Bounded Confidence-based Opinion Formation for Opinion Leaders and Opinion Followers on Social Networks

Yiyi ZHAO[1], Gang KOU[2]

[1] School of Economics and Management,
University of Electronic Science and Technology of China,
Chengdu, 611731, China,
zyisarah@163.com

[2] School of Business Administration,
Southwest University of Finance and Economics of China,
Chengdu, 610074, China,
kougang@swufe.edu.cn

Abstract: Opinion dynamics is a complex collective behavior in human societies. When individuals exchange opinions with others, they usually adopt a bounded confidence rule and only accept the opinions within the confidence range. Furthermore, individuals are heterogeneous in real social systems. Thus, they have distinct confidence levels, and also play different roles in the collective opinion formation. In this paper, a leader-follower bounded confidence model is proposed for a group of social agents, who have heterogeneous confidence levels, at the same time, come from two subgroups: opinion leaders and opinion followers. Simulation results are obtained for the collective opinion evolution influenced by three factors: the leader fraction, the group size and the trust degree. The results show that the roles of opinion leaders are remarkable when the opinion followers have high confidence levels and trust degrees.

Keywords: Bounded confidence; opinion formation; heterogeneous confidence levels; opinion leaders

1. Introduction

Recently great attention has been paid to social network science, which concerns the influence of the networking structure and the social behavior of individuals in the networks. The references [1-5] investigated some interesting social behaviors, such as patter searching, online recommendation, reputation formation, et al, on computer networks. The references [6-7] considered decision making clustering for social networks. Opinion formation is also an important kind of social behaviors in social networks, which is closely related with opinion dynamics modeling.

The modeling of a collective opinion evolution can be generally classified into two categories: discrete opinion dynamics and continuous opinion dynamics. The bounded confidence model is a representative model used to study continuous opinion dynamics. In a network of multiple agents, initially every agent is assigned randomly an opinion described by a real value within some intervals. A pair of agents begins to interact only if their opinion difference is smaller than a given threshold, which is referred to as bounded confidence level. The Deffuant model [8] and the Hegselmann-Krause (HK) model [9-10] are two common bounded confidence models.

In the original Deffeunt model and HK model, all agents are homogeneous and have an identical confidence level. However, in a real society, different agents should have different confidence levels due to diverse individual characteristics. Motivated by these facts, Lorenz et al. proposed an agent-based and a density-based bounded confidence model with heterogeneous confidence levels in [11] and [12], respectively. Kou, Zhao et al. built up a heterogeneous HK opinion dynamics with multi-level confidence level to analyze the impacts of confidence levels, initial opinions and group size on the evolution of the collective opinion systematically in [13].

Many studies on opinion leader mainly focused on election of a party and marketing science. According to different opinion update rules, a lot of opinion dynamics models have been built to analyze the function of opinion leaders. An collective invitation process to an event organized by facebook was considered in [14]. Elihu Katz, et al. had a profound contribution on the theory of public opinion formation, because a “two-step flow” model describes the information influence “flows” from the media through opinion leaders to their respective followers with various decision-making scenarios. In a two-step flow model, compared with the rest of the population, opinion leaders were found to be considerably more exposed to the formal media of communication [15-16]. Since then, the idea of opinion leaders, or "influentials" as they are also called in [17], had occupied a central place in the literatures of the marketing [18], diffusion of innovations [19], and communication research [20].

It is clear that most literatures indicate that opinion leaders play an important role in information propagation. In many cases, opinion leaders may transfer the information to the neighboring agents unconsciously. However, in some other cases, opinion leaders hope to guide the neighbors to an expected opinion for a purpose, such as panic buying or social harmony. In this paper, we consider the collective opinion formation through the bounded confidence communication among opinion followers and opinion leaders, who want to actively guide the neighboring agents to an expected opinion. Three main questions are left: can the guiding powers of the opinion leaders increase with the leader fraction in a fixed-size group, whether the group size has impact on the final opinion profile? And what is the influence of the opinion followers' trust degrees on the final opinion distribution? We will answer the three questions one by one.

In this paper, the evolution of the collective opinion will be investigated under the framework of heterogeneous HK opinion dynamics for a group of social agents. One important extension is made on the HK model: divide the social agents into two subgroups, opinion leaders and opinion followers. The impacts of the opinion leaders on the evolution of the collective opinion will be investigated deeply and some practical measures will be provided for some related public departments to guild the collective human behaviors.

The rest of this paper is organized as follows. A leader-follower opinion formation model with heterogeneous confidence levels is proposed based on a Hegselmann and Krause (HK) bounded confidence rule in Section 2. Section 3 presents some computer simulation results to study the impacts of opinion leaders on the opinion propagation with the proposed heterogeneous opinion dynamics. Section 4 concludes the paper.

2. Leader-follower Opinion Formation Model

In a human community, the individual influence is diverse for the neighbors, which we also call opinion neighbors. Especially, when he is an expert or message promulgator in the opinion field, his opinion neighbors often accept his opinion credulously. Thus, the expert or the promulgator has a more significant influence than the ordinary in the opinion communication. For example, in the panic buying of iodine salt, people are more likely influenced by the announcements of the governmental medical institutions or the advice of some well-known medical experts. According to the characteristics of opinion leaders mentioned in Section 1, opinion leaders generally have their own expected opinions and often intend to persuade the neighbors to follow their opinions. Thus, a conscious guiding of opinion followers becomes the main task of the opinion leaders. Additionally, the opinion leaders are not influenced by the followers and just communicate with other leaders.

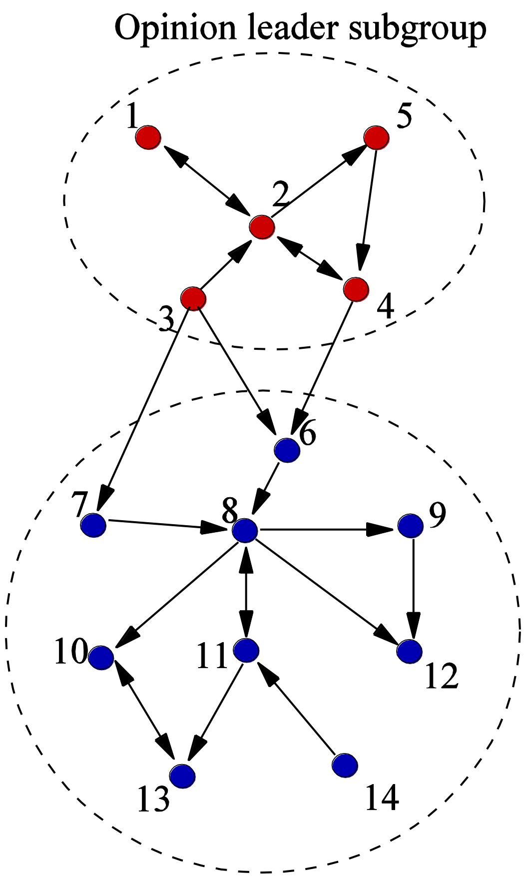


Figure 1. A social group with two subgroups

Based on the above considerations, it is reasonable to divide the whole community into two subgroups: leader subgroup and follower subgroup (see Figure 1). In the social network illustrated in Figure 1, the red nodes 1, 2, 3, 4, 5 denote the opinion leaders and the blue nodes $6, 7, \cdots, 14$ denote the opinion followers. Since the confidence levels of all the agents are heterogeneous, the communication network formed by the 14 agents is a directed graph. Thus, even though the agent j is in the confidence range of the agent i, the agent i is not always the neighbor of agent j. For example, the pair of agents, 2 and 5, 5 and 4, 3 and 2, 6 and 8, 7 and 8, have unidirectional communication while the agents 1 and 2, 2 and 4, 8 and 11, 10 and 13 have interactive opinion exchange.

The first subgroup consists of opinion leaders, which have a confirmed purpose and are hardly influenced by opinion followers, so only communicate with the peers. The second subgroup is composed of opinion followers, which will take all opinions within the confidence range into consideration. Under such a group differentiation, the opinion leaders update the opinions within the leader subgroup by neglecting the interference of opinion followers. On the contrary, opinion followers assign a different weight on the opinions from the two subgroups in the opinion updating.

Consider a social network with N agents, where there are N_1 opinion followers and $N - N_1$ opinion leaders. The opinion of agent i is denoted by $x_i(t)$ for $i = 1, \cdots, N$, which is a variable in the opinion interval $[0,1]$. When $x_i(t) = 1$, agent i has a completely positive opinion to support the opinion object, which may be a rumor, a fact, or a political party, and so on. When $x_i(t) = 0$, agent i holds a negative opinion to oppose the opinion object.

The opinion update law of opinion follower i is described as follows.

$$x_i(t+1) = (1-\alpha_i)\frac{1}{N_i^S(t)}\sum_{j=1}^{N} a_{ij}(t)x_j(t) + \alpha_i \frac{1}{N_i^L(t)}\sum_{j=N_1+1}^{N} a_{ij}(t)x_j(t) \quad (1)$$

where $i = 1, \cdots, N_1, j = 1, \cdots, N,$ the weights $a_{ij}(t) = 1$ if agent j is the opinion neighbor of agent i, i.e., $\| x_i(t) - x_j(t) | \le \varepsilon_i$, otherwise $a_{ij}(t) = 0$. The two sums $N_i^S(t) = \sum_{j=1}^{N_1} a_{ij}(t)$ and $N_i^L(t) = \sum_{j=N_1+1}^{N} a_{ij}(t)$ denotes, respectively, the number of opinion neighbors in the follower fraction and the leader fraction. The parameter $0 \le \alpha_i \le 1$ denotes the trust degree of agent i on the leader fraction. Generally, if an opinion follower has more trust of the opinion leaders, he will have a lower trust of the peers. Therefore, it is proper to weight the two average opinions $\frac{1}{N_i^S(t)}\sum_{j=1}^{N_1} a_{ij}(t)x_j(t)$ and $\frac{1}{N_i^L(t)}\sum_{j=N_1+1}^{N} a_{ij}(t)x_j(t)$ with the two coefficients $1-\alpha_i$ and α_i, respectively.

Here, the opinions of the leaders are influenced by two important factors: the peers and the expected opinion object. To this end, the opinion update law of the opinion leader i is given by

$$x_i(t+1) = \left(1 - w_g\right)\frac{1}{N_i^L(t)}\sum_{j=N_1+1}^{N} a_{ij}(t)x_j(t) + w_g d \quad (2)$$

where $i, j = N_1 + 1, \cdots, N$, $a_{ij}(t) = 1$ if $\| x_i(t) - x_j(t) | \le \varepsilon_i$, otherwise, $a_{ij}(t) = 0$. The sum $N_i^L(t) = \sum_{j=N_1+1}^{N} a_{ij}(t)$ denotes the number of neighbors in the opinion leader subgroup, the constant $0 \le d \le 1$ denotes the expected opinion value by opinion leaders, w_g denotes the influence weight of the expected opinion value on the opinion leaders.

3. Simulation Results

In this section, simulation studies are given to the proposed leader-follower opinion formation model (1) - (2). We mainly investigate the roles of opinion leaders in the collective opinion dynamics from the following three aspects: the leader fraction, the size of social network and the trust degree on opinion leaders.

In the subsequent experiments, the initial opinion of each agent obeys a uniform distribution between 0 and1. The heterogeneous confidence levels ε_i^S of the opinion followers are uniformally distributed in [0,1]. The confidence levels of the opinion leaders ε_i^L are taken as 0.25. The expected goal opinion for the opinion leaders is $d = 1$. The influence weight of the expected goal value on the opinion leaders is $w_g = 0.5$. Each experiment runs 1000 times Monte Caro simulations and 1000 time steps.

The influence of the leader fraction

The size of the considered social network is selected as $N = 200$, including two subgroups, opinion leaders and opinion followers. For the opinion formation model (1) and (2), the trust degrees of followers i on the opinion leaders are $\alpha_i = 0.5$. In order to investigate the influence of the leader fraction on the collective opinion formation, we start the computer experiment by changing the leader fraction from 0 to 99% (see Table 1). In each experiment, the initial opinions are randomly produced and then keep invariant in the 1000 Monte Carlo runs.

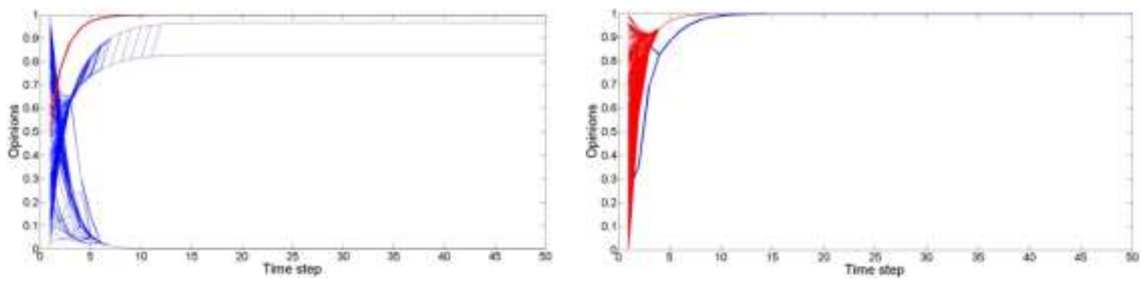
Table 1. The relationship between the opinion leader fraction and the number of the opinion followers close to the expected opinion 1

The opinion leader fraction P_L	The number N_1 of opinion followers	The number N_S of opinion followers close to 1	N_S/N_1
0	200	6	0.0300
0.005	199	102	0.5126
0.01	198	104	0.5253
0.05	190	154	0.8105
0.1	180	121	0.6722
0.2	160	98	0.6125
0.3	140	114	0.8143
0.4	120	69	0.5750
0.5	100	50	0.5000
0.6	80	48	0.6000
0.7	60	52	0.8667
0.8	40	35	0.8750
0.9	20	8	0.4000
0.99	2	2	1.0000

Intuitively, one may conclude that the guiding powers of the opinion leaders increase with the fraction of the opinion leaders in a fixed-size group. However, the computer simulation gives a surprising result. As shown in Table 1, when the leader fraction changes from 0 to 0.5%, the number of the opinion follower close to the leaders increases sharply from 6 to 102, which means that only one leader can guide over a half of the group to the expected opinion and the role of the leader is very strong. As the fraction of the opinion leaders increases to 5%, the influenced fraction of the opinion followers is increasing. However, the guiding powers of the opinion leaders begin to fluctuate while the leader fraction is bigger than 5%. Even if the leader fraction exceeds 90%, it is unable to realize the opinion consensus of the whole social network. Figure 2 gives an illustration of the evolution of the collective opinions with different leader fractions. The global opinion consensus is reached only when there are just two opinion followers in the social network (see Figure 2(b)). As shown in Figure 2, the opinion leaders can finally approach to the expected opinion value even if its initial opinions are apart away from the goal value 1, and can guide some followers to the expected opinion value.

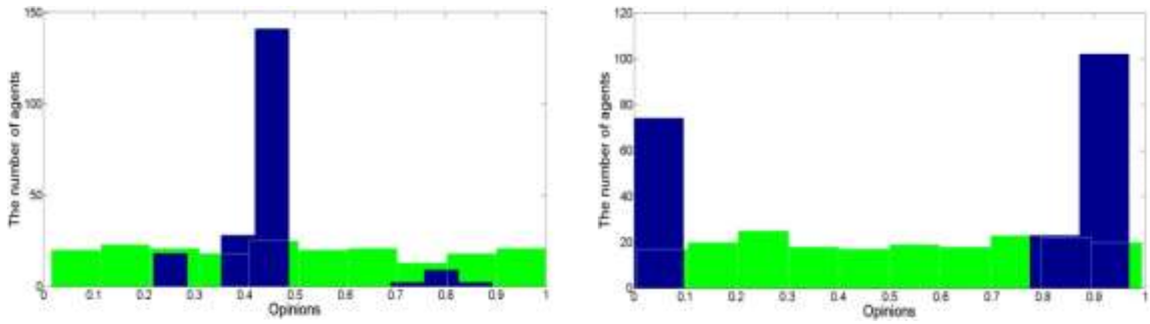
In Figure 3(a), when there are no opinion leaders, the final opinions of over 70% agents lie in the middle of the opinion interval. Once opinion leaders exist in the group, the largest opinion cluster near the opinion 0.5 is split into two opposite opinion clusters, as shown in Figure 3(b). There are always some opinion followers who have opinions near 0, which may be caused by the fact that some very stubborn opinion followers persist in their opinions and are not affected by the other individuals.

When all the opinion followers have the same confidence levels, will the guiding powers of the opinion leader increase with the leader fraction? In order to answer the question, we



(a) (b)

Figure 2. The evolution of the collective opinions with different leader fractions. The red and blue lines represent, respectively, the opinions of the leaders and followers. (a) $P_L = 0.01$ (b) $P_L = 0.99$.



(a) (b)

Figure 3. The collective opinion distribution of the opinion followers with different leader fractions. The green and blue bars represent, respectively, the initial and final opinion distribution.
(a) $P_L = 0$ (b) $P_L = 0.005$.

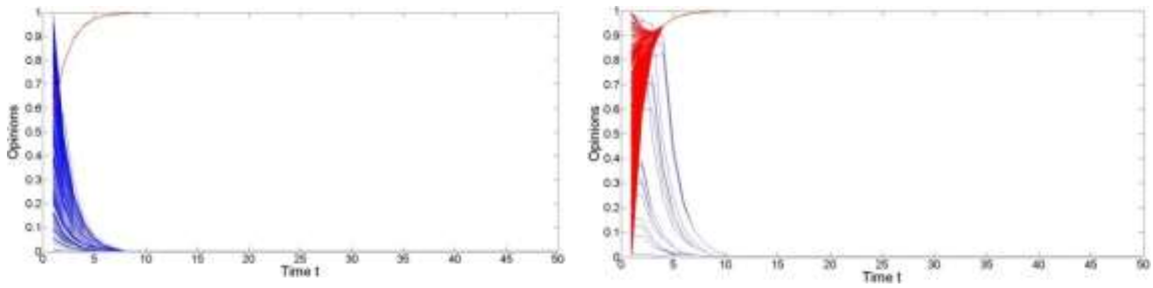
do the following simulation experiments based on the model (1) and (2). In each experiment, the leader fraction is fixed and the homogeneous confidence levels are changed

from 0.01 until the collective opinions reach consensus steadily. The initial opinions are randomly produced and then keep invariant in the 1000 Monte Carlo runs.

When the confidence levels of the opinion followers are homogeneous, Table 2 shows that the influenced fraction of the opinion followers does not basically increase with the leader fraction. When the confidence levels of the followers are less than 0.04, the guiding powers of the leaders are very weak. In the original HK model, there are no opinion leaders; the final opinion distribution is determined by the confidence levels of the opinion followers [2-3]. The fragmentation phenomenon gradually disappears as the confidence levels of agents increase. Especially, when the confidence levels are 0.23, consensus is reached for the opinion followers**.** However, once the social network has opinion leaders, even if the leader proportion is just 0.5%, namely only one opinion leader in the 200 individuals, a great change happens in the collective opinion

Table 2. The relationship between the leader fraction and the influenced fraction of the followers by the leaders with different confidence levels

ε_i^s / P_L	0.01	0.04	0.05	0.06	0.1	0.2	0.22	0.3	0.35	0.37	0.38	0.39	0.4	0.45	0.5	0.52
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.005	0	0	0	0	0	0	0.060	0.482	0.663	0.754	0.769	0.829	0.829	0.905	0.954	1
0.01	0	0	0	0	0	0	0.051	0.480	0.657	0.778	0.843	0.904	0.924	0.990	1	1
0.05	0	0	0	0.090	0.132	0.347	0.421	0.568	0.826	0.990	1	1	1	1	1	1
0.1	0	0.061	0.083	0.106	0.161	0.394	0.467	0.572	0.744	0.978	1	1	1	1	1	1
0.2	0	0.075	0.063	0.100	0.175	0.419	0.450	0.569	0.819	0.981	1	1	1	1	1	1
0.3	0	0	0.071	0.100	0.214	0.414	0.443	0.557	0.771	0.986	1	1	1	1	1	1
0.4	0	0	0.100	0.108	0.175	0.408	0.425	0.558	0.767	0.967	1	1	1	1	1	1
0.5	0	0	0.080	0.080	0.190	0.430	0.460	0.570	0.730	0.910	1	1	1	1	1	1
0.6	0	0.075	0.075	0	0.186	0.438	0.463	0.563	0.738	0.925	1	1	1	1	1	1
0.7	0	0.083	0.083	0.133	0.217	0.417	0.417	0.517	0.617	0.900	0.983	1	1	1	1	1
0.8	0	0.075	0.075	0	0.250	0.475	0.525	0.550	0.650	0.975	1	1	1	1	1	1
0.9	0	0.100	0.100	0.150	0.250	0.450	0.450	0.450	0.600	0.600	0.950	1	1	1	1	1
0.99	0	0	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	1	1	1	1	1



(a) (b)

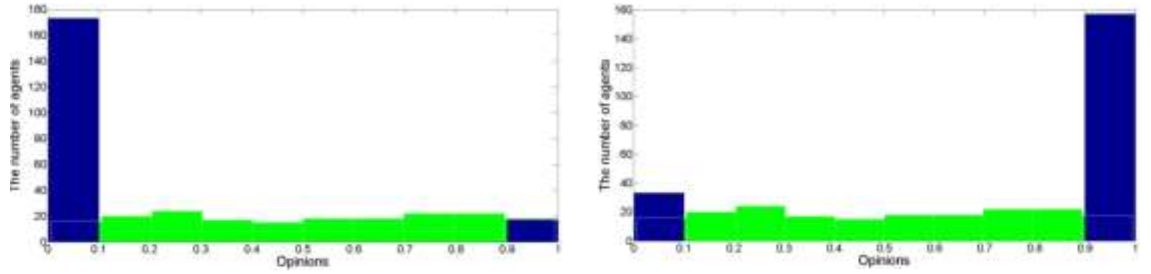
Figure 4. The evolution of the collective opinions with opinion leaders. The red and blue lines represent, respectively, the opinions of the leaders and followers.
(a) $P_L = 0.005$, $\varepsilon_i^S = 0.01$ (b) $P_L = 0.9$ $\varepsilon_i^S = 0.03$.

evolution. When the confidence levels of the opinion followers are small, for example, $\varepsilon_i^S = 0.01$, the leaders can hardly guide the followers to the expected opinion and most of the followers even tend to approach to the opinion 0 (see Figure 4 (a)).

Table 2 and Figure 4 show that, when the confidence levels are fixed and the leader fraction is changing, the guiding powers of the opinion leaders do not have a steady increase and basically fluctuate within a bounded range; when the leader fraction is fixed and the confidence levels are changing, the guiding powers of the opinion leaders increase with the confidence levels. Particularly, as the confidence levels are bigger than 0.38, the leaders can guide the followers to a consensus in high probability. Thus, the confidence levels have more significant influence than the leader fraction on the final distribution of the collective opinions.

Figures 5 and 6 demonstrate the evolution of the collective opinions as the leader fraction is $P_L = 5\%$ .When the confidence levels of the opinion followers increase from 0.06 to 0.35, figure 5 shows that the number of the opinion followers closing the opinion 1 have a substantial rise. Figure 6 shows that, as the confidence levels are no less than 0.38, the fraction of the influenced opinion followers converges to 1 and thus all the followers approach to the expected opinion under the guidance of the leaders.

The simulations results above further show that the guiding powers of the leaders are constrained. In fact, according to the bounded confidence rule, agents only communicate with the agents who have similar opinions with theirs. Thus, if the followers have low confidence levels, the leaders may be more likely regarded as strangers and their opinions are neglected by the followers. Therefore, the guiding powers of the leaders cannot be exerted to the opinion followers. As the confidence levels of the opinion followers increase, the leaders can be the neighbors of the followers and thus influence the opinion update of the followers through the interactions with the trust degrees. Therefore, the guiding powers of the



(a) (b)

Figure 5. The opinion distribution with the leader fraction $P_L = 0.05$. The green and blue bars represent, respectively, the initial and final opinion distribution of the opinion followers. (a) $\varepsilon_i^S = 0.06$ (b) $\varepsilon_i^S = 0.35$

leaders are mainly constrained by the confidence levels of the opinion followers. In addition, since individuals in the real world are generally heterogeneous, thus, the opinion leaders, no matter how large the number of the leaders is, are difficult to guide all the opinion followers to the expected opinion.

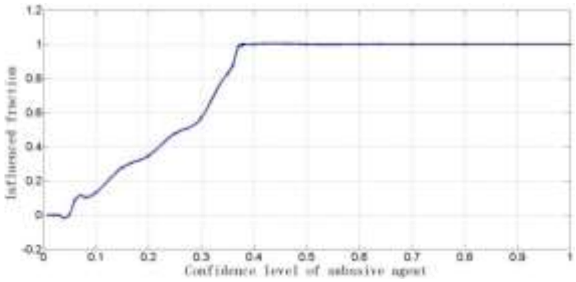


Figure 6. The relationship between the influenced fraction and the confidence levels of the followers

The influence of the group size

The studies by using homogeneous DW model and HK model show that the group size only influence the convergence time of the collective opinion evolution. Then a question comes: can the group size influence the final distribution of the collective opinions when opinion leaders are involved?

The simulation results in Section 3.1 indicates that when the leader fraction is not less than 5%, the final distribution of the collective approaches to a stable pattern. Thus, the leader fraction is taken 5% in this subsection. The trust degrees of the opinion followers are $\alpha_i = 0.5$.

When the group size N increases from 100 to 5000, the influenced fraction, i.e., the number of the opinion followers close to 1 over the number of the opinion followers, does not increase or decrease monotonously. In fact, as illustrated in Figure 7, the influenced fraction is fluctuating around 60% after the group size is bigger than 1500.

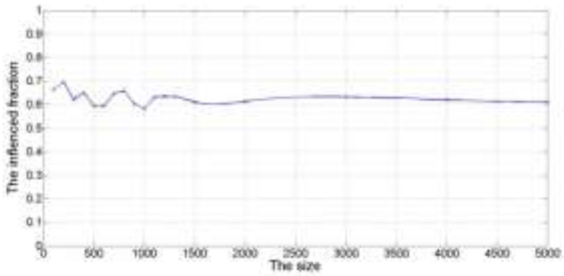


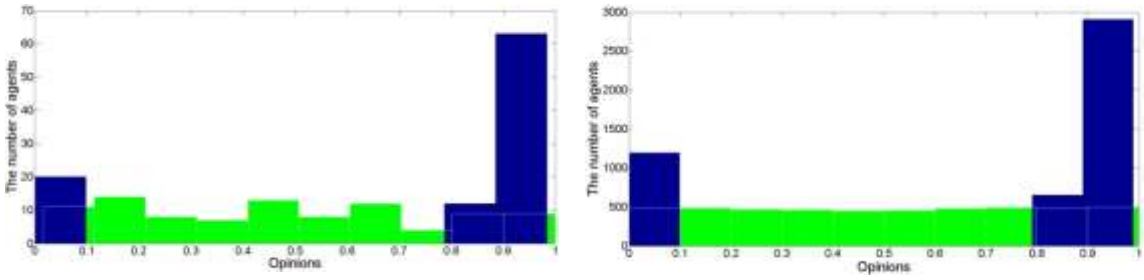
Figure 7. The relationship between the influenced fraction of the opinion followers and the group size

On the other hand, from Figure 8, one can see that the final opinion distribution is basically same in the two cases: $N=100$ and $N=5000$. The collective opinions are fragmental and have three final clusters. The first is near the opinion 1, the second and the third locate at the opinion interval [0.8,0.9] and [0,0.1]. Moreover, the size of the first cluster is the biggest while the second is the smallest.

Both the Figures 7 and 8 show that, as the group size increases, even though the number of the opinion leaders is growing, the guiding powers of the leaders seem somewhat limited.

The influence of the trust degree

It is well known that the confidence levels of the social agents determine how many neighbors one agent can have and thus play a significant role in the final pattern of the collective opinions. However, the confidence levels cannot reflect the interaction strength between one agent and its neighbor. In many real cases, the trust degrees of agents on



(a) (b)

Figure 8. The opinion distribution with the leader fraction $P_L = 0.05$. The green and blue bars represent, respectively, the initial and final opinion distribution of the opinion followers. (a) $N = 100$;(b) $N = 5000$

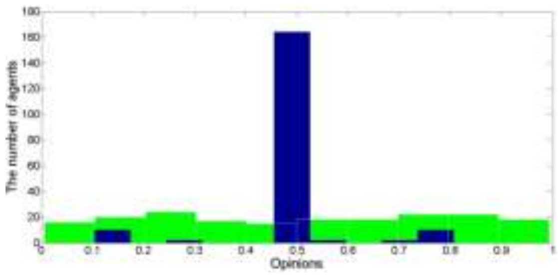
different neighbors are not identical. Generally, agents have a bigger trust degree on those special agents, who have high social state, professional knowledge, or intimacy. Then, we may ask one question: if the trust degrees of the opinion followers on the leaders are higher, is the guiding power of the leaders stronger? Some computer simulations are undertaken, based on the leader-follower model (1) - (2), to analyze the influence of the trust degrees of the opinion followers on the evolution of the collective opinions.

The group size is still taken as $N = 200$ and the leader fraction is fixed as 5%. The Table 3 indicates that, as the trust degrees increase from 0 to 0.3. In fact, when the trust degrees of the opinion followers are small, the followers often have a skeptical attitude on the opinions of the leaders, and at the same time, are inclined to communicate with the peers. However, when the trust degrees increase from 0.3 to 0.4, the guiding powers of the leaders have a sharp increase and the influenced number of the opinion followers exceeds quickly the half of the whole follower subgroup. When the trust degrees increase from 0.4 to 0.8, the guiding powers of the leaders keep a stable increase. However, when the trust degrees are bigger than 0.8, the influenced fraction of the opinion followers gradually approaches to 0.8053. Even the trust degrees equal 1, the leaders cannot influence the followers any longer.

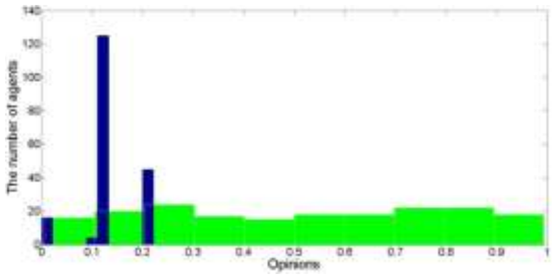
Table 3. The relationship between the trust degrees and the influenced fraction of the opinion followers

The trust degree α_i	**The number N_1 of the opinion followers**	**The number N_S of opinion followers close to 1**	**N_S/N_1**
0	190	0	0
0.1	190	0	0
0.2	190	3	0.0158
0.3	190	3	0.0158
0.4	190	97	0.5105
0.5	190	116	0.6105
0.6	190	148	0.7789
0.7	190	150	0.7895
0.8	190	152	0.8000
0.9	190	152	0.8000
0.99	190	153	0.8053
1	190	153	0.8053

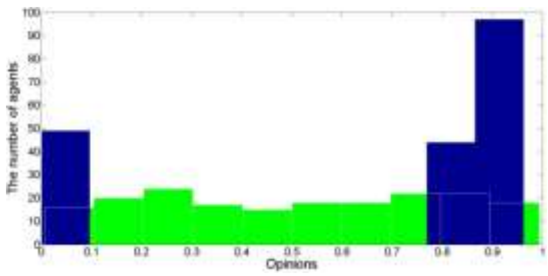
Figure 9 shows that the final opinion distributions of the opinion followers have distinct differences as the trust degrees change. From Figures 9(a) and (b), when the opinion followers do not believe in or have very low trust with the leaders, most of the opinions of



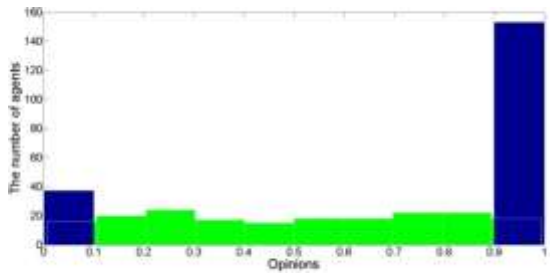
(a)



(b)



(c)



(d)

Figure 9. The relationship between the trust degrees α_i and the final distribution of the opinion followers. The green bars and the blue bars, respectively, denote the initial distribution and the final distribution of the opinion followers. (a) $\alpha_i = 0$ (b) $\alpha_i = 0.1$ (c) $\alpha_i = 0.4$ (d) $\alpha_i = 1$

the followers locate far away from the expected opinion 1. Once the trust degrees are taken as 0.4, 0.7 and 1, respectively, most of the opinion followers have final opinions close to the expected opinion 1 (see Figures 9(c) and (d)).

The relationship between the trust degrees and the evolution of the collective opinion gives a good explanation that the leaders cannot exert effective influence on the opinion followers in a society with low trust. In order to guide the opinion followers powerfully, a preliminary condition for the opinion leaders is to get enough confidence from the opinion leaders. However, when there are some extremists, who have low trust on the leaders and opinions round 0, in the group, the leaders can hardly guide all the opinion followers to an opinion consensus.

4. Conclusion

In this paper, a leader-follower model has been built to investigate the evolution of the collective opinions of a group of social agents, who have heterogeneous bounded confidence levels. Firstly, when the group size is fixed, the simulation results have shown that, as the confidence levels of the followers increase to a certain threshold, the followers are influenced strongly by the opinion leaders. Secondly, regardless of the group size, the influenced fraction of the opinion followers converges to a bounded range. Finally, smaller trust degrees of the opinion followers will restrain the guiding powers of the opinion leaders. In summary, the simulation results have indicated that the guiding powers of the opinion leaders in a social group are constrained with low confidence levels and trust degrees.

Acknowledgements

This research has been partially supported by grants from the National Natural Science Foundation of China (#71222108), the Fundamental Research Funds for the Central Universities, the Research Fund for the Doctoral Program of Higher Education (#20120185110031) and Program for New Century Excellent Talents in University (NCET-10-0293).

REFERENCES

1. JUNG, H., S. PARK, **Pattern Searching in a Social Network,** Studies in Informatics and Control, vol. 19, no. 2, 2010, pp. 125-134.
2. BANCIU, D, A. G. PITIC, D. VOLOVICI, A. C. MITEA, **Using Social Networking Software to Promote Digital Libraries**, Studies in Informatics and Control, vol. 21, no. 2, 2012, pp. 221-226.
3. LAMANAUSKAS, V., V. SLEKIENE, A. BALOG, C. PRIBEANU, **Exploring the Usefulness of Social Networking Websites: a Multidimensional Model,** Studies in Informatics and Control, vol. 22, no. 2, 2013, pp. 175-184.
4. ALBOAIE L., M. - F. VAIDA, **Trust and Reputation Model for Various Online Communities,** Studies in Informatics and Control, vol. 20, no. 2, 2011, pp. 143-156.
5. KOMPAN, M., M. BIELIKOVA, **Personalized Recommendation for Individual Users Based on the Group Recommendation Principles,** Studies in Informatics and Control, vol. 22, no. 3, 2013, pp. 331-342.
6. KOU, G., Y. LU, Y. PENG, Y. SHI, **Evaluation of Classification Algorithms using MCDM and Rank Correlation,** International Journal of Information Technology & Decision Making, vol. 11, no.1, 2012, pp. 197-225.
7. KOU G., C. LOU, **Multiple Factor Hierarchical Clustering Algorithm for Large Scale Web Page and Search Engine Clickstream Data,** Annals of Operations Research, vol. 197, no.1, 2012, pp. 123-134.
8. DEFFUANT, G., D. NEAU, F. AMBLARD, G. WEISBUCH , **Mixing Beliefs Among Interacting Agents** , Advances in Complex Systems, vol. 3, 2000, pp. 87-98.
9. KRAUSE, U., **A Discrete Nonlinear and Non-autonomous Model of Consensus Formation,** Communications in Difference Equations, Gordon and Breach Publications, Amsterdam, 2000, pp.227-236.
10. HEGSELMANN, R., U. KRAUSE, **Opinion Dynamics and Bounded**

Confidence: Models, Analysis and Simulation. Journal of Artificial Societies and Social Simulation, vol. 5, 2002, pp. 1-33.

11. LORENZ, J., **Continuous Opinion Dynamics under Bounded Confidence: A Survey,** International Journal of Modern Physics, C, vol. 18, 2007, pp. 1819-1838.
12. LORENZ, J., **Consensus Strikes Back in the Hegselmann-Krause Model of Continuous Opinion Dynamics under Bounded Confidence,** Journal of Artificial Societies and Social Simulation, vol. 9, no. 8, 2006.
13. KOU, G., Y. Y. ZHAO, Y. PENG, Y. SHI, **Multi-level Opinion Dynamics under Bounded Confidence,** PLoS One, vol.7, no.9, 2012, e43507.
14. MICHALCO, J., P. NAVRAT, **Arrangement of Face-to-Face Meetings using Social Media**, Studies in Informatics and Control, vol. 21, no. 4, 2012, pp. 383-392.
15. KATZ, E., P. F. LAZARSFELD, **Personal Influence; The Part Played by People in the Flow of Mass Communications**, Glencoe, IL: Free Press, 1955.
16. KATZ, E., **The Two-Step Flow of Communication: An Up-To-Date Report on an Hypothesis,** Annenberg School for Communication Departmental Papers, 1957.
17. MERTON, R. K., **Social Theory and Social Structure,** New York: Free Press, 1968.
18. VAN, D. B. C., V. J. YOGESH, **New Product Diffusion with Influentials and Imitators,** Marketing Science, vol.26, no.3 , 2007, pp. 400-421.
19. ROCH, C. H., **The Dual Roots of Opinion Leadership**, Journal of Politics, vol. 67, 2005, pp. 110-131.
20. WEIMANN, G., **The Influentials: People Who Influence People,** Albany: SUNY Press, 1994.