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Jianmin He
Hefei University of Technology, China, hejianmin@hfut.edu.cn

Linyi Xin
Hefei University of Technology, China,, Lynn_xinn@163.com

Suxia Wei
Hefei University of Technology, China, tjweisx@163.com

Molson Han
Hefei University of Technology, China, hanmaoxin@126.com

Yezheng Liu
Hefei University of Technology, China, liuyezheng@hfut.edu.cn

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Maoxin Han, Hefei University of Technology, China, hanmaoxin@126.com

Yezheng Liu, Hefei University of Technology, China, liuyezheng@ hfut.edu.cn

ABSTRACT

Measuring online user influence is a major research topic in social marketing performance maximization. In this study, we comprehensively investigate how online influential users gain, accumulate, and use their social capital from the perspective of information resource management and social capital measurement. First, we define the social capital of online influential users and the attribute characters and relationships reflected fully by personality and sociality index data. We then construct a social capital measurement indicator system and information entropy model of online users. After the calculations of this model, we finally forma social capital measure method of online influential users. The rationality and validity of proposed model are tested by experimental study on real datasets.

Keywords: Online user influence, Social capital of influence, Individual social capital measurement, Information entropy measure method.

1 INTRODUCTION

"Online celebrities" gain increasing popularity on the Internet, and their commercial value of influence attracts much interest and wide concern in the society. Some of them realize their commercial value rapidly and become social advertising endorsers pursued by a large number of enterprises. "Online celebrity" refers to a class of online users who own unique charisma, high industry visibility, and professional content supply capacity. Given that information interaction via the Internet is unaffected by time and space limit, online celebrities construct their social network and control it by publishing, spreading, and interacting various kinds of valuable information. They accumulate and use their social capital, thereby integrating and utilizing social resources and relationships; consequently, they exert online influence on the values, lifestyles, and information selection behavior of other online users[14]. Online influence is an important manifestation of individual social capital and is an important marketing resource of enterprise implementation of Internet strategy[15]. Therefore, determining how to measure the social capital of online influential users and calculate their online influence is important. Such determination depends on a clear realization of the process during which the online influential users gain, accumulate, and use their social capital. Therefore, we provide a social capital measure method of online influential users. Measuring online user influence is a scientific issue in social marketing performance maximization and a major topic in enterprise Internet marketing management.

Much research on social capital has achieved several achievements. For example, Lin Nan[18][19] considered social capital as resource, ability, and influence embedded in the social network, and involves mainly prestige, power, and wealth. Wellman B[31], Marsden PV[23][24], and Wei Jianwen, Zhao Yandong et al.[35][36] studied the attributes of individual cognition, structure, and relationship in the offline social network. They also used "name-generator"[5] and "position-generator"[20] to measure individual social capital. BianYanjie and Li Yu[1][2] and Zeng Mingbin and Zhou Chaowen[37] adopted the "Chinese New Year Greeting Network," the "Maximum Banquet Network," and other offline social networks to measure individual social capital among social groups. At present, the Internet social media develop rapidly and increasing online users affected by "online celebrities." have begun to gather, accumulate, and take advantage of their social capital of online influence to achieve their commercial value. A few users with business sense have regarded their online influence as realizable social capital for online rent seeking, and enterprises use their full capability to find influential "online celebrities" as spokespersons to push social advertisements[12]. Research about online user influence is also abundant. Considerable research has been conducted on information choice behavior and social interaction behavior of user. The research focus is mostly on the formation process and development of online user influence, and the attributes and correlation of influence from the physical

topology[32][38], link structure[6][30], and interactive relationship[3][16].The online user influence is usually obtained by calculating the occurrence of user network behavior. The social capital value of online influential users has begun to cause social concern, but the social capital formation of online users has not been explored from the perspective of social capital measurement. Its law of value is still unclear, and no effective method is available for computing the social capital of influential users. The social capital utility value of online influential users is an important decision basis for enterprises in selecting social advertising spokespersons for their Internet strategy implementation. Therefore, how online influential users gain, accumulate, and use their social capital must be comprehensively studied, the element composition and relationships in this process must be determined, and the general rule of formatting and making the most of social capital must be revealed to form a social capital measure method of online influential users.

In the present study, we comprehensively investigate how online influential users gain, accumulate, and use their social capital from the perspective of information resource management and social capital measurement. Accordingly, we can explore the measure method of online influential users. First, we define the social capital of online influential users and the attribute characters and relationships reflected fully by personality and sociality index data. We then construct a social capital measurement indicator system and information entropy model of online users. After the calculations of this model, we finally form a social capital measure method of online influential users. The research achievements enrich the theory system of information resource management and social capital measurement, and provide theoretical basis and practical method for enterprises in implementing Internet strategy and decision support for online advertising management.

2 SOCIAL RELATIONSHIP MAP OF SOCIAL NETWORK PLATFORM USERS

Online influential users publish and spread topic information that shows their specific opinion tendency to attract considerable attention and interact with other online users. Subsequently, they construct a manageable social network on which they can exert influence. The constituent elements in this social network are the big V users, general users, the mapping relation between user and topic, and the interactive relationship among users created by information choice behavior (Figure 2.1).
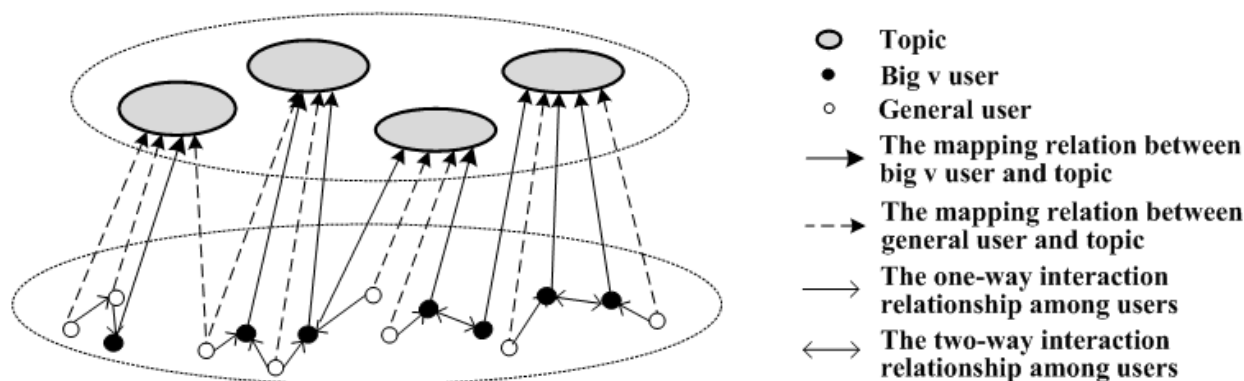

Figure 2.1 Social network structure diagrams among online users

On the Internet, assuming that any user i posts valuable topic information, user j immediately notices this information and conducts one or more interactive behaviors among "Read," "Reply," and "Share." Accordingly, the social network forms. In this network, the following three kinds of interactive relationships exist between the two users:

(1) Read. User j reads the topic information posted by user i, thereby establishing the reading relationship.

(2) Reply. User j not only reads but also replies the topic information, thereby establishing the replying relationship.

(3) Share. User j reads the topic information and shares it with others, thereby establishing the sharing relationship.

At this point, the basic social network map between user i and user j can be constructed as shown in Figure 2.2.
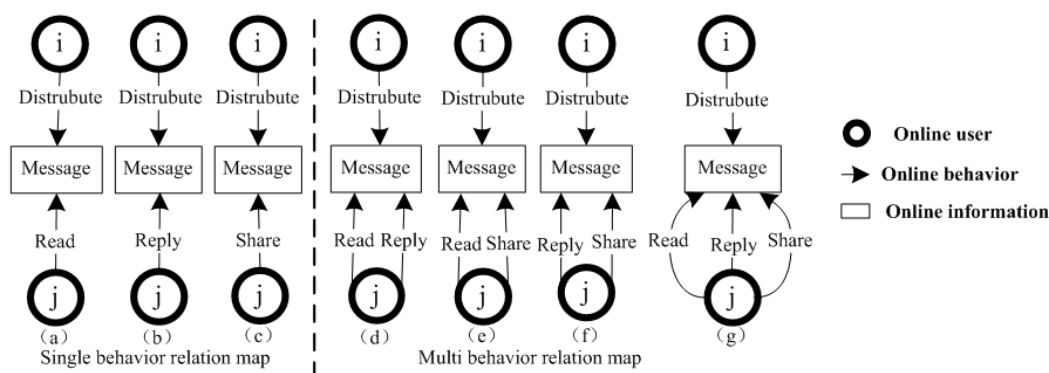
Figure 2.2 Basic social network map between two online users

As shown in Figure 2.2, the online influential users take good advantage of their unique personality and sociality to publish, spread, and interact topic information that shows their specific opinion tendency. This information attracts much attention and interest of other online users, and leads to emotional resonance and trust among those individuals. In this social network, each individual member can create, accumulate, and use social capital relying on the trust relationship. As individual social scope and dabbled content increase, the social capital of online users also gradually increases. The commercial value of these online users are thus discovered and given much attention by the society and enterprises.

3 SOCIAL CAPITAL EVALUATION INDEX SYSTEM OF ONLINE INFLUENTIAL USERS

Coleman JS[7], O'ConnorLG et al.[25], and Barnes-Mauthe M et al.[4] found that characteristic properties, such as online authority, discourse quality, propagation aging, and interaction relationship, are important for individual social capital. These characteristic properties are also the data sources manifesting the personal charisma and social interactive skills of an individual in a social network. After analyzing the online behavior of online users, we choose "personality" and "sociality" as the two dimensions for the social capital measurement index system of online influential users.

Individual social capital in the social network can be measured in two kinds of environment: online and offline. In this study, we measure mainly the individual social capital of online users.

3.1 Social Capital Indexes of "Personality"

The cultural literacy, speech quality, trustworthiness, own experience, and social status of social members can be used as attributes of "personality" to measure their social capital[8][21][27]. When adopted to online network, these offline attributes can be described as attribute data, such as user level, fan number, text number, and text quality[34][39]. FalconeRino et al.[13] and Pal A et al.[26] found that the trust among users is an important source of gaining and accumulating social capital. They also revealed that the individual attributes, such as authentication, community level, and fan number, can enhance the degree of trust. WoudstraL et al.[33][believed that the total number and quality of text posted by users can promote the dissemination of information, thereby helping users to gather high social capital resources and relationship. Zhang Peng Yi[39] and Leticia Bode et al.[22] discovered that, when the network platform users participate in more interactive topic, their speech becomes more powerful and they can gain, accumulate, and take advantage of their social capital more easily. Therefore, we select the user identity authentication, user level, fan number, text number, high-quality text number, and self-reply number as the second grade indexes to reflect "personality."

3.2 Social Capital Indexes of "Sociality"

The degree of concern, interactive collaboration, and communication frequency are the effective social capital indexes for evaluating "sociality"[9][28][40]. When mapped into network platform, these indexes manifest as the text hits, the number of reply and share, and the participant number in discussions[6][17].Zuo Wenming et al.[41]found that the user who can interact with other influential users must own high social capital commercial value. On this basis, we choose average text hits, average

number of text replies, and average number of high-rank participants in discussion as the second grade indexes to measure "sociality."

Accordingly, the social capital evaluation index system of online influential users is obtained(Table 3.2.1).

Table 3.2.1 Social capital evaluation index system of online influential users

First grade index	Second grade index	Index description	References
Personality	User identity authentication	The value is 1 if the user identity is authenticated and 0 if otherwise.	[13],[26]
	User level	The rank of user in the community.	
	Fan number	The total number of valid fans after the zombie powder.	
	Text number	The total number of texts posted by the community user.	
	High-quality text number	The quality of single text is judged comprehensively by its key words, word count, picture number, and hyperlink number.	[22],[28] [34],[39]
	Self-reply number	The number of replies provided by user to other users.	
Sociality	Average text hits	The ratio of the total number of text hits and the text number.	
	Average number of text replies	The ratio of the total number of text replies and the text number.	[6],[17],[41]
	Average number of high-rank participants in discussion	The ratio of the total number of high-rank participants and the text number.	

4 INFORMATION-ENTROPY BASED SOCIAL CAPITAL MEASURE MODEL OF ONLINE INFLUENTIAL USERS

Information entropy is proposed by Shannon and is used to measure the uncertainty value of information and its influence[29]. Cheng Qiyue, Qiu Wanhua, et al.[10]used timeliness entropy to calculate the size of bullwhip effect in supply chain and evaluate the efficiency of command process. Liang Changyong, Zhaoshuping, et al.[11] constructed environmental emergency severity level of assessment methods based on information entropy theory. He Jianmin and Hu Mengna[17] used the three-dimensional index system composed of the quality, transmission timeliness, and interaction degree of complaint text to construct an information entropy model for obtaining the influence of complaint text. Thus, information entropy is an effective method for measuring information influence.

On the social network platform, online users post, spread, and interact all kinds of information, and the information value is the main basis used by other users in judging its usefulness. The information influence depends on the "personality" value and "sociality" value of individual social capital[14].Therefore, information entropy can be used to measure the social capital of online users. Based on the two-dimensional social capital index system, we propose an information entropy model to measure the individual social capital. We form a set of social capital measure methods of online influential users, and this set may provide decision support for enterprises.

4.1 Definition of Social Capital Measure Indexes

Definition On the social network platform, we suppose an arbitrary user as u_i, and U as a set of users $U=\{u_1, u_2, \cdots, u_i, \cdots, u_n\}, (i=1,2,\Lambda,n)$ .The social capital indexes of u_i are $C_i = \{c_i^{p1}, c_i^{p2}, \Lambda, c_i^{pg}, c_i^{s1}, c_i^{s2}, \Lambda, c_i^{sk}\}$, $(i=1,2,\Lambda,n; g=1,2,\Lambda,6; k=1,2,3)$ where $c_i^{p1}, c_i^{p2}, \Lambda, c_i^{p6}$ denote the identity authentication, user level, fan number, text number, high-quality text number, and self-reply number; and $c_i^{s1}, c_i^{s2}, c_i^{s3}$ denote the average text hits, average number of text replies, and average number of high-rank participants in discussion.

4.2 Determination of Social Capital Measure Indexes Weights

The personality and sociality of each user significantly differ and different indexes weights can produce different results. Thus, the index weighting method must be properly selected. Zhou Wei and Li Xiaojing[42] used the entropy weight assignment

method to calculate the weights of indexes combined with objective and subjective factors. This method avoids the undesirable manual setting of weight and results in reasonable and effective evaluation system. In this study, we consider the objective and subjective evaluation factors also use the expert grading method to determine the weights of first grade indexes first, and then adopt the entropy weight assignment method to calculate the weights of second grade indexes. Finally, we obtain the synthetic weight. The method of calculating indexes weights is given below.

Step 1. Determine the weights of first grade indexes using expert grading method, and select n experts to percentile scores on the importance of first grade indexes, as follows:

Table 4.2.1 Expert grading method to determine the weights of first grade indexes.

First grade indexes	Experts				Average score
	1	2	…	n	
Personality	s_{11}	s_{12}	…	s_{1n}	$\overline{s_1} = \dfrac{1}{n}\sum\limits_{j=1}^{n} s_{1j}$
Sociality	s_{21}	s_{22}	…	s_{2n}	$\overline{s_2} = \dfrac{1}{n}\sum\limits_{j=1}^{n} s_{2j}$

Therefore, the weight proportion of "personality" and "sociality" is $\overline{s_1} : \overline{s_2}$. After normalization, the two-dimensional weights of

the first grade indexes are α_1, α_2, where $\alpha_i = \overline{s_i} \Big/ \sum\limits_{i=1}^{2} \overline{s_i}$, $\alpha_1 + \alpha_2 = 1$.

Step 2. Using the entropy weight method, calculate the weights of second grade indexes, as follows:
(1) Build the initial matrix as follows:

$$D = \begin{matrix} u_1 \\ u_2 \\ M \\ u_n \end{matrix} \begin{bmatrix} c_1^{p1} & \Lambda & c_1^{p6} & c_1^{s1}\Lambda & c_1^{s3} \\ c_2^{p1} & \Lambda & c_2^{p6} & c_1^{s1}\Lambda & c_1^{s3} \\ M & M & M & MM & M \\ c_n^{p1} & \Lambda & c_n^{p6} & c_1^{s1}\Lambda & c_1^{s3} \end{bmatrix}.$$

(2) Data dimensionless processing. Given that the dimension of each index is distinct, the data for comparison must be normalized. All indexes in this study are positive indexes, and the greater the index values, the better. The normalization method is as follows:

$$c_i'^{pg} = \frac{c_i^{pg} - \min_g(c_i^{pg})}{\max_g(c_i^{pg}) - \min_g(c_i^{pg})}, (i=1,2,\Lambda\ n; g=1,2,\Lambda\ ,6),$$

$$c_i'^{sk} = \frac{c_i^{sk} - \min_k(c_i^{sk})}{\max_k(c_i^{sk}) - \min_k(c_i^{sk})}, (i=1,2,\Lambda\ n; k=1,2,3).$$

The matrix after normalizing can be expressed by

$$D' = \begin{matrix} u_1 \\ u_2 \\ M \\ u_n \end{matrix} \begin{bmatrix} c_1'^{p1} & \Lambda & c_1'^{p6} & c_1'^{s1}\Lambda & c_1'^{s3} \\ c_2'^{p1} & \Lambda & c_2'^{p6} & c_1'^{s1}\Lambda & c_1'^{s3} \\ M & M & M & M\ M & M \\ c_n'^{p1} & \Lambda & c_n'^{p6} & c_1'^{s1}\Lambda & c_1'^{s3} \end{bmatrix}.$$

(3) Calculate the proportion of indexes as follows:

$$p(c_i^{pg}) = \frac{c_i'^{pg}}{\sum\limits_{i=1}^{n} c_i'^{pg}} (i=1,2,\Lambda\ n; g=1,2,\Lambda\ ,6),$$

$$p(c_i^{sk}) = \frac{c_i'^{sk}}{\sum\limits_{i=1}^{n} c_i'^{sk}} (i=1,2,\Lambda\ n; k=1,2,3).$$

(4) Calculate the entropy value of each index as follows:

$$E_g = -a \cdot \sum_{i=1}^{n} p(c_i{}^{pg}) Lnp(c_i{}^{pg}), (g = 1,2,\Lambda,6) \text{ where } a = 1/\ln n, \text{When } p(c_i{}^{pg}) = 0, \quad p(c_i{}^{pg})\ln p(c_i{}^{pg}) = 0.$$

The entropy value of E_k can be calculated in the same way.

(5) Weight each index as follows:

$$\omega_g = \frac{1-E_g}{\sum_{g=1}^{6}(1-E_g)}, (g=1,2,\cdots,6); \omega_k = \frac{1-S_k}{\sum_{k=1}^{3}(1-S_k)}, (k=1,2,3) \text{ where } \sum_{g=1}^{6}\omega_g = 1, \sum_{k=1}^{3}\omega_k = 1.$$

Thus, based on the weights of first grade indexes α_1, α_2, the weights of second grade indexes are $\omega'_g = \alpha_1 \omega_g (g=1,2,\Lambda,6), \omega'_k = \alpha_2 \omega_k (k=1,2,3)$.

4.3 Social Capital Measure Model of Online Influential Users

On the social network platform, for an arbitrary user such as u_i, the set of social capital indexes is $C_i = \{c_i^{p1}, c_i^{p2}, \Lambda, c_i^{pg}, c_i^{s1}, c_i^{s2}, \Lambda, c_i^{sk}\}, (i=1,2,\Lambda,n; g=1,2,\Lambda,6; k=1,2,3)$, the personality value is $IP(u_i)$, and the sociality value is $IS(u_i)$. Their calculation formulas are given below.

$$IP(u_i) = \sum_{g=1}^{6} \omega'_g c_i^{pg}, (i=1,2,\Lambda,n; g=1,2,\Lambda,6) \tag{1}$$

$$IS(u_i) = \sum_{k=1}^{3} \omega'_k c_i^{sk}, (i=1,2,\Lambda,n; k=1,2,3) \tag{2}$$

The total social capital value of u_i is $ISC(u_i)$.

$$ISC(u_i) = IP(u_i) + IS(u_i) \tag{3}$$

5 EMPIRICAL RESEARCH AND RESULTS

5.1 Data Collection and Pretreatment

We conduct an empirical research by choosing the "autohome.com.cn" as the research platform and the "Golf" brand community members as research object to measure social capital of online users and examine the rationality and validity of the proposed model. We collect the source data of their social capital index attribute daily and the observation period lasts six months, from June 1, 2015 to November 30, 2015.

(1) Data collection. We obtain the required data of 80 online users from GooSeeKer (www.gooseeker.com), and store them in an Excel file. The captured data mainly include user name, registration time, last login time, identity authentication, user level, the number of concerns, fan number, text number, high-quality text number, self-reply number, text hits, text replies, and the rank of participants.

(2) Data processing and explanation. We assume that the high-quality text number is higher than or equal to 1 (as the initial threshold) and reject the invalid users. We reorganize the social capital index data of the remaining 50 online users in an Excel file. The main workflow is as follows:

1) Use identity authentication. The value is 1 if the user identity is authenticated and 0 if otherwise.

2) User level. The rank of user in the community.

3) Fan number. The total number of valid fans after the zombie powder.

4) Text number. The total number of texts posted by the community user.

5) High-quality text number. Text quality is obtained by calculating the comprehensive text key words, text word counts, and picture and link number counts in the "Golf" brand community. The high-quality text is generally listed as the essence post. Accordingly, we use the essence post number as the high-quality text number for calculation.

6)Self-reply number. The total number of replies provided by user to other users.

7) Average number of text hits. The ratio of the total number of text hits and the text number.

8) Average number of text replies. The ratio of the total number of text replies and the text number.

9) Average number of high-rank participants in discussion. The ratio of the total number of high-rank participants and text number. The level of general users in the "Golf" brand community is less than 15. As a result, we consider users whose level is beyond 15 as high-rank participants.

The data processed by the above procedure only retain the entire digital items and are stored into the "Golf" brand community user data table. The interception of index data of a few users at the beginning and end of the observation period is shown in Tables 5.1.1 and 5.1.2.

Table 5.1.1 Part of online user index data in "Golf" brand community at the beginning of observation

User number	Personality value IP(u_i)						Sociality value IS(u_i)		
	User identity authentication	User level	Fan number	Text number	High-quality text number	Self-reply number	Average text hits	Average number of text replies	Average number of high-rank participants in discussion
u_1	1	13	502	250	28	5422	7773	406	46
u_2	0	8	138	190	6	7000	1996	9	9
u_3	1	10	199	88	6	3866	4126	123	12
u_4	1	15	3862	216	7	40120	6986	429	54
u_5	1	16	422	308	9	45665	6016	316	34
u_6	1	23	7869	158	69	20004	21255	1622	159
u_7	1	22	989	198	106	10256	16649	1348	124
u_8	1	17	4865	224	57	10524	8841	698	89
u_9	1	25	4475	166	145	57125	17692	1556	199
u_{10}	1	28	3658	1089	386	60223	24865	2296	301
…	…	…	…	…	…	…	…	…	…

Table 5.1.2 Part of online user index data in "Golf" brand community at the end of observation

User number	Personality value IP(u_i)						Sociality value IS(u_i)		
	User identity authentication	User level	Fan number	Text number	High-quality text number	Self-reply number	Average text hits	Average number of text replies	Average number of high-rank participants in discussion
u_1	1	14	662	290	39	7800	9566	423	57
u_2	0	9	162	236	10	9023	2498	25	13
u_3	1	10	217	116	7	5455	3275	83	11
u_4	1	17	5958	321	16	47778	7172	408	64
u_5	1	17	2612	480	12	52185	10698	427	33
u_6	1	25	10442	194	86	23189	24041	1847	144
u_7	1	24	1988	235	152	19998	29857	2665	201
u_8	1	18	5127	288	63	17078	9451	708	92
u_9	1	28	6876	207	189	92848	23482	2183	255
u_{10}	1	29	5289	1439	420	79944	20049	1889	289
…	…	…	…	…	…	…	…	…	…

5.2 Calculation of Social Capital

(1)Determine the weights of indexes

We invite 10 experts from MBA to determine the weights of first grade indexes. We then employ the entropy weight method to calculate the weights of second grade indexes. Finally, we obtain the comprehensive weights of the two grade indexes. The results are shown in Table 5.2.1.

Table 5.2.1 Weight of first grade and second grade indexes.

First grade index	Weight	Second grade index	Weight	Comprehensive weight
Personality	0.55	User identity authentication	0.155	0.085
		User level	0.227	0.125
		Fan number	0.265	0.146
		Text number	0.118	0.065
		High-quality text number	0.164	0.090
		Self-reply number	0.071	0.039
Sociality	0.45	Average text hits	0.382	0.172
		Average number of text replies	0.344	0.155
		Average number of high-rank participants in discussion	0.274	0.123
Total	1	—	—	1

Table 5.2.1 shows that, in the first grade indexes, personality value is more important to social capital value than sociality value. In the second grade indexes, fan number and user level highly contribute to personality value, while text average hits highly contribute to sociality value.

(2) Numerical calculation of social capital

After normalizing Tables 5.1.1 and 5.1.2 according to Table 5.2.1 and using the proposed social capital model, we calculate the social capital value of these online users at the beginning and end of the experimental observation. The calculation results are presented in Table 5.2.2.

Table 5.2.2 Social capital value of online users at the beginning and end of the observation

Online user u_i	Personality value $IP(u_i)$		Sociality value $IS(u_i)$		Social capital $ISC(u_i)$	
	Beginning	end	beginning	end	beginning	end
u_1	0.140	0.210	0.086	0.133	0.226	0.343
u_2	0.008	0.012	0.001	0.051	0.009	0.063
u_3	0.099	0.112	0.025	0.033	0.124	0.145
u_4	0.233	0.248	0.085	0.095	0.318	0.343
u_5	0.184	0.241	0.062	0.085	0.246	0.326
u_6	0.355	0.360	0.317	0.301	0.672	0.661
u_7	0.224	0.406	0.249	0.411	0.473	0.817
u_8	0.256	0.289	0.132	0.146	0.388	0.435
u_9	0.348	0.412	0.303	0.367	0.651	0.779
u_{10}	0.309	0.411	0.288	0.387	0.597	0.798
…	…	…	…	…	…	…

On the basis of the data in Table 5.2.2, we draw the comparison chart of personality value, sociality value, and total social capital of 50 observation objects during experimental observation(Figures 5.2.1–5.2.4).
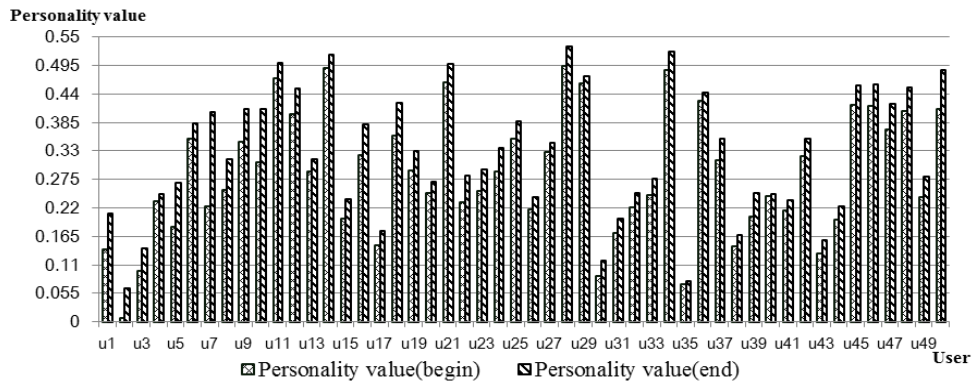
Figure 5.2.1 Column bar comparison chart of personality value
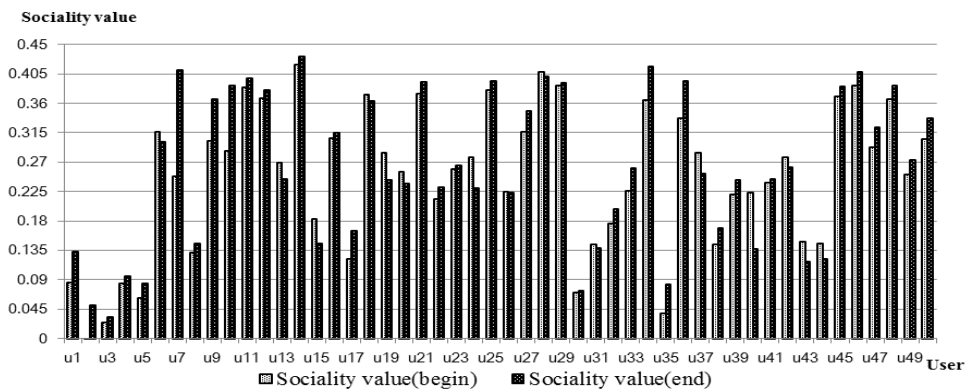

Figure 5.2.2 Column bar comparison chart of sociality value
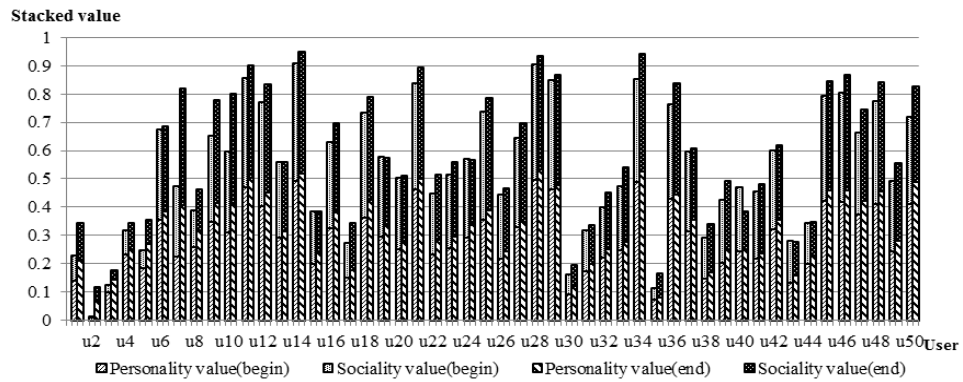

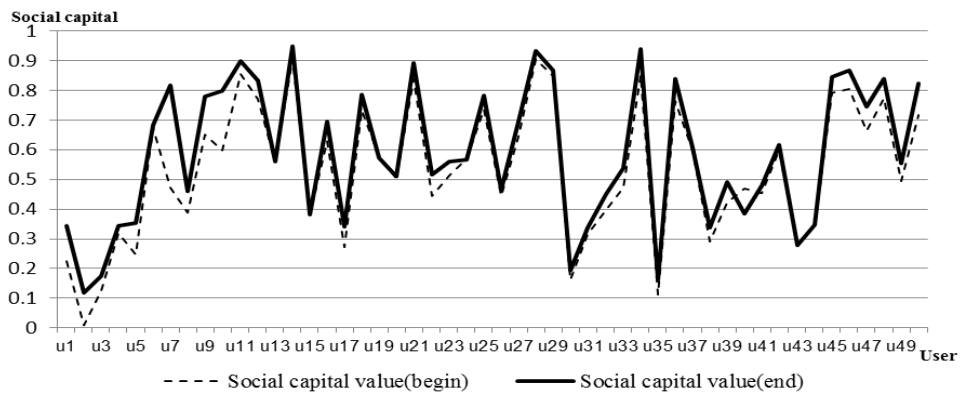Figure 5.2.3 Stacked bar comparison chart of personality and sociality value

Figure 5.2.4 Line comparison chart of total social capital

(3) Dynamic social capital map of online users

Given that the change of index data in this study cannot be recorded obviously in a daily basis, we use "week" as a unit to observe data. The social capital index data of u_7 and u_{10} in six months are shown in Table 5.2.3.

Table 5.2.3   Social capital dynamic change of online users u_7 and u_{10}

Observation		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
	IP	0.224	0.227	0.233	0.235	0.241	0.249	0.255	0.264	0.271	0.277	0.278	0.283
u_7	*IS*	0.249	0.251	0.253	0.267	0.273	0.281	0.299	0.317	0.32	0.324	0.341	0.348
	ISC	0.473	0.478	0.486	0.502	0.514	0.53	0.554	0.581	0.591	0.601	0.619	0.631
	IP	0.309	0.314	0.319	0.323	0.323	0.334	0.334	0.339	0.346	0.346	0.346	0.349
u_{10}	*IS*	0.288	0.301	0.307	0.311	0.313	0.322	0.324	0.331	0.323	0.325	0.325	0.32
	ISC	0.597	0.615	0.626	0.634	0.636	0.656	0.658	0.67	0.669	0.671	0.671	0.669
Observation		T_{13}	T_{14}	T_{15}	T_{16}	T_{17}	T_{18}	T_{19}	T_{20}	T_{21}	T_{22}	T_{23}	T_{24}
	IP	0.287	0.299	0.314	0.32	0.328	0.349	0.362	0.371	0.378	0.389	0.395	0.406
u_7	*IS*	0.345	0.361	0.362	0.371	0.377	0.382	0.386	0.391	0.399	0.404	0.407	0.411
	ISC	0.632	0.66	0.676	0.691	0.705	0.731	0.748	0.762	0.777	0.793	0.802	0.817
	IP	0.349	0.355	0.363	0.37	0.381	0.388	0.391	0.394	0.402	0.407	0.409	0.411
u_{10}	*IS*	0.321	0.339	0.344	0.35	0.359	0.37	0.368	0.371	0.384	0.39	0.393	0.387
	ISC	0.67	0.694	0.707	0.72	0.74	0.758	0.759	0.765	0.786	0.797	0.802	0.798

On the basis of the data in Table5.2.3, we draw the social capital dynamic change chart of u_7 and u_{10} (Figures 5.2.5–5.2.7).
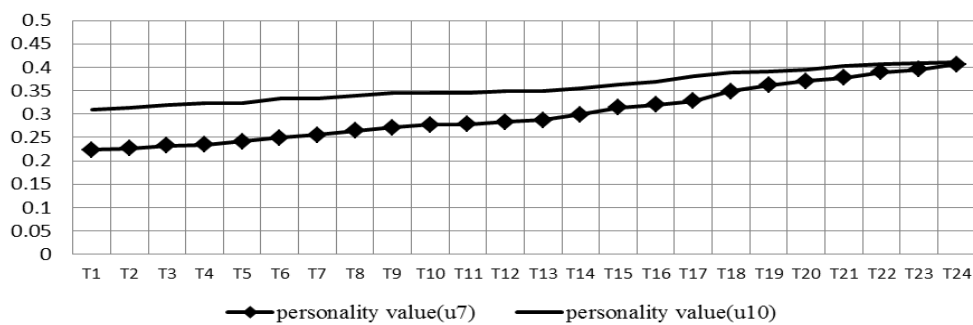

Figure 5.2.5 Dynamic change comparison chart of personality value
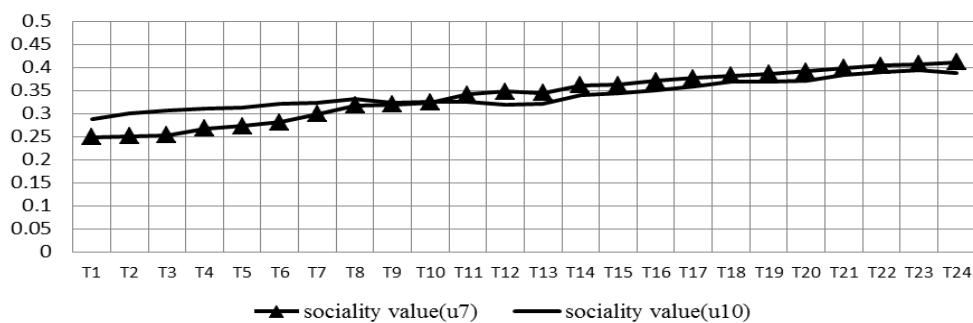

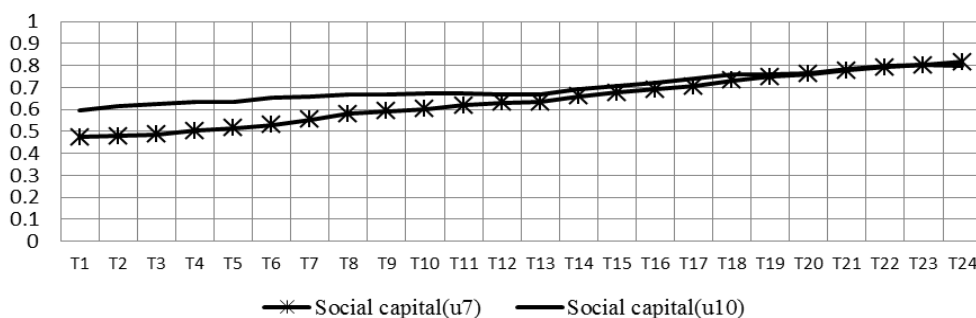Figure 5.2.6 Dynamic change comparison chart of sociality value

Figure5.2.7 Dynamic change comparison chart of total social capital

5.3 Experimental Results and Discussion

On the social network platform, the social capital of online influential users is determined by "personality" and "sociality." The experimental results from Figures 5.2.1 to 5.2.4 indicate that, although influential users own the same amount of total social capital, they show different kinds of influence on their "personality" and "sociality," such as u_{10} and u_{37}. In addition, the "personality," "sociality," and total social capital values of online users change with time, and the change rates vary from one to another. For example, the growth rates in "personality," "sociality," and total social capital value of u_7 are all higher than in those of u_{10}. At the end of observation period, personality value: $u_7 < u_{10}$, sociality value: $u_7 > u_{10}$, and the total social capital value: $u_7 > u_{10}$(Figures5.2.5–5.2.7).

The social capital of online individual users mainly reflects as online influence, which is identified by personality and sociality index data. The social capital influence embodied by personality depends on its personal resources, which are represented by personal attribute. They are the internal factors distinguishing a user from other users in the social network. Meanwhile, the social capital influence created by the sociality depends on the social resource, relationship, and ability of online user in this social network, which are represented by social attributes. They are the external factors used to differentiate online users.

The experimental results show that enterprises can establish the dynamic evaluation of social capital value and the selection mechanism of advertising spokesperson candidates based on the acquisition and utility features of individual social capital. From the beginning of influence germination, enterprises can track and pay close attention to the growth of influential users and constantly reevaluate the comprehensive performance in terms of pushing online advertisements. Thus, enterprises must analyze the social capital value from the two-dimensional measure index system composed of personality and sociality. Enterprises must make the most out of the relative advantage of the social capital of online users. They must also find the most suitable candidate to be the advertising spokesperson who can assist them in achieving advertising performance maximization.

Apart from selecting online influential users, the social capital formation and increasing rates of online users must also be analyzed according to the specific objectives and requirements of enterprise advertising. Enterprises must discover the potential influence characteristics of users with rapidly increasing social capital utility and excavate the potential burst of their social capital. In this way, enterprises can develop upfront training and investment plan, thereby obtaining good advertising performance with small advertising investment.

6 CONCLUSIONS

The proposed information entropy-based social capital measure method of online influential users is used to explore an effective way for calculating online influence of users and provide references for enterprises on choosing suitable online users to push advertisements. This area is a major research issue in social marketing performance maximization.

In this study, we comprehensively investigate how online influential users gain, accumulate, and use their social capital from the perspective of information resource management and social capital measurement. First, we define the social capital of online influential users and the attribute characters and relationships reflected fully by personality and sociality index data. We

then construct a social capital measurement indicator system and information entropy model of online users. After the calculations of this model, we finally form a social capital measure method of online influential users. The research achievements enrich the theory system of information resource management and social capital measurement, and provide theoretical basis and practical method for enterprises in implementing Internet strategy and decision support for online advertising management.

The main research work and conclusions are as follows:

1) On the social network platform, influential users fully utilize their unique personality charm and social abilities to publish, spread, and interact valuable information to attract attention and interest of other users. They then build their own social network and gain social resource, relationship, and ability, which can help them increase and accumulate individual social capital. From the perspective of information resource management and social capital measurement, we investigate the online information selection and interactive behavior attributes of online users. After comprehensively studying how online influential users gain, accumulate, and use their social capital, we obtain the general rule of individual social capital utility. On this basis, we draw a social relationship map of online users forming during online social interactions, then reveal the social capital elements and composition of online influential users, which reflect as attribute data of user personality and sociality, and establish a social capital measurement indicator system and information entropy model of influential online users. We finally form a social capital measure method of online influential users. The rationality and validity of the proposed model are tested by experimental study on real datasets.

2) The individual social capital value of online influential users dynamically varies with time. The total value of individual social capital changes according to their own "personality" and "sociality." This conclusion may help enterprises in establishing a relationship between the online influence and the factors of advertising performance. When pushing social network advertisement, they can make a targeted choice among those influential online users who own the advantage of "personality" or "sociality" as advertising spokesperson according to the marketing goals. In addition, enterprises can develop upfront training and investment plan for online users with rapidly increasing social capital utility. Such planning can offer significant support for mining potential "online celebrities." Unlike the way of selecting advertising spokesperson by using the influential user ranking offered on sites, our measure method is more scientific and reasonable.

REFERENCES

[1] Bian, Y. (2004)'Origins and effects of social capital for Chinese urbanites: Network viewpoints and survey findings', *Chinese Social Sciences*, Vol.147, No.3, pp.136-146.

[2] Bian, Y., & Li, Y. (2000)'Social network capital of Chinese urban families', *Tsinghua Sociological Review*, Vol.2, pp.1-18.

[3] Boyd, D., Golder, S., & Lotan, G. (2010)'Tweet, tweet, retweet: Conversational aspects of retweeting on twitter', *System Sciences (HICSS), 2010 43rd Hawaii International Conference on*, Hawaii, pp.1-10.

[4] Barnes-Mauthe, M., Gray, S. A., Arita, S., Lynham, J., & Leung, P. (2015)'What determines social capital in a social–ecological system? Insights from a network perspective', *Environmental management*, Vol.55, No.2, pp.392-410.

[5] Campbell, K. E., Marsden, P. V., & Hurlbert, J. S. (1986)' Social resources and socioeconomic status', *Social networks*, Vol.8, No.1, pp. 97-117.

[6] Cha, M., Haddadi, H., Benevenuto, F., &Gummadi, P. K. (2010),'Measuring User Influence in Twitter: The Million Follower Fallacy', *ICWSM*, Vol.10, No.14, pp. 30.

[7] Coleman, J.S.(1988)' Social capital in the creation of human capital', *American Journal of Sociology*,Vol.94, pp. 95-120.

[8] Choi, S. M., Kim, Y., Sung, Y., & Sohn, D. (2011)' Bridging or Bonding? A cross-cultural study of social relationships in social networking sites', *Information, Communication & Society*, Vol.14, No.1, pp.107-129.

[9] Chu, S. C., & Kim, Y. (2011)'Determinants of consumer engagement in electronic word-of-mouth (eWOM) in social networking sites', *International journal of Advertising*, Vol.30, No.1, pp.47-75.

[10] Cheng, Q., Qiu, W., & Fu, Y.(2008)' The method efficiency valuation studies in the command of process based on the system of the time efficacy entropy', *Systems Engineering-Theory & Practice*,Vol.4, pp. 155-158.

[11] Cai, Z., Liang, C., & Zhao, S.(2014)' Research on emergency environmental accidents grade evaluation', *Application Research of Computers*, Vol.31, No.11, pp.3217-3220.

[12] Drushel, B. E. (2013) 'HIV/AIDS, social capital, and online social networks', *Journal of homosexuality*, Vol.60, No.8, pp.1230-1249.

[13] Falcone, R., & Castelfranchi, C. (2011)'Trust and relational capital', *Computational and Mathematical Organization Theory*, Vol.17, No.2, pp.179-195.

[14] He, J., & Yin, S. (2016) 'Identifying influential users in social networks',Vol.4, pp.20-30.

[15] Hackley, C., & Hackley, R. A. (2015)' Marketing and the cultural production of celebrity in the era of media convergence', *Journal of marketing management*, Vol.31, No.5, pp.461-477.

[16] Heidemann, J., Klier, M., & Probst, F. (2010)'Identifying key users in online social networks: A pagerank based approach', *A pagerank based approach*, Vol.2, pp.267-273.

[17] He, J., Hu, M., Shi, M., & Liu, Y.(2014)'Research on the measure method of complaint theme influence on online social network', *Expert Systems with Applications*, Vol.41, No.13, pp. 6039-6046.

[18] Lin, N. (2002)'Social capital: A theory of social structure and action', Cambridge university press, NewYork, Vol. 19, pp. 69-70.

[19] Lin, N. (1999) 'Building a network theory of social capital', *Connections*, Vol.22, No.1, pp.28-51.

[20] Lin, N., & Dumin, M. (1986)'Access to occupations through social ties', *Social networks*, Vol.8, No.4, pp.365-385.

[21] Woudstra, L., van den Hooff, B., & Schouten, A. P. (2012)'Dimensions of quality and accessibility: Selection of human information sources from a social capital perspective', *Information Processing & Management*, Vol.48, No.4, pp.618-630.

[22] Bode, L. (2012)'Facebooking it to the polls: A study in online social networking and political behavior', *Journal of Information Technology & Politics*, Vol.9, No.4, pp.352-369.

[23] Marsden, P. V. (1987)' Core discussion networks of Americans', *American sociological review*, Vol.52, No.1, pp.122-131.

[24] Marsden, P. V. (1990)'Network data and measurement', *Annual review of sociology*, Vol.16, pp.435-463.

[25] O'Connor, L. G., & Dillingham, L. L. (2014)' Personal experience as social capital in online investor forums', *Library & Information Science Research*, Vol.36, No.1, pp.27-35.

[26] Pal, A., & Counts, S. (2011)'Identifying topical authorities in microblogs', *Proceedings of the fourth ACM international conference on Web search and data mining* ,New York, US, pp. 45-54.

[27] Song, L. (2012)'Raising network resources while raising children? Access to social capital by parenthood status, gender, and marital status', *Social Networks*, Vol.34, No.2, pp.241-252.

[28] Subbian, K., Sharma, D., Wen, Z., & Srivastava, J. (2014)'Finding influencers in networks using social capital', *Social Network Analysis and Mining*, Vol.4, No.1, pp.1-13.

[29] Shannon, C. E. (2001)'A mathematical theory of communication', ACM SIGMOBILE Mobile Computing and Communications Review, Vol.5, No.1, pp.3-55.

[30] Vergani, M. (2011)' Are party activists potential opinion leaders?', *Javnost-The Public*, Vol.18, No.3, pp.71-82.

[31] Wellman, B. (1979)'The community question: The intimate networks of East Yorkers', *American journal of Sociology*, Vol.84, No.5, pp.1201-1231.

[32] Weng, J., Lim, E. P., Jiang, J., & He, Q. (2010) 'Twitterrank: finding topic-sensitive influential twitterers', Proceedings of the third ACM international conference on Web search and data mining, New York, US, pp. 261-270.

[33] Woudstra, L., van den Hooff, B., & Schouten, A. P. (2012)'Dimensions of quality and accessibility: Selection of human information sources from a social capital perspective', *Information Processing & Management*, Vol.48, No.4, pp.618-630.

[34] Xue, K., & Chen, X.(2010)' Research on the influence of opinion leaders in BBS——In the case of -BBS from Shanghai Jiao Tong University', *Journalistic University*,Vol.4, pp.87-93.

[35]Yu, J., & Zhao, Y.(2011)' Power Or Presitge? The Debate And Validation Of The Social Capitalstrategy', *Sociological Research*, Vol.3, pp.64-83.

[36] Zhao, Y., & Luo, J.(2005)' How to Measure Social Capital: A Review of Empirical Studies', *Foreign Social Science*, Vol.2, pp.18-24.

[37] Zeng, M., & Zhou, C.(2012)' The maximum banquet network: the exploration of individual social capital measurement', *Academic edition of management*, No.5, pp.31-45.

[38] Zhang, M., Sun, C., & Liu, W. (2011)'Identifying influential users of micro-blogging services: A dynamic action-based network approach', *Pacific Asia Conference on Information Systems (PACIS)*, Vol.4, pp.223.

[39] Zhang, P.(2013)' Information-seeking behaviors in online social network:the case of microblogging', *Journal of intelligence*, Vol.32, No.7, pp.83-88.

[40] Zhao, H., Wang, C., & Hu, F.(2014)' Determinants of Micro-blog's Influence-Based on Micro-blog's Multilayer Structure', *Chinese Journal of Management*,Vol.11, No.7, pp.1062-1068.

[41] Zuo, W., Wang, X., & Fan, C.((2014)' Relationship between Electronic Word of Mouth and Purchase Intention in Social Comerce Environment: A Social capital Perspective', *School of Economics and Commerce.South china University of Technology*, Vol.17, No.4, pp.140-150.

[42] Zhou, W., & Li, X. (2010)'A Comprehensive Evaluation Method Based on Information Entropy', *Science Technology and Engineering*, Vol.23, pp.59.