Constructing and Applying Influence Evaluation Model of Web Quality Information for Consumer Products

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Abstract: With the sufficient consideration to Web information characteristics of consumer products' quality, this paper establishes the influence evaluation model of Web quality information for Consumer Products based on four dissemination channels, such as web portals, forum, blogs and microblog etc. What's more, it combines entropy weight method with gray theory to put forward the multilevel gray entropy Comprehensive Influence Evaluation Model of Web Quality Information for Consumer Products. In conclusion, the paper takes "Anxin Floor Event" as an example to carry out the empirical research so as to verify the validity and feasibility of evaluation model.

1. Introduction

With the development of Web2.0 technology, quality information of consumer products can be obtained not only from the traditional web portals but also from the newly-developing social media, such as blogs, forum, microblog and social network etc. Being different with the model of former traditional media disseminating information, the Web-based information dissemination of consumer products is characterized by its strong crypticity, as well as its large possibility of giving rise to significant public opinion incidents. If it fails to conduct influence evaluation to the quality information of consumer products disseminated on the Web in time, determine its severity degree and propose effective intervention and control measures; it may cause the devastating consequences. The main contributions of this paper lie in two aspects: firstly, it puts forward the Influence Evaluation Index System of Web Quality Information for Consumer Products; secondly, it establishes multilevel Influence Evaluation Model for Consumer Products based on Gray Entropy. At present, there are so many research achievements on influence evaluation of Web information. Cha etc. (2010) analyzes the scope and speed of information dissemination in the social network, presents the influence model of users in Twitter and points out that the more fans do not mean the greater influence. Chen Hao etc (2012) takes advantage of Linear Threshold Model to propose Node Activation Threshold-Based Heuristic Algorithm which takes influence and Activation Threshold between nodes into comprehensive consideration and calculate the PIN value in accordance with the dynamically-changed threshold value of each node in the activation process. In the initial process, the node with the highest PIN value shall be selected every time as seed node and be activated; in the greedy phase, the node with the largest increment of influence sphere would be selected greedily as seed node. Kempe etc (2005) aims at the issue of influence maximization for social network and raises the diffusion model. Zhang Weizhe etc (2012) presents the quantification method for the influence of public opinion leader in the community.

Although many researchers have been conducted on influence evaluation of Web information, the results are still far from satisfying. First, the depth and the mode of influence evaluation of Web information need to be further analyzed. Additionally, influence evaluation of Web information in terms of the main channels, structure, path, and evolutionary cycles should be investigated as well.

Second, existing researches focus more on traditional news websites. Research on the influence evaluation of Web information about consumer product quality and safety incidents are still rare. Finally, there are many empirical researches about influence evaluation of Web information. However, the theory and the practice of the influence evaluation of Web information are not sufficiently related to each other. Accordingly, this paper focuses on influence evaluation of Web information about consumer product quality and safety based on gray entropy

2. Establishment of Influence Evaluation Index System

Major dissemination channels for Web-based quality information of consumer products mainly include web portals, forum, blogs and microblog which belong to first level index; the subordinate sub-item that could represent its characteristics are second level index which basically can be divided into index of event information, index of netizen's attention, index of information source and index of information receivers. Event information index refers to quantity of occurrence of dependent event information in the four dissemination channels; netizen's attention index covers number of participation, forum post pageviews, click rate of blog articles, number of comments, participation resonance, number of recommendation of blog articles and number of forwarding; information source index means the importance of information source; and information receivers index includes geographic distribution degree, number of certified user and number of original user. The index system is shown as Table 1.

Table 1 Influence Evaluation Index System of Web Information

	First Level Index	Second Level Index
Influence Evaluation System of Web Information for Consumer Products	Web Portals	Quantity of occurrence of dependent event information
		Number of participation
		Number of comments
		Participation resonance
		Index for importance of information source
	Forum	Quantity of occurrence of dependent event information
		Forum post pageviews
		Number of comments
		Index for importance of information source
	Blogs	Quantity of occurrence of dependent event information
		Click rate of blog articles
		Number of recommendation of blog articles
		Number of comments
		Index for importance of information source
	Microblog	Quantity of occurrence of relevant contents
		Number of forwarding
		Number of comments
		Geographic distribution degree
		Number of certified user
		Number of original user

2.1 Index of Event Information

Quantity of occurrence of dependent event information index describes the amount of information delivered by information source. The larger the amount of information is, the easier the information could draw attention from network media, as well as the attention of netizens. For web portals, dependent event information might be followed up and reported successively by the form of special subject. For information in the forum and blog, they can be divided into two kinds: original information and re-printed information in which the latter is more common. For information on the microblog, they can be divided into two kinds: information issued by portals and professional information source, and scattered information provided by the individual in which the former is prone to attract the forwarding and comments from netizens and equipped with the links of net news as the detailed reports and the latter is formed on account of the former and mostly with the form of forwarding. Microblog data source in this paper derives from Sina microblog and Tencent microblog. With the aid of crawling tools, we can calculate the quantity of occurrence of dependent event from their respective Search Engine (SE). Quantity of occurrence of dependent event has a positive correlation with the attention degree of event information.

2.2 Index of Netizen's Attention

Index of netizen's attention describes netizens' attention degree to information source of network information. The stronger the influence of information source is, the easier the information source could obtain netizens' attention. That is to say, the netizens' attention reflects the influence of information source.

For news, netizens' attentions are implied in their access frequency to information source which is definitely the click frequency to the information delivered by information source. The higher the access frequency is, the higher the netizens' attention degree is. In addition, netizens' replying frequency to the information issued by information source shows their participation degree. The higher the netizens' participation degree is, the higher the netizens' attention degree is. As a result, the calculation of index of netizen's attention to information source of news shall be based on indices of click frequency and replying frequency.

For forum and blogs, netizens' attentions are implied in their frequency of publishing an article, access frequency to information source and replying frequency to the information issued by information source. The higher the netizens' frequency of publishing an article is, the higher the netizens' attention degree is. Access frequency to information source is the click frequency to the information delivered by information source. The higher the access frequency is, the higher the netizens' attention degree is. Netizens' replying frequency to the information issued by information source shows their participation degree. The higher the netizens' participation degree is, the higher the netizens' attention degree is. Consequently, the calculation of index of netizen's attention to information source of forum and blogs hall be based on indices of frequency of publishing an article, click frequency and replying frequency.

(1) Click Rate of Webpages and Number of Participation

These two indices are used to describe the click rate of event information. For the traditional web portals, considering the access load of the system, generally, the click rate for the single webpage would not be counted on the webpage. Therefore, netizens' click rates can be measured in accordance with their participation in commenting information and the number of participation is the interaction index by which netizens could express their supports or objections to top comments and it's convenient for netizens to participate the attention to events dynamically without inputting any comments.

(2) Forum Post Pageviews and Click Rate of Blog Articles

These two indices are used to reflect netizens' attention degree to relevant forum posts and blog articles, that are their click rate to forum posts and blog articles. These indices can be shown by the statistical counting on the webpages.

(3) Number of Comments

Number of comments describes users' participation degree to information issued by information

source. The more the number of comments is, the more attractive the issued information is and the higher the users' attention degree is and the stronger their participation degree is. So far, traditional web portals, forum, blogs and microblog are all equipped with comment function. With the development of network technique and change of users' behavior habits, there are more comments on traditional web portals, forum and microblogs while little comments on blogs.

(4) Participation Resonance

Receivers' resonance indicate the degree of resonating among information receivers to network information. It can use the number of people who make comments to current event information divide the number of netizens who participate in event discussing to calculate the value of resonance.

(5) Number of Recommendation of Blog Articles

Number of recommendation of blog articles refers to the amount of blog articles that are recommended in portal blog. Portal blog would make some recommendation by integrating hot issues and significant information and labelling them. Consequently, there would be more and more "weak ties" nodes being attracted to keep an eye on the blogs which promotes the dissemination of network information among users in larger scope to some extent.

(6) Number of Forwarding

Number of forwarding means the forwarding of microblog users to a certain piece of event information. According to netizens' behavior habits, generally speaking, there are more forwarding than comments on microblogs. Therefore, number of forwarding is an essential index for microblogs in the evaluation process. What's more, forwarding represents the course of information dissemination and the regional dissemination of information would be directly reflected by this index.

2.3 Index of Importance of Information Source

Importance of information source describes the influence degree of information source itself, that is to say, the ability of information source disseminating information in the Internet. The higher the influence of information source is, the stronger the ability of disseminating information is.

Index of importance of information source shall be measured in line with Alexa ranking which can be divided into two kinds: comprehensive ranking and classified ranking. Alexa provides the information of several evaluation indices, including comprehensive ranking, visiting quantity ranking and pageviews ranking etc. Most of researchers regard it as authoritative evaluation index for website pageviews at present.

Because the empirical analysis in this paper adopts the date as its dividing dimension and Alexa rankings from various channels would not undergo significant changes, this index can be used as reserve index. However, the index is suitable for analyzing the degree of importance of specific media to the influence of information dissemination within the sub-system of various channels.

2.4 Index of Information Receivers

2.4.1 Geographic Distribution Degree

At the time of analyzing geographic distribution, it's necessary to consider the geographic distribution degree which refers to geographical range and density of information receivers. With the classification by attribution, it could use the number of microblog users within the attribution place divide the total number of microblog users to calculate geographic distribution degree.

The function of index of geographic distribution mainly embody at the dissemination of event information and it can be reflected by the location of netizens who take part in interaction on microblogs. In the first place, fetch the geographic information of receivers and represent the regional dissemination condition of information on the map; then, delineate the course of information dissemination with the combination of time series.

If this paper merely conduct quantitative evaluation to influence of information, this index can be used as reserve index. If there is a necessary to carry out further research on spatial diffusion of information, it's the right time to adopt this index.

2.4.2 Number of Certified User

Certified users refer in particular to celebrities, well-known media, column and their core employees, famous grassroots, person involved in news and Internet stars who possess a certain influence in the fields of acting, sports and culture, or in a specified field or industry. Generally speaking, the influence of the information issued or forwarded by certified users is much greater than the information provided by ordinary users which means that certified users' information exist in the form of "strong ties" nodes. With regard to case related information, the more the certified users participate in forwarding and commenting them, the easier the information is noticed by netizens of "weak ties" nodes and disseminated.

2.4.3 Number of Original User

Original means that users demonstrate the contents made by themselves or provide them to other users through the Internet platform. It reflects the netizens' intention of expressing their own opinions to dependent event information. Original contents are represented on the basis of a certain information. Nonetheless, it is differ from the forwarding information. The more original users, the greater extent the netizens' concern and interactive participation to event information.

3. Establishment of Influence Evaluation Model Based on Gray Entropy

3.1 Assumed Conditions

Assumed that there are k dissemination channels of quality information for a representative consumer product, they form a dissemination system set A, A= {dissemination channel 1, dissemination channel 2, …dissemination channel k}; map these dissemination channels into V sub-systems respectively, $V =[V_1,V_2,...,V_k]$, and every sub-system has $m_1,m_2,...,m_j$ indexes for information dissemination; supposed that there are n targets for information influence evaluation, the evaluation target could be several influence of quality information for one representative consumer product at different time points, or several influence of quality information for several representative consumer products at the same time point. In these two cases, the adopted indices for information dissemination are the same. So, both of them are suitable for this model. Ordinary Multilevel Comprehensive Evaluation Model is shown as Figure 1.
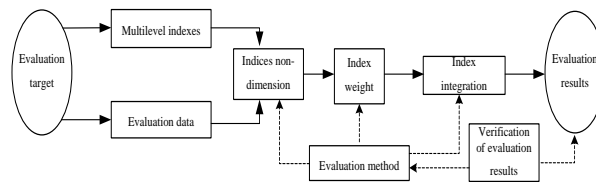

Figure 1 Multilevel Comprehensive Evaluation Model

3.2 Evaluation Steps

Process for influence evaluation of Web quality information for consumer products based on gray entropy includes the following six steps:

Step 1: Judgment matrix constituted by evaluation indexes.

Use the matrix to represent the characteristic value of m_j evaluation indices for all n evaluation targets of information influence. The matrix is shown as follows:

$$x_{ij}^h = \begin{bmatrix} x_{m_1 1}^h & x_{m_1 2}^h & ... & x_{m_1 n}^h \\ x_{m_2 1}^h & x_{m_2 1}^h & ... & x_{m_2 n}^h \\ & & ... & \\ x_{m_i 1}^h & x_{m_i 2}^h & ... & x_{m_i n}^h \end{bmatrix}$$

In which, $i = m_1, m_2 \ldots m_i$ $h = 1, 2, \cdots, n$; $j = 1, 2, \cdots, n$

If the index becomes better and better as the value grows bigger and bigger, it shall be calculated in accordance with formula (1) as below:

$$r_{ij}^h = \frac{x_{ij}^h - \wedge x_{ij}^h}{\vee x_{ij}^h - \wedge x_{ij}^h} \qquad (1)$$

If the index becomes better and better as the value grows smaller and smaller, it shall be calculated in accordance with formula (2) as below:

$$r_{ij}^h = \frac{\vee x_{ij}^h - x_{ij}^h}{\vee x_{ij}^h - \wedge x_{ij}^h} \qquad (2)$$

In the formula, $\vee, \wedge$ are symbols respectively indicating taking bigger value or smaller value.

After normative processing, the matrix is shown as below:

$$r_{ij}^h = \begin{bmatrix} r_{m_1 1}^h & r_{m_1 2}^h & \ldots & r_{m_1 n}^h \\ r_{m_2 1}^h & r_{m_2 2}^h & \cdots & r_{m_2 n}^h \\ & & \ldots & \\ r_{m_i 1}^h & r_{m_i 2}^h & \cdots & r_{m_i n}^h \end{bmatrix}$$

Step 2: Determine correlation coefficient for various evaluation targets systems and reference sequence.

Because the influences of Web information on n information dissemination channels (correspond to n sub-systems) is featured by comparatively relativity. The largest extent influence in the number h sub-system is in terms of m_i information dissemination indices. Therefore, it shall select the idealized and optimal program firstly which could ensure every dissemination index maintain its biggest value. It can be denoted as:

$$F_i^h = [f_{m_1}^h, f_{m_2}^h, \ldots, f_{m_i}^h]$$

In the formula, $f_i^h = \max(r_{i1}^h, r_{i2}^h, \ldots, r_{in}^h)$, $i = m_1, m_2, \ldots, m_i$, that is to say, f_i in F_i^h is the maximum value of a certain dissemination index for all influence evaluation targets on the dissemination channel and it can be regarded as the standard extreme reference program. Taking it as the reference sequence, n programs shall be taken as comparative sequence respectively. Similarity degree of data geometrical relationship between reference sequence and comparative sequence is usually measured by the correlation degree. The correlation coefficient between j comparative sequence and i index in F_i^h reference sequence can be donated by $\varepsilon_{Fj}^h(i)$ and it can be calculated in accordance with formula (3) as below:

$$\varepsilon_{Fj}^h(i) = \frac{\min_j \min_i \left| f_i^h - r_{ij}^h \right| + \rho \max_j \max_i \left| f_i^h - r_{ij}^h \right|}{\left| f_i^h - r_{ij}^h \right| + \rho \max_j \max_i \left| f_i^h - r_{ij}^h \right|} \qquad (3)$$

In which, $j = 1, 2, \ldots, n$; $i = m_1, m_2, \ldots, m_i$, in the formula (3), $\rho \in [0,1]$, in general, $\rho = 0.5$.

Step 3: Determine the weight of each evaluation index.

According to Entropy theory, if there has a big difference of a certain index value between every evaluation target and the entropy is less, it indicates that the amount of effective information provided by this index is large and its weight is supposed to large as well. On the contrary, if there has a small difference of a certain index value between every evaluation target and the entropy is large, it indicates that the amount of effective information provided by this index is small and its weight is supposed to small as well. When the certain index values between every evaluation target are the same, the entropy reaches its maximum value which means that there is not any available information of the index and it shall be removed from the evaluation index.

Steps for determining the weight of each evaluation index with the entropy are as follows:

1) The entropy for the number V_h sub-system can be defined as:

$$H_{vh} = -\frac{1}{\ln n} \sum_{j=1}^{n} \frac{\varepsilon_{Fj}^h(i)}{\sum_{j=1}^{n} \varepsilon_{Fj}^h(i)} \ln \frac{\varepsilon_{Fj}^h(i)}{\sum_{j=1}^{n} \varepsilon_{Fj}^h(i)} \quad (4)$$

In the formula, $j = 1,2,...,n$, $i = m_1, m_2,...,m_i$.

2) Weight is calculated in accordance with formula (5) as below:

$$\omega_{vh} = \frac{1}{\sum_{j=1}^{m}(1-H_{vh})}(1-H_{vh}) \quad (5)$$

In the formula, $0 \le \omega_{vh} \le 1$, $\sum_{i=m_1}^{m_i} \omega_i = 1$.

Weight vector constituted by m_i index weight in the number V_h sub-system is represented as below:

$$\omega_{m_i}^{vh} = [\omega_{m_1}^{vh}, \omega_{m_2}^{vh},...,\omega_{m_i}^{vh}]$$

Step 4: Make up correlation degree matrix.

Calculate the correlation degree between each reference sequence and comparative sequence in accordance with the recombination of every index weight and correlation coefficient obtained in Step 2:

$$R_j^{vh} = \omega_{m_i}^{vh} \varepsilon_{Fj}^h(i), \quad j = 1,2,...,n \quad (6)$$

Calculate correlation degree for V_h sub-systems separately and establish correlation degree matrix constituted by n influence information evaluation targets of V_h sub-systems:

$$R_{Vh \times n} = \begin{bmatrix} R_1^1 & R_2^1 & ... & R_2^1 \\ R_1^2 & R_2^2 & ... & R_n^2 \\ & & ... & \\ R_1^{Vh} & R_2^{Vh} & ... & R_2^{Vh} \end{bmatrix}$$

Step 5: Determine the weight of sub-system.

Select the reference sequence from correlation degree matrix determined by Step 4 and the rest are comparative sequences. Work out the correlation coefficient $\varepsilon_{Fj}(v)$ between reference sequence and comparative sequence. Then calculate the weight of V_h sub-systems by entropy weight method:

$$\omega_v = [\omega_{v_1}, \omega_{v_2},...\omega_{v_h}] \text{ and } \sum_{v_1}^{v_h} \omega_v = 1$$

Step 6: Determine the correlation degree.

Recombine the weight of sub-system and correlation coefficient obtained in Step 5 to work out the correlation degree for comprehensive evaluation of information influence. The size of correlation degree determines the degree of information influence.

Correlation degree of system's comprehensive evaluation is as below:

$$R_j = \omega_v \cdot \varepsilon_{Fj}(v), \quad v = v_1, v_2,...,v_h \quad (7)$$

4. Case Study

Aiming at "Anxin Floor Event" disclosed on the Internet, this paper conducts researches on

information influence of the event on the network. Through four kinds of network information dissemination channels, such as web portals, forum, blogs and microblog etc and on the basis of index system established in advance, data for almost one month are collected successively to build up multilevel comprehensive evaluation model based on gray entropy and finally acquire the evaluation results of information influence.

4.1 Model Calculation

If the whole Web is one complex system, the four network dissemination channels can be regarded as four sub-systems. Tracking to weight change of four sub-systems could keep pace with the change of four channels' function reflected in the process of information influence dissemination. After evaluating four sub-systems, add them up to obtain correlation coefficient which could represent the quantification value of event information influence and its variations.

(1) Normalization Processing

Carry out normalization processing to every index in line with formula (1) and formula (2). Basically, indices for research objects in this paper belong to the type that the index becomes better and better as the value grows bigger and bigger, such as number of comments and number of forwarding etc. When these indices become bigger and bigger, it indicates that the information influence grows stronger and stronger. As a result, it shall calculate in accordance with formula (1) during normalization computing.

(2) Calculate correlation coefficient between each evaluation target system and reference sequence.

Calculate correlation coefficient according to formula (3). Take the data ten days ago as example and the calculation results are shown in Table 2:

Through the correlation coefficient matrix, use formula (4) to work out the entropy of sub-system; then, use formula (5) to calculate weight vector of every evaluation element for sub-system of each dissemination channels, $\omega =$ {0.06,0.07,0.07,0.06,0.06,0.09,0.06,0.09,0.08,0.06,0.07,0.06,0.06,0.05,0.05,0.08}; at last, recombine weight vector with correlation coefficient matrix by formula (6) to acquire the first layer correlation degree vector quantity for each reference sequence and comparative sequence, that is to say {0.06, 0.18, 0.11, 0.09, 0.07, 0.07, 0.07, 0.09, 0.07, 0.06}. With the same methods, evaluation index weight for the rest three sub-systems could be determined as well, respectively concluding three weight vectors, as well as three first layer correlation coefficient vectors.

With the same methods, select the reference sequence from the matrix constituted by four groups of first layer correlation degree vectors and take the matrix itself as comparative sequence; re-calculate the second layer correlation coefficient for reference sequence and comparative sequence; utilize entropy weight method to work out the weight of four sub-systems and the calculation results are {0.14, 0.18, 0.28, 0.4}; recombine the vector with second layer correlation coefficient and finally conclude the array of correlation degree for comprehensive evaluation of information influence with the value of {0.46, 0.94, 0.68, 0.47, 0.44, 0.42, 0.44, 0.47, 0.43, 0.42, 0.42, 0.41}.

4.2 Result Analysis

In order to represent the influence evaluation results of "Anxin Floor Event" information on the Web more intuitively, conduct normalization processing to 32 comprehensive evaluation correlation degree and the result is shown in Figure 2.
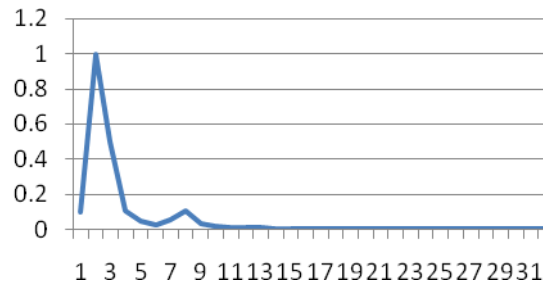
Figure 2 Information Influence of "Anxin Floor Event"

As we can see from Figure 1, in the first three days, the influence of event information increases intensively and declines immediately soon afterwards; one week later, there is a rebound within a narrow range but then declines again and reduces to the minimum level and tends to level off in the end. The calculation result conforms to the actual situation. It's exactly the several days after the explosion of event that netizens discuss it with the strongest enthusiasm. But then the influence of event reduces at once. After one week, it's the time for relevant enterprise to deliver the clarification to the public which causes a rebound within a narrow range. However, it's obvious that the influence is inferior to the influence at the time of event explosion. Later on, the influence tends to the minimum level and has relatively stable condition which indicates that the influence of the event on the Web lasts short duration.

The tracking to weight of influence of four major network information dissemination channels could reflect the influence change of four major channels to information dissemination. Tracking results are shown as Figure 3.
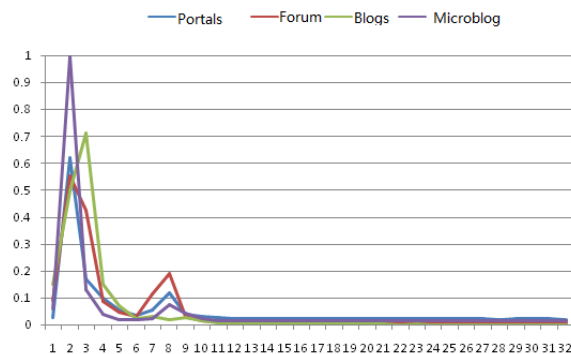

Figure 3 Influence of Dissemination Channel of "Anxin Floor Event"

As it is shown in Figure 3, in the first three days after event explosion, as a newly-born network information dissemination channel, the function of microblog for information dissemination has already exceeded traditional web portals and it be followed by forum, the blogs come last. Besides, the influence of blogs obviously lags behind microblog, web portals and forum but it can catch up from behind. In the following days, the influence of microblog sharply reduces and ranks to the last place among four channels which means that its influence has a strong time sensitive. After that, the microblog never ranks to the preceding places. From the slope aspect, the influence of forum reduces at the slowest speed. At the stage of rebounding within a narrow range, it can be seen that forum has the strongest influence, following by web portals, and it reflects that the forum works as an excellent carrier for netizens' continuous discussion.

5. Conclusion

Aiming at typical consumer quality and safety events, the paper studies on the dissemination of relevant information on the Web; analyzes the four dissemination channels that include web portals, forum, blogs and microblog; proposes the comprehensive evaluation method to information influence; establishes the comprehensive evaluation model based on gray entropy; evaluates the

level of Web information influence on the basis of Web information influence evaluation system; conducts empirical analysis to consumer quality and safety events; and at the same time carries out comparative analysis to mean weighted evaluation model and TOPSIS evaluation model to verify the effectiveness of the model. The paper takes most of quantitative indices into consideration and has no regard for qualitative indices. Web information influence can be effected not only by quantitative indices, such as information content of dependent events and number of netizens who take in the interaction; but also by social factors like regional informatization network environment, political environment and policy environment in local places etc.

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