correlation degree algorithm proposed in this paper is significantly faster than grey correlation analysis and entropy weight coefficient method. (2) **Solution Accuracy:** The optimal values obtained by

the proposed algorithm are all higher than those of the other two algorithms, while the worst values and average values are all lower than those of the other two algorithms, and the evaluation value variance is greater than that of the other two algorithms. Since the measured solution of the proposed algorithm is generated by variable-weight grey correlation degree, making weight sets variable within partitions in complex systems, the obtained measured solution has the highest proximity to the true opinion leader values, and the identification results have the most obvious differentiation. (3) **Success Rate:** For measured results at each stage, the proposed algorithm's solution success rate is 100%, while other algorithms' success rates are all below 100%, with entropy weight coefficient method outperforming grey correlation analysis. For the entire process measured results, all three identification algorithms have success rates below 100%, but the proposed algorithm's success rate remains above 95%, still much higher than other algorithms, with grey correlation analysis's success rate as low as 72%. Therefore, when there are many opinion leaders with similar influence evaluations, other algorithms become fatigued and difficult to identify, while the proposed algorithm can still effectively distinguish them. In summary, the algorithm performance of the variable-weight grey correlation degree model proposed in this paper is significantly superior to previous algorithms.

**4.4.3 Comparative Analysis of Evaluation Systems** Given that two “medium-V” users, Bitter Coffee Xia Lian (1.49 million fans) and Phoenix Li Miao (650,000 fans), could be listed as TOP1 opinion leaders in the moral appeal and court trial stages respectively, this paper attempts to explain the differences in empirical results of the Jiang Ge Case from the evaluation system perspective. Evaluation indicators from existing literature were selected for comparative analysis (see Table 10 ) to seek a balance between theoretical rigor and practical relevance.

Scholars have used information interaction behaviors to construct network structures or evaluated opinion leader influence based on audience emotional polarity, isolating entity interaction and emotion. This paper employs the “Butterfly Schema” for system analysis, arguing that opinion leader influence originates from the entire public opinion system composed of various components in social networks, emphasizing understanding opinion leader formation through a public opinion system encompassing entity interaction and emotional flow. Scholars have established bidirectional mapping chains based on entity interaction, abstracting inter-node connections into information interaction and forming a structural skeleton of explicit relationships. This paper argues that opinion leaders and audience communities constitute an aggregation system where interaction covers information, emotion, and various combinations. System entities transition from interaction relationships to intergroup relations, constrained by system contexts, causing social networks to evolve into changing aggregation system lattices under different contexts. Therefore, the former applies to social networks under static time sections, with top-level design mixing measurement indicators of interaction behavior and emotional tendency, lacking interpreta-

tion of the basis for selecting opinion leader influence indicators. Bottom-level indicators rely on paired relationships such as following/being followed and forwarding/being forwarded, constructing adjacency relationship matrices based on binary logical variables, and ranking nodes according to obtained network structures and characteristic indicators. The latter focuses on the dynamic process of opinion leader formation, with top-level design emphasizing feedback loops within the system and focusing on how multi-attributes and their compound effects influence opinion leader roles. Bottom-level indicators use interconnected state variables and rate variables to form correlated indicator combinations, making the theoretical framework more general in practical application. In summary, the evaluation system in this paper better conforms to opinion leader formation mechanisms and public opinion system operation laws, making the role of opinion leaders on public opinion system behavior more sensitive and causing empirical results under different systems to show differences.

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### Author Contributions

**Guo Yong:** Proposed research ideas and wrote the paper;

**Gao Ge:** Revised, reviewed, and finalized the paper;

**Wang Tianyong:** Designed the paper's structural framework;

**Harris Wu:** Guided experimental design;

**Zhou Shiyu:** Provided revision suggestions.

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

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