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Using a Hybrid Multiple-Criteria Decision-Making Technique to Identify Key Factors Influencing Microblog Users' Diffusion Behaviors in Emergencies: Evidence from Generations Born after 2000

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Abstract: Recently, some appalling events have attracted wide attention, such as the RYB (Red, Yellow and Blue) child abuse incident, the killing of stewardesses by online car-hailing, and the swine fever epidemic. With the development of mobile Internet, Microblog has accelerated the spread of emergencies. Diffusion behavior is affected by different motivations, and motivation theory declared that internal and external motivations are the direct influencing factors of users' behavioral intention. Therefore, this study uses a hybrid multiple-criteria decision-making (MCDM) technique, combining the decision-making trial and evaluation laboratory (DEMATEL) and analytical network process (ANP) to identify the key factors influencing user's diffusion behaviors in emergencies. According to the results of empirical study, perceived usefulness, perceived emotionality, perceived accessibility, information timeliness, and information authoritativeness are identified as the key factors influencing user's diffusion behaviors. Finally, we propose some managerial suggestions to help stakeholders control online public opinion effectively.

Keywords: emergencies; Microblog; diffusion behavior; DEMATEL; ANP; MCDM

1. Introduction

In recent years, social networks like Microblog and WeChat have become an integral part of people's lives. At the same time, all kinds of emergencies frequently occur around the world. As a new propagation paradigm, social media, in the context of emergencies, is a tool that promotes information dissemination and the diffusion of social networks. Users often share special, outrageous, or compelling news on social media [1]. Social media allows people to quickly exchange risk-related information [2] in matters of self-preservation, and an increasing number of people are using social media to send and receive emergency-related information [3], especially in undergraduates, who are young and enthusiastic, but lack of social maturity and are more easily affected by public opinion.

Microblog, China's largest weak-relationship-based communication platform, has become increasingly popular in recent years. Individuals can post original microblogs and retweet other people's posts to share them with their followers. Different to WeChat, Microblog is a "weak relationship" platform, and its essence is media, not social contact. Microblog, the "weak relationship" platform is more conductive to the dissemination of knowledge and information; however, WeChat is a "strong tie" platform, which tends to more about communication and sharing. Due to the sudden

nature, uncertainty, and deficiency of information in emergency situations, people are more likely to feel compelled to share their feelings at the moment they experience an emergency or when they are stimulated by their circumstances. The posting and forwarding of microblogs rapidly spread emergency-related information [4].

There are a number of factors affecting users' information diffusion behavior, and how to identify them is a difficult problem. Key factors identification is a classical multiple-criteria decision-making (MCDM) problem. A novel hybrid MCDM technique, combining the decision-making trial and evaluation laboratory (DEMATEL) and analytical network process (ANP), named D-ANP [5], can solve the problem efficiently. In this study, D-ANP is used to identify the key factors influencing diffusion behavior. According to empirical results, perceived usefulness, perceived emotionality, perceived accessibility, information timeliness, and information authoritativeness are identified as the key factors.

The remainder of this paper is organized as follows. Section 2 introduces related works about information diffusion behavior and proposes the research gap. Section 3 proposes the identification of factors affecting diffusion behavior. Section 4 introduces the Delphi method and the D-ANP technique. In Section 5, we use D-ANP to identify the key factors influencing Microblog users' information diffusion behavior, and discuss the management implications and outcomes. Finally, Section 6 draws our discussion and conclusions.

2. Related Works

More and more scholars pay attention to the information dissemination behavior of Microblog users. Allsop and Bassett [6] believe that information dissemination is a very common phenomenon, and found that nearly 60% of people indicate that they often share online information with others. Morris [7] investigated a range of public information dissemination procedures and believed that clear, accurate, and fair information should be disseminated to the public to correct any public misunderstanding of events. Yu and To [8] investigated the impact of internal information generation and dissemination on employees' work-related behaviors, and found that both informal and formal information have a significant impact on information transmission. Gough, Hunter, and Ajao [9] studied the use of social media for issuing and disseminating public health information regarding skin cancer to improve the awareness and attitudes of the target population.

Diffusion behavior is affected by different motivations [10]; motivation theory [11] declared that internal and external motivations are the direct influencing factors of users' behavioral intention. Wilson [12] proposed three factors that influence information behavior: interpersonal relationships, personal traits, and environmental factors. Li et al. [13] stated that the independent variables of interpersonal relationships, personal characteristics, the information environment, and the intermediate variables of social attraction and conversion cost all had an impact on the information communication behavior of network users. Zhang [14] identified the main factors influencing the crisis information propagation behavior of college students, for whom he found the propagation of external emergency information to be inevitable. Alm, Jackson, and Mckee [15] studied the dissemination of audit information and found that informal communication has a strong indirect effect on compliance, whereas official information announcements may not always enhance voluntary compliance. Kim [16] studied the change in people's forwarding mode following the great earthquake in northeast China, and found that after learning of the disaster, users became more sensitive to information containing earthquake-related keywords. People are more likely to be influenced by environmental factors when sharing information with friends.

With the popularity of mobile networks, emergency events are spreading faster than ever before [17], especially the surge in the number of Microblog users [4]. The aforementioned studies have proposed some factors influencing information diffusion behavior. However, they are not systematic and comprehensive. Therefore, building an index for Microblog users' diffusion behavior for emergencies is necessary. In addition, due to limited resources, it is important to identify the key factors among the many influencing factors for stakeholders.

3. Identification of Factors Affecting Diffusion Behavior

The expression of any viewpoint or sharing of any information on social media may affect or even mislead public opinion. The public opinion found in microblogs in the context of emergencies, from generation to upsurge, is the result of continuous propagation. The propagation of public opinion cannot be separated from the extensive participation of Microblog users [18]. Identifying the key factors influencing users' participation in the propagation of microblogs is an important subject in current research. After much research, scholars have identified the main factors affecting information transmission behavior from different perspectives.

3.1. User Perception

User perception, a very important aspect of diffusion behavior in emergencies, is the intrinsic motivation of the user, which is the user's perception of usefulness, happiness, and risk when posting or forwarding microblogs. Jin, Feng, and Zhou [19] studied the mechanism influencing WeChat user behavior in disseminating electronic health information, on the WeChat Moments platform, from the perspective of the communicator's intrinsic motivation. With respect to healthcare information on the WeChat Moments platform, the results showed that information that was perceived to be interesting, novel, accurate, awesome, positive, emotional, or useful has significant and positive effects on users' intention to share it. Xie, An, and Wang [17] discussed the information publishing behavior of WeChat users, and found that factors such as perceived usefulness, perceived trust, and perceived risk had a significant influence on personal information disclosure and the behavioral intention to release information. Ding, Wu, and Xia [20] found that microblogs that express sentiment are more likely to be retweeted. Taking Microblog as an example, Stieglitz and Dang [21] studied emotions and information diffusion behaviors in social media, and found that emotional microblogs generally tend to be retweeted more often. Xu and Lu [22] found that external motivation, as represented by perceived usefulness, and internal motivation, as represented by perceived pleasure, had positive influences on behavioral intention.

3.2. Platform Perception

The platform being used is the second aspect influencing diffusion behavior, which in this case relates to the perception of users of the Microblog platform. This aspect consists of factors such as ease of use, system reliability, and interface friendliness. Shi [23] studied the communication of public crisis information in the mobile Internet environment, and identified motivation, channel, and object as three factors influencing user information propagation behavior. Ge, Wang, and Zhou [24] identified the motivations of online retail consumers in publishing online comments from three dimensions and found platform correlation to be very important.

3.3. Information Content

Information content is the third important aspect influencing behavior, particularly in emergencies, and has been the focus of many scholars. This includes the integrity, timeliness, authoritativeness, and reliability of the information. Shan, Liu, and Xu [25] studied the key factors influencing the dissemination behavior and motivation regarding haze-related information in WeChat, and found that the information source, information content, and information receiver are its three main elements. Li et al. [26] studied the factors influencing the health information diffusion behavior of users in the Microblog environment, and found the health information diffusion intention of Microblog users to be positively affected by the health information's explicit characteristics, the perceived information quality, and the strength of the user relationship, and that user diffusion intention significantly and positively influences diffusion behavior. Wang and Wang [27] studied the forwarding behavior of Microblog users. Their empirical results indicated that the quality of perceived information will influence user perception of risk, trust, and belief, and that these three factors influence the desire to share. Jin et al. [28]

discussed the mechanism influencing Microblog users' forwarding behavior in emergencies, and found the characteristics of the information source to significantly affect information forwarding behavior.

3.4. Social Factors

Social factors have been widely studied by many scholars. Shi et al. [29] adopted the Twitter data set to study the main features affecting the forwarding of personal information on social networking sites, and emphasized that the motivation for self-presentation plays an important role in decision-making regarding the propagation of information. Wang, Xia, and Yu [30] built a motivation model of the sharing of online social network user information, and found cognitive uses, affective uses, gratification, altruism, and the perception of ethics to have a positive effect on information sharing in online social networks. Peng, Zhu, and Wang [31] found trust and reciprocity to have obvious effects on the sharing behavior of Microblog users. Yang, Chen, and Gan [32] found that the perception of social norms in rational situations play a leading role in behavioral intention. However, in irrational situations, uncertain information and intergroup emotional contagion play a dominate role. Jin, Fang, and Zhou [33] found that a user's perception of the external environment has a significant impact on both emotions and the sharing of original information on Microblog.

3.5. Personal Characteristics

Personal characteristics are also very important in network information diffusion behaviors. Wang and Zhang [10] studied the behavior of WeChat user information release in the mobile social network environment, and found that user-generated content was affected by user characteristics, such as the WeChat user characteristics, information publication time, and the numbers of likes and comments. Xie, An, and Wang [17] also reported that personal characteristics have important influence on diffusion behavior.

During the process of public opinion propagation, microblogs are transmitted among users through the Microblog platform. Therefore, personal characteristics, user perception, the Microblog platform, and emergencies are the main factors that can be used to characterize user behavior in Microblog information diffusion. In addition, Stefanone and Jang [34] argued that the purpose of blog design is to maintain existing interpersonal relationships, and that the social environment is also an important factor in whether users choose to post or forward information. In this paper, we present a prototype architecture consisting of five perspectives and 21 criteria, as shown in Table 1.

Table 1. Prototype architecture of factors influencing Microblog users' information diffusion behavior.

Aspect	Criteria	Definition	Reference
User	Perceived usefulness	Users perceive that posting or forwarding microblogs is useful for their personal image, enhancement of their social relationships, emotional catharsis, etc.	Davis [35]; Hsu and Lin [36]
	Perceived happiness	Users feel happy when posting or forwarding microblogs.	Stuart and Martin, [37]
	Perceived risk	Users perceive that the risk of posting or forwarding microblogs, with respect to personal information leakage or spreading false information, may possibly affect their reputation and that they may possibly be breaking the law.	Ropeik [38]
Platform	Perceived ease of use	Users perceive that the platform is easy to use, such as when posting or forwarding, and that it can be accessed in a variety of ways (mobile phone, computer, iPad).	Davis [35]
	Perceived system reliability	Users perceive that the Microblog system platform is reliable. If posting or forwarding microblogs, it will not crash, break down, or fail to respond.	Xu [39]
	Perceived interface friendliness	Users perceive the interface of the Microblog platform to be user friendly, for example, the client or mobile client interface is reasonable and easy to use.	Xu [39]

Table 1. *Cont.*

Aspect	Criteria	Definition	Reference
Platform	Perceived accessibility	Users perceive the Microblog platform to be accessible (i.e., that it meets their needs to publish or forward their microblogs at any time and place).	Xu [39]
	Perceived platform trust	Users trust the Microblog platform regarding its information authenticity, and trust that their private personal details will not be revealed when posting or forwarding on the platform.	Gefen, Karahanna, and Straub [40]
Information Content	Information integrity	Users perceive Microblog information to be of good quality, and not one-sided but complete.	Li et al. [26]
	Timeliness of information	Users perceive the Microblog information content to be timely.	Li et al. [26]
	Information authoritativeness	Users perceived the Microblog information content to be authoritative.	Li et al. [26]
	Information reliability	Users perceive the Microblog information content to be authentic and reliable.	Li et al. [26]
Social Factors	Civic responsibility	Users perceive that posting or forwarding emergency microblog information is consistent with their roles and responsibilities as citizens.	Wang, Xia, and Yu Liping [30]
	Subjective norm	Users perceive some social pressure regarding whether to publish or forward emergency microblog information.	Ajzen [41]
	Reciprocity consciousness	Users perceive that posting or forwarding emergency microblog information is reciprocal.	Shi and Lu [42]
	Reputation seeking	Users perceive that posting or forwarding emergency microblog information can serve to enhance personal prestige.	Shi and Lu [42]
	Altruism	Users believe that they were in the same situation as those who had experienced an emergency, posting or forwarding this information would be of use to them.	Shi and Lu [42]
	Moral perception	Users feel an emotional response in posting or forwarding emergency microblog information, that they are meeting ethical expectations they have for themselves and toward others.	Wang, Xia, and Yu Liping [30]
	Emotional sharing	Users post or forward microblogs to vent their emotions during emergencies.	Ge, Wang, and Zhou [24]
Personal Factors	Personal characteristic	Users' personal characteristics, such as gender, age, education degree, etc.	Wang and Zhang [10]
	Microblog involvement	Microblog involvement, such as the years of use, number of followers, number of follows, and number of posts.	Henri and Jon [43]

Among the criteria, perceived usefulness, perceived happiness, and perceived ease of use are derived from motivation theory and the technology acceptance model. References [10,17,22] have applied perceived usefulness, perceived happiness, perceived risk, perceived ease of use, and personal characteristics to WeChat situations. We extended them into Microblog circumstance in emergencies. Perceived system reliability, perceived interface friendliness, civic responsibility, perceived accessibility, moral perception, and Microblog involvement were consistent with references [30,39,43]. Perceived platform trust has been applied to online shopping in reference [40] and we also extended to Microblog. Fours criteria of information aspect, reciprocity consciousness, reputation seeking, and altruism were consistent with references [26,42]. The applied field switched from health information diffusion to emergencies information. Subjective norm has been applied to organizational behavior and we extended to Microblog. Emotional sharing were applied from online shopping to the Microblog situation.

4. Methodology

Identifying key factors influencing Microblog users' diffusion behaviors is a classical MCDM problem, because the factors have interdependent impacts. MCDM methods are often used to resolve problems characterized by several incommensurable and conflicting (competing) criteria, where no one solution satisfies all criteria simultaneously [5]. Therefore, we organize this section as follows. Section 4.1 introduces the Delphi method and Section 4.2 presents the framework of the D-ANP method.

4.1. Delphi Method

The objective of the Delphi method [44], as proposed by the RAND Corporation in the 1950s, is to obtain the most reliable consensus of a group of experts. Researchers have applied this method primarily to cases in which judgmental information was indispensable, and have typically used a series of questionnaires interspersed with controlled feedback. The Delphi method has been applied in many management fields. For example, Ferri et al. [45] applied the Delphi method to determine the worldwide prevalence of dementia. Hu et al. [46] indicated that the Delphi method depends on the experience, instincts, and values of experts to determine outcomes. In practice, these experts from different fields are usually expected to provide varying perspectives on a topic, to understand one another's perspectives in one round of the questionnaires, and to adjust their own perspectives in the next round to attain consistency. Briefly, this process avoids the occurrence of direct confrontation among experts [47]. In this paper, a consensus deviation index (CDI) is adopted to indicate the degree of expert consensus. The CDI can be expresses as follows:

$$\mathrm{CDI} = \frac{S_{ij}}{\overline{x}_{ij}}$$

Here, $\overline{x}_{ij}$ represents the average value of item j and S_{ij} is the standard deviation. The larger the CDI is, the weaker the expert consensus is. In this paper, we used 0.1 as the basis for judgment of the CDI. Figure 1 shows the process of the Delphi method.

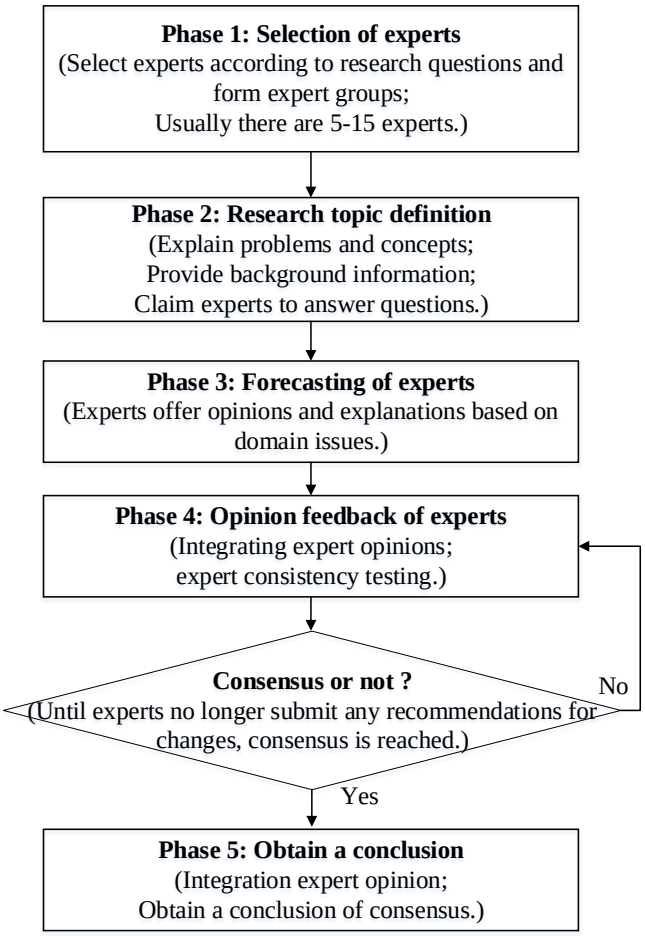

Figure 1. Process of Delphi.

4.2. D-ANP

Traditionally, the analytic hierarchy process (AHP) proposed by Saaty [48] is a classical method for evaluation weights, but it has certain limitations. For example, the AHP requires that the studied aspects and criteria be independent of each other, which is not often the case in real work situations. The ANP method proposed by Saaty [49] is often used to solve decision problems and stems directly from the AHP. Although ANP can accommodate interdependence and feedback among its criteria and alternatives, it has a serious problem in achieving consistency in pairwise comparisons, due to the limitations in human cognition [50] and the shortcomings associated with the typical one-to-nine scale, especially in a high order matrix [51]. In addition, it also inherits theoretical weaknesses of the assumptions of the AHP, such as the rank reversal problem and the priorities derivation method [52,53].

In practice, DEMATEL and ANP are usually used in combination [54]. DEMATEL, developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 [55,56], has been considered one of the best tools to deal with the importance and causal-effect relationships among the evaluation criteria [57]. Therefore, DEMATEL can be applied to construct a network relation map (NRM) [58] for ANP by describing interdependencies, visually, in the form of networks of explainable nodes and directed arcs [57]. Ou Yang et al. [5] proposed a D-ANP method in which the total influence matrix generated by DEMATEL is directly employed as the unweighted supermatrix of the ANP, thus avoiding the troublesome pairwise comparisons that impede the ANP. Furthermore, the rank reversal problem and the priorities derivation problem no longer exist. Currently, the D-ANP method is widely used in various fields [46,54,59–64].

The DEMATEL method does not require the elements to be independent. The correlation between the elements in the system can be determined in a cause–effect relationship graph, and then the elemental influence factors can be identified from a number of influence factors. A direct influence relationship matrix $\mathbf{Z}$ is generated by questionnaire, and then the direct influence matrix $\mathbf{Z}$ is normalized and substituted into the formula, $\mathbf{T} = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}$, to obtain the total influence matrix $\mathbf{T}$. Let us assume that the sum of the row elements in $\mathbf{T}$ is $\mathbf{D}$, and the sum of the column elements is $\mathbf{R}$. $\mathbf{D} + \mathbf{R}$ is defined as the degree of importance, and the higher the $\mathbf{D} + \mathbf{R}$ value is, the higher the importance of the criterion is. $\mathbf{D} - \mathbf{R}$ is defined as the degree of correlation. If it has a positive value, this criterion is an active influencer, and the higher its value is, the higher its degree of direct influence on other factors is. However, if the degree of correlation of the criterion is negative, this indicates that the criterion is itself affected, and the higher the negative value is, the greater it is influenced by other factors.

The traditional ANP method requires that the consistency of each paired comparison matrix be verified following the comparison questionnaire. However, when there are many items, this is often difficult to achieve. Therefore, the total influence matrix of DEMATEL can be directly used as the unweighted super matrix of the ANP, which eliminates the need for the consistency check of the paired comparison matrix. Respondents must simply fill out the direct impact matrix, which greatly reduces the complexity of filling out the questionnaire and improves survey efficiency.

Figure 2 shows details of the D-ANP method process, revised from [65].

Since both DEMATEL and ANP provide the importance of each factor [63], we combined them using the Borda method, rather than depending only on the degree of importance from ANP. The Borda rule is a scoring method that yields a unique ranking, which is a maximum likelihood estimator of the true order. The assumptions are that there is indeed a true order and that all judges or voters are able to order any two alternatives as they are in the true order with the same probability [66]. For example, if a factor's prominence is ranked second in DEMATEL, and fourth in ANP, then its Borda score is six. Thus, a smaller Borda score implies greater importance, which provides a method to select key factors.

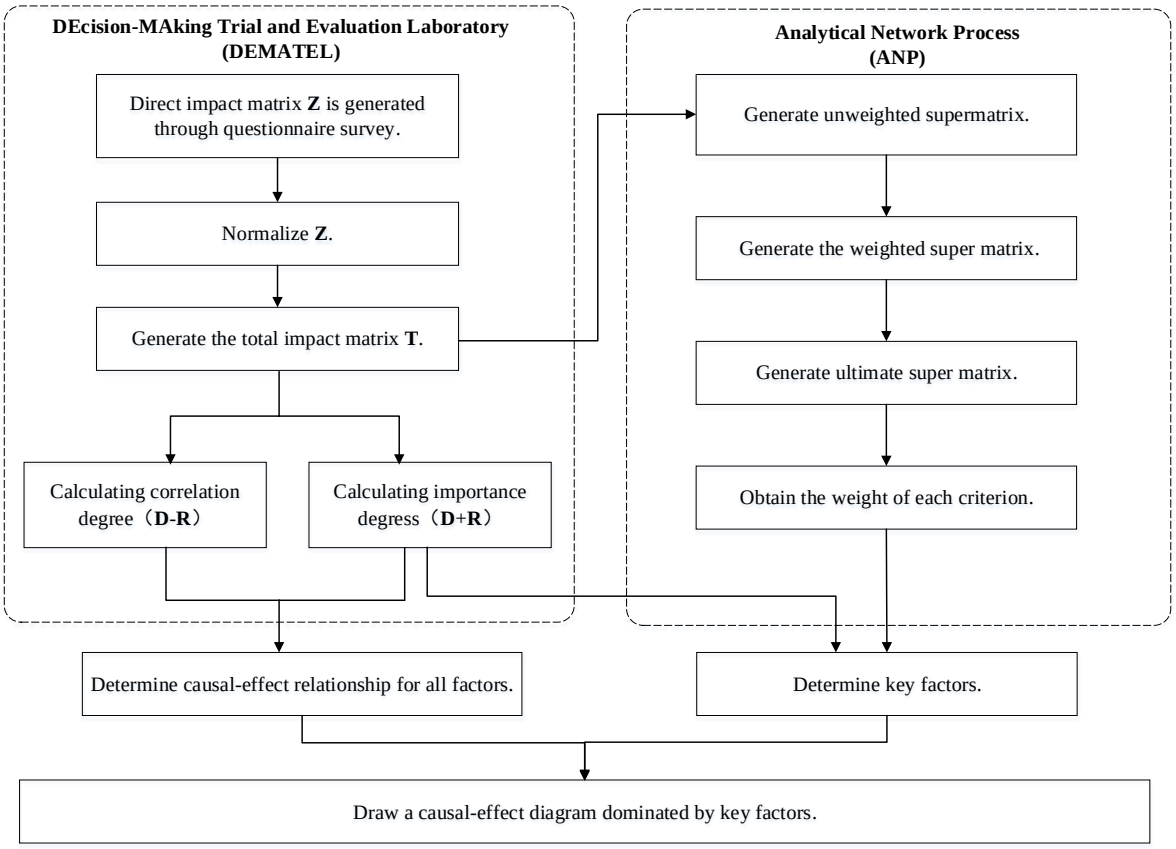

Figure 2. Process of D-ANP.

5. Empirical Study

5.1. Establishing the Formal Decision Structure

Delphi is a decision-making method in which experts gradually reach a consensus in the process of multiple rounds of communication. This method greatly reduces the subjectivity of people's awareness and experience, and it can prevent wrong decisions from being made. In this study, to form a group of experts, we selected five experts either with industry experience or years of research experience on Microblog user behavior, whose background information is shown in Table 2. In order to avoid the possible homogeneity of the experts, five experts from different domains were selected, including three associate professors, one psychological consultant, and one office staff member. First, the selected associate professors focus on different interests in emergency events management, social media, and public opinion control, respectively. Second, the selected psychological consultant, with the certification of National Level 2, has been engaged in psychological counseling for students for a long time. Furthermore, the selected university office staff member often deals with some student's affairs by Microblog, and is very familiar with their ideas and behaviors.

Table 2. Expert background information.

Experts	Title	Gender	Research Field or Jobs	Work Experience (Year)
A	Associate professor	Male	Emergency events management	10–15
B	Associate professor	Male	Social media	20–25
C	Associate professor	Male	Public opinion control	10–15
D	National level 2 psychological counselor	Female	Psychological counseling for students	20–25
E	Office staff member	Male	Student's affairs	10–15

In the literature, we identified five dimensions and 21 criteria that influence the information diffusion behavior of Microblog users, as shown in Table 1. This paper mainly addresses user information diffusion behavior in the context of emergencies, so it is not appropriate in this context to define the concept of perceived pleasure from the expert interviews. Instead, we describe the pleasant feeling of forwarding or posting a microblog that might help other people in the emergency situation, which may induce users to post or forward microblog information. However, in addition to the pleasure of helping others, there are other kinds of emotions associated with emergencies, such as anger, fear, disgust, etc. Emotion contagion brought on by emergencies can overcome user reticence, making it easier to engage in user information diffusion behavior. Therefore, in this paper, we modified the definition of perceived pleasantness to perceived emotionality, and reached a consensus in this regard through expert interviews.

After two rounds of Delphi investigation, we identified four aspects and 15 criteria and reached a consensus. All CDI values were less than 0.1, as shown in Table 3.

Table 3. Expert's score of criteria necessities and consensus deviation index (CDI).

Aspect	Criteria		Score of Criteria Necessities (0–100)					Mean	SD	CDI
			A	B	C	D	E			
User	Perceived usefulness		85	95	100	80	100	92	8.1240	0.0883
	Perceived emotionality		80	95	90	90	100	91	6.6332	0.0729
	Perceived risk		85	85	95	75	100	88	8.7178	0.0991
	Microblog involvement	Age of using	86	80	80	90	80	83.2	4.1183	0.0495
		Number of followers	90	100	85	90	90	91	4.8990	0.0538
		Number of follows	95	95	90	90	90	92	2.4495	0.0266
		number of posts	95	90	100	90	100	95	4.4721	0.0471
Platform	Perceived ease of use		90	90	90	95	100	93	4.0000	0.0430
	Perceived system reliability		80	80	90	90	100	88	7.4833	0.0850
	Perceived interface friendliness		80	85	85	90	100	88	6.7823	0.0771
	Perceived accessibility		90	85	85	99	100	91.8	6.5544	0.0714
Information content	Timeliness of information		90	95	100	100	100	97	4.0000	0.0412
	Information authoritativeness		80	95	95	90	100	92	6.7823	0.0737
	Information reliability		75	95	85	100	95	90	8.9443	0.0994
Social factors	Reputation seeking		70	90	95	88	90	86.6	8.6163	0.0995
	Altruism		90	95	85	95	100	93	5.0990	0.0548
	Moral perception		75	95	90	95	100	91	8.6023	0.0945
	Emotional sharing		85	95	85	100	90	91	5.8310	0.0641

The criterion with an average value of less than 80 marks was deleted because this indicator was of negligible importance. In this case, there were no criteria in accord with this condition, so all of the criteria in Table 3 were retained. Table 4 shows the resulting modified formal research decision framework.

Table 4. The formal research architecture.

Aspect	Criteria	Definition
User (A)	Perceived usefulness (A_1)	Users perceive that posting or forwarding microblogs is useful for personal image, social relationship enhancement, emotional catharsis, etc.
	Perceived emotionality (A_2)	Users feel some kind of emotion to post or forward microblogs.
	Perceived risk (A_3)	Users perceive the risk of posting or forwarding microblogs, such as personal information leakage, spreading unreal information, possibly affecting reputation and possibly breaking the law.
	Microblog involvement (A_4)	Microblog involvement, such as the age of using, number of followers, number of follows and number of posts.
Platform (B)	Perceived ease of use (B_1)	Users perceive that the platform is easy to use, such as posting or forwarding, and can be accessed in a variety of ways (mobile phone, computer, iPad).
	Perceived system reliability (B_2)	Users perceive that the system platform of Microblog is reliable. If posting or forwarding microblogs, it will not crash, breakdown, or fail to respond.
	Perceived interface friendliness (B_3)	Users perceive the friendly interface of Microblog platform, for example, the client or mobile client interface is reasonable and easy to use.
	Perceived accessibility (B_4)	Users are aware of the accessibility of the Microblog platform, such as being able to meet the needs of users to publish or forward the microblogs at any time and place.
Information Content (C)	Timeliness of information (C_1)	User's perception of the Microblog information content quality and believed that they are timely.
	Information authoritativeness (C_2)	User's perception of the Microblog information content quality and believed that they are authoritative.
	Information reliability (C_3)	User's perception of the Microblog information content quality and believed that they are authentic and reliable.
Social Factors (D)	Reputation seeking (D_1)	Users perceive that posting or forwarding emergency microblogs information can improve personal prestige effectively.
	Altruism (D_2)	Users perceive a kind of emotion of that in the same situation with someone who experienced an emergency, and posting or forwarding is to realize the utility satisfaction of others.
	Moral perception (D_3)	Users perceive that posting or forwarding emergency microblog information is an emotional response of self-ethics and ethics.
	Emotional sharing (D_4)	Users post or forward microblogs for releasing emotions in emergencies.

5.2. Determine the Total Influence Matrix

In this study, we adopted the DEMATEL method to clarify the cause–effect relationship between the factors influencing the information diffusion behavior of Microblog users in the context of emergencies. To facilitate the respondents' thinking, we adopted a simple 0–2 three-point scale (where 0 indicates no effect, 1 indicates an impact, and 2 indicates a big impact), and invited participants to respond. The interviewees were college students with more than two years of experience using Microblog and who had a relatively active status. A total of 112 questionnaires were distributed, and 107 were returned. Five of them were not included due to incompleteness of the comparison matrix. Forty-five out of the 107 respondents did not fulfill the requirements of the questionnaire. Some filled in a number diagonal to the criterion comparison, while others filled in the same value, so these were

all deleted. Finally, we obtained 62 valid questionnaires and generated an initial direct-influence matrix by sorting out the X results, as shown in Table 5.

Table 5. Initial direct-influence matrix.

Criteria.	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C_1	C_2	C_3	D_1	D_2	D_3	D_4
A_1	0.0000	1.1290	1.0968	1.0000	1.1129	1.1290	1.1613	1.0806	1.2097	1.1290	1.1129	1.0484	1.0806	1.2131	1.2459
A_2	1.1613	0.0000	1.0806	1.1129	1.1639	1.2295	1.1129	1.1290	1.0820	1.1613	1.0968	1.1452	1.0806	1.1967	1.1311
A_3	1.0968	1.0968	0.0000	1.0984	0.9839	1.0968	1.1475	1.0161	0.9839	1.1452	1.0323	1.2097	0.9677	1.0164	1.0656
A_4	0.9516	1.1129	1.2295	0.0000	1.0164	1.0484	1.0968	1.1613	1.1452	1.1452	1.1935	1.0000	1.0000	1.0323	1.2419
B_1	1.0484	1.0984	1.0806	0.9194	0.0000	1.1311	1.1452	1.1129	1.0323	1.1452	1.0645	1.0000	1.1129	1.1452	1.1452
B_2	1.0645	1.1290	1.1129	1.0968	0.9839	0.0000	1.0645	1.0484	1.2419	1.0968	1.1935	0.9355	1.1290	1.1452	1.1129
B_3	1.0984	1.0806	1.0323	0.9839	0.9032	0.9839	0.0000	1.1148	1.1774	1.0484	1.0000	0.9839	1.1129	1.2419	1.0645
B_4	1.0645	1.0968	1.1613	1.0968	1.0806	1.1290	1.1129	0.0000	1.0806	1.1129	1.0806	0.9516	1.0161	1.1290	1.3871
C_1	1.1129	1.1129	1.0161	1.1129	1.0161	1.0806	1.1935	1.1290	0.0000	1.0645	1.0806	1.0820	1.0968	1.1667	1.1129
C_2	1.0806	0.9839	1.1452	1.1935	1.0806	1.0000	1.0806	1.1452	1.1639	0.0000	1.1290	1.0968	0.9839	1.1613	1.0806
C_3	1.0000	0.8548	1.0000	1.0161	1.1129	0.8871	0.9839	1.0323	1.2097	1.0484	0.0000	1.0656	1.0161	1.1129	1.0645
D_1	1.0806	1.1935	0.9355	1.0806	0.9016	1.0323	1.0806	1.0645	1.0806	1.1774	0.9344	0.0000	1.0161	1.0323	0.8871
D_2	0.8871	0.9194	0.9355	0.9677	1.0968	1.0000	1.0806	0.9839	1.0645	0.9839	0.9355	0.9836	0.0000	1.0492	0.9355
D_3	1.0968	1.0806	1.0484	0.8871	1.1129	0.9344	1.0968	1.1129	0.9194	1.0161	1.1452	0.9180	1.0984	0.0000	1.0484
D_4	1.0656	1.0984	1.0484	0.9355	0.9355	1.1290	1.1290	0.8871	1.1452	1.1290	0.8871	0.9677	1.0323	1.0820	0.0000

By normalizing the initial direct influence matrix, we obtained the total influence relationship matrix by the formula, $\mathbf{T} = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}$, as shown in Table 6.

Table 6. Total influence relationship matrix **T.**

Criteria	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C_1	C_2	C_3	D_1	D_2	D_3	D_4
A_1	1.1293	1.2073	1.2010	1.1654	1.1719	1.1945	1.2451	1.2069	1.2507	1.2364	1.1993	1.1600	1.1878	1.2653	1.2521
A_2	1.2069	1.1506	1.2099	1.1811	1.1842	1.2096	1.2524	1.2194	1.2538	1.2482	1.2082	1.1746	1.1973	1.2745	1.2558
A_3	1.1412	1.1524	1.0836	1.1195	1.1131	1.1402	1.1894	1.1502	1.1834	1.1829	1.1420	1.1178	1.1290	1.1988	1.1872
A_4	1.1609	1.1811	1.1834	1.0819	1.1421	1.1652	1.2155	1.1861	1.2212	1.2115	1.1787	1.1332	1.1583	1.2289	1.2259
B_1	1.1528	1.1668	1.1616	1.1234	1.0689	1.1563	1.2042	1.1699	1.2009	1.1976	1.1581	1.1200	1.1513	1.2210	1.2065
B_2	1.1656	1.1805	1.1754	1.1450	1.1391	1.1017	1.2122	1.1785	1.2250	1.2072	1.1774	1.1281	1.1641	1.2336	1.2173
B_3	1.1318	1.1419	1.1350	1.1037	1.0996	1.1245	1.1123	1.1460	1.1840	1.1676	1.1308	1.0960	1.1277	1.2013	1.1773
B_4	1.1755	1.1888	1.1881	1.1545	1.1539	1.1781	1.2252	1.1264	1.2264	1.2184	1.1809	1.1385	1.1676	1.2431	1.2427
C_1	1.1699	1.1813	1.1717	1.1474	1.1423	1.1670	1.2210	1.1845	1.1540	1.2072	1.1726	1.1376	1.1639	1.2365	1.2189
C_2	1.1647	1.1709	1.1755	1.1486	1.1426	1.1592	1.2113	1.1821	1.2188	1.1410	1.1720	1.1353	1.1543	1.2326	1.2137
C_3	1.0972	1.1000	1.1039	1.0770	1.0826	1.0900	1.1403	1.1120	1.1554	1.1375	1.0423	1.0723	1.0934	1.1633	1.1469
D_1	1.1105	1.1275	1.1092	1.0893	1.0795	1.1068	1.1546	1.1228	1.1575	1.1537	1.1068	1.0179	1.1020	1.1682	1.1463
D_2	1.0520	1.0642	1.0611	1.0361	1.0435	1.0573	1.1050	1.0699	1.1067	1.0935	1.0588	1.0297	0.9945	1.1186	1.0990
D_3	1.1105	1.1203	1.1145	1.0775	1.0905	1.1005	1.1547	1.1244	1.1477	1.1439	1.1174	1.0718	1.1058	1.1062	1.1543
D_4	1.1069	1.1195	1.1126	1.0784	1.0785	1.1094	1.1545	1.1100	1.1582	1.1481	1.1013	1.0727	1.1002	1.1680	1.0902

Table 7 shows the degree of importance ($\mathbf{D} + \mathbf{R}$) and the degree of correlation ($\mathbf{D} - \mathbf{R}$) of each factor.

Table 7. The importance and correlation degree of each factors.

	D	R	D + R	D − R	RANK
A_1	18.0731	17.0757	35.1488	0.9974	4
A_2	18.2264	17.2529	35.4792	0.9735	2
A_3	17.2307	17.1864	34.4171	0.0443	10
A_4	17.6739	16.7289	34.4028	0.9450	11
B_1	17.4594	16.7323	34.1916	0.7271	12
B_2	17.6506	17.0603	34.7109	0.5903	8
B_3	17.0795	17.7975	34.8770	–0.7180	6
B_4	17.8079	17.2889	35.0968	0.5190	5
C_1	17.6758	17.8436	35.5193	–0.1678	1
C_2	17.6225	17.6947	35.3172	–0.0721	3
C_3	16.6140	17.1465	33.7605	–0.5326	13
D_1	16.7528	16.6056	33.3584	0.1472	14
D_2	15.9898	16.9971	32.9869	–1.0074	15
D_3	16.7398	18.0599	34.7997	–1.3202	7
D_4	16.7084	17.8341	34.5425	–1.1257	9

5.3. Identification of Key Factors

A weighted supermatrix was obtained by normalizing the total impact matrix, and a limiting supermatrix was derived from a weighted supermatrix, as shown in Table 8.

Table 8. Limiting supermatrix.

W	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C_1	C_2	C_3	D_1	D_2	D_3	D_4
A_1	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697
A_2	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703	0.0703
A_3	0.0665	0.0665	0.0665	0.0665	0.0665	0.0665	0.0665	0.0665	0.0665	0.0665	0.0665	0.0664	0.0665	0.0665	0.0665
A_4	0.0681	0.0681	0.0681	0.0682	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681
B_1	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673	0.0673
B_2	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681	0.0681
B_3	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659	0.0659
B_4	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687	0.0687
C_1	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682
C_2	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680	0.0680
C_3	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641
D_1	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646
D_2	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617	0.0617
D_3	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646	0.0646
D_4	0.0644	0.0644	0.0644	0.0645	0.0645	0.0644	0.0644	0.0645	0.0644	0.0644	0.0645	0.0645	0.0644	0.0644	0.0645

By combining DEMATEL with ANP and adopting Borda rules, we obtained the overall ranking of the influencing factors, as shown in Table 9.

Table 9. Comprehensive ranking of each factor.

	DEMATEL	ANP	Borda Score	Overall Ranking
A_1	4	2	6	3
A_2	2	1	3	1
A_3	10	9	19	9
A_4	11	5	16	7
B_1	12	8	20	11
B_2	8	6	14	6
B_3	6	10	16	7
B_4	5	3	8	4
C_1	1	4	5	2
C_2	3	7	10	5
C_3	13	14	27	14
D_1	14	11	25	13
D_2	15	15	30	15
D_3	7	12	19	9
D_4	9	13	22	12

By discussing the above ranking results with experts, the top five were defined as key criteria. These included perceived usefulness (A_1), perceived emotionality (A_2), perceived accessibility (B_4), timeliness of information (C_1), and information authoritativeness (C_2). Figure 3 shows the causal-effect diagram of the key factors.

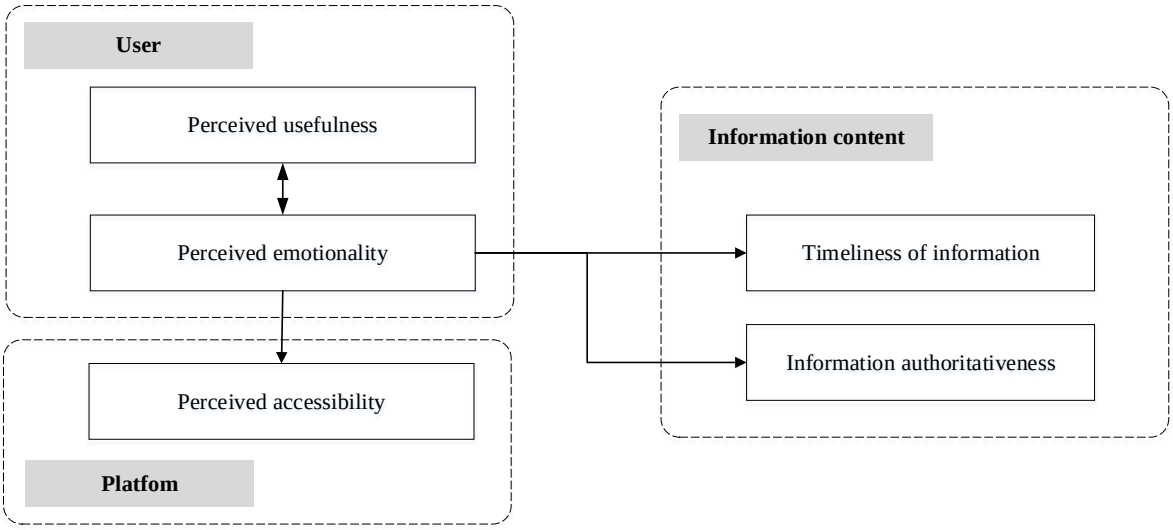

Figure 3. Causal-effect diagram of key factors.

5.4. Management Implications

As one of the most important forms of online social networks, Microblog has become an indispensable part of people's lives. Research on Microblog users' information diffusion behavior is particularly important regarding the control and guidance of online public opinion. This paper identified the key factors influencing the information diffusion behavior of Microblog users in the context of emergencies, including the information subject (Microblog user), information object (Microblog platform), and information content. Although social factors may exert some influence on

user diffusion behavior, they are not the key factors. According to the results of our empirical research, we identified perceived usefulness, perceived emotionality, perceived accessibility, information timeliness, and information authoritativeness as the key criteria that influence user information diffusion behavior. In Figure 3 and Table 7, we can see that perceived usefulness and perceived emotionality were the most important active influence factors. Therefore, we can get management practice as follows:

(1) According to Figure 3, the selection of perceived emotionality as the starting point is appropriate because it is categorized into the class of "cause". Emotion is the beginning of information diffusion and the intrinsic motivation for user behavior. In the case of emergency events, the government or public opinion response department should guide public sentiment in a timely fashion to avoid the increase of negative emotion and to guide the trend of online public opinion effectively.

(2) In the case of emergency, the government or public opinion response department should release timely information about the emergency. To improve a user's understanding of the content of emergency information, the government should release timely information about the event progress, response process, and results processing to enhance its perceived usefulness to users, and thereby promote the spread of positive emotions to a certain extent and inhibit the spread of negative emotions.

(3) The degree of approval a user has toward the platform can also affect users' perception of platform accessibility to some extent, so institutions such as public opinion regulators and Microblog platforms should optimize platform performance, enhance platform functions, and improve platform usability and accessibility to provide Microblog users with a good user experience. Targeted measures should be taken to guide Microblog users to think rationally and reduce negative emotions and blind followers.

(4) The timeliness and authoritativeness of information are important factors influencing the forwarding of information by users. Therefore, the government or public opinion event-response departments should pay close attention to the timeliness of information and ensure the authoritativeness of the information through official channels to avoid the random propagation and spread of rumors.

6. Discussion and Conclusions

Based on real-world relationships, this study constructed a hybrid MCDM model, integrating the DEMATEL method and the ANP method, to identify the key factors influencing Microblog users' diffusion behaviors for emergencies. According to the empirical results, perceived usefulness, perceived emotionality, perceived accessibility, information timeliness, and information authoritativeness were identified as key criteria. Several of the main contributions of this study are described below.

First, this paper identifies the key factors influencing diffusion behavior comparing with the literatures cited. Previous studies have found some influencing factors of diffusion behavior, such as user perception [35–38], platform perception [35,39,40], information content [26], social factors [12,24,30,41,42], and personal characteristics [10,13,43]. However, according to the empirical results, social factors and personal characteristics are no longer the main influencing factors in the context of emergency. Furthermore, according to the total influence matrix, social factors such as reputation seeking, altruism, moral perception, and emotional sharing have effects on information sharing, which is consistent with references [30–33], but not the key factors.

Second, the undergraduates, who are the most representative Microblog user group, usually post information through Microblog. However, their diffusion behavior is often irrational and susceptible to other people's influence. Therefore, we asked the generations born after 2000, as the respondents, to fill out the initial influence matrix of DEMATEL, to identify the critical factors influence the information diffusion behavior, which has strong practical significance.

Third, based on motivation theory, this paper establishes an evaluation index that consist of four aspects including user, platform, information content, and social factors, to influence the information diffusion behavior of Microblog users. This extends the application scenario of the motivation theory.

In future study, some limitations and considerations need to be taken into account. First, this paper uses D-ANP method to identify key factors influencing microblog user's diffusion behavior, which focuses on the application of methods rather than on the innovation of methods. However, some shortcomings of the method should be paid attention to, such as the rank reversal problem, the priorities derivation method, and the comparison scale. Furthermore, if the cluster of alternatives participate in calculation of weights by means of ANP, the weights of criteria would be different, and the ranking would change accordingly. Second, an assumption of additivity may not be realistic in some applications [67], because the variables are not always independent of each other. Therefore, it would be interesting and useful to explore a non-additive approach [46,59,63]. In future study, the performance of non-additive D-ANP should be examined.

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