Weibo network, information diffusion and implications for collective action in China

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This study examines information diffusion and the follower network among a group of Sina Weibo users interested in homeowner associations. Using social network analysis techniques, this paper explores the network structure, the formation of follower relations and information diffusion. It reveals that micro-blogging is an important online platform because it can conveniently and inexpensively foster public online issue-networks beyond geographical boundaries. Specifically, Weibo has the potential to enable cross-province networking and communication, although geographical proximity is still at work; the trustworthiness of micro-blog users indirectly contributes to information diffusion by facilitating the formation of follower relations; and issue-specific follower networks facilitate information diffusion pertinent to the issue at stake. These findings suggest that micro-blogging services might have long-term effects on collective action by fostering issue-networks among civil society organizations or activists in different provinces.

Keywords: issue-networks; information diffusion; micro-blogging; China

Introduction

The Internet has long been regarded as both a public sphere and a means for mobilization (Zheng & Wu, 2005). Blogs and micro-blogs in particular provide a medium for sophisticated political expression (Esarey & Xiao, 2008; Pu & Scanlan, 2012; Xiao, 2011; Zhou, 2009). It has been argued that the primary role of China's microblogosphere is to provide a liberal-leaning space for counter-hegemony and public engagement (Tong & Lei, 2013). Still, the power of the Internet is limited by censorship (King, Pan, & Roberts, 2013; MacKinnon, 2008; Tsui, 2003), and the state is adept at using micro-blogs to its own advantage (Sullivan, in press). Perhaps a more realistic view is that the public sphere is the result of interactions between the state, the market, civil societies, and transnational actors (Hassid, 2012; Yang, 2009). For example, the secondary role of micro-blogs as a mobilization structure might hinge on the state's effort to silence collective action (King et al., 2013). Although studies of social media are increasingly gaining publication, the majority involve case studies of one or a few mass incidents, and only a few have conducted systematic quantitative investigations (Hassid, 2012). This 'incident-based' approach is inadequate for understanding the long-term political repercussions of social media (MacKinnon,

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2008; Shirky, 2011) because online incidents 'may achieve a short-term effect but lose long-term credibility' (Tong & Lei, 2013, p. 306).

This paper argues that the micro-blog issue-network, defined as a network among micro-bloggers from different localities joining to advocate a specific issue, can better shed light on the long-term implications of social media for the future development of collective action and the emergence of social movements in China. For one, activism in China fails to meet the definition of a 'social movement' because it is usually localized and falls short of sustained contention, partially because of the tight control of organizational infrastructure (Stalley & Yang, 2006; Zhu & Ho, 2008). Issue-networks on micro-blogging sites can thus be seen as online extensions of and/or substitutes for organizational infrastructure in real life: they are not only a relational platform for reflexive interactions and a set of networks linking activists in a common front, but also a breeding ground for mobilization (Yip & Jiang, 2011). Second, previous studies have demonstrated that online networks and information dissemination facilitate the development of collective action (Diani, 2000; Garrido & Halavais, 2003), and that follower networks on micro-blogging sites can be turned into mobilization structures when the political conditions are ripe (Cao, Fan, & Peng, 2011; Ji, 2011).

This study takes homeowner activism as an issue area and aims to map the follower network among a group of micro-bloggers, explicate the formation of such a network, and explore the relationship between the follower network and information diffusion. Given that many of these micro-bloggers are directors/members of homeowner associations, the study of this issue network will also shed light on the inter-organizational relations between homeowner associations, which few studies have examined (Yip & Jiang, 2011). This study will analyse the micro-blog issue-network in a rigorous and systematic manner not often found in previous studies.

Homeowner collective action and the role of the Internet

China's housing reforms, privatization and marketization of housing (Wang & Murie, 1999, 2000), have resulted in a dramatic increase in homeownership (Huang, 2004). In a not-yet-mature market, however, developers and property management companies tend to encroach on the property rights of homeowners. China's weak legal system makes it difficult for homeowners to protect their rights through individual lawsuits. More and more homeowners have turned to collective action[1] to defend their rights and interests, usually through the platform of homeowner association (Read, 2008; Shi, 2008; Shi & Cai, 2006; Yip & Jiang, 2011).

Most collective action is, however, isolated and confined to specific neighbourhoods. The Property Management Ordinance (2007) sets an institutional barrier by stipulating that homeowner associations 'shall only represent and safeguard the legitimate rights and interests of all homeowners within the property management area and in property management activities'. Limiting the scale of action to the neighbourhood level is also a conscious homeowner tactic to depoliticize collective action and thus avoid a repressive government response (Zhu & Ho, 2008). Since homeowner activists encounter serious difficulty defending lawful rights and interests against powerful real-estate interest groups (Zhang, 2005), they have recently attempted to create lateral networks at the city level, in part to exchange governance experience and knowledge of policies (Interviews of homeowner association directors, July and August 2007). These initiatives can be found in almost every major city in China – Beijing,[2] Guangzhou (Yip & Jiang, 2011), Shanghai,[3] Shenyang,[4] Suzhou,[5] Suqian,[6] Xi'an[7] and Wenzhou.[8] While such lateral networks are still under the tight control of Chinese authorities, they do facilitate homeowner self-governance. The networks are not only important communication platforms for homeowner associations to share information and experience; they can also formulate codes of conduct among homeowner

associations as well as provide substantial support for member associations.[9] Sometimes, they even pressure the government for favourable policies (Zhuang, 2011).

Homeowners are usually well-off, and many are middle class (Logan, Fang, & Zhang, 2010; Tomba, 2004); they thus are poised to use multiple online communication platforms in rights-defending activities (Huang & Yip, 2012). Homeowner activists have utilized homeowners' online forums (mainly BBS on soufun.com) as information disclosure and online discussion platforms (Huang, 2010). Because many homeowners' forums are public, and because online information may also be exploited by adversaries and/or local governments to counteract activists' strategies, activists prefer QQ (a popular instant messaging system in China) groups as a strategy-crafting venue to which only a handful of activists have access (Interview of a homeowner activist, 20090709). These online communication channels, however, do not change the localized nature of homeowner action. Discussions on homeowners' forums usually take place among homeowners from a single neighbourhood, and information diffusion across neighbourhoods is not common (Huang, Zhang, & Gui, 2011).

Publicly visible networking and communications between homeowner associations from different cities were not prevalent until the recent blossoming of micro-blogging services such as Sina Weibo. In this sense, these services provide homeowners a new and unique venue to advance their rights and interests. Micro-blogging offers homeowners in different provinces a low-cost way to communicate with each other. This is of great significance because activists do not have the resources to build nationwide communications networks (Interview with a Weibo user, 20130104), and the offline lateral networks described above operate only at the city level and do not include a large number of member associations. As a homeowner activist said, 'It is difficult to find someone nearby to discuss the problems I encounter, and even harder to seek professional advice from experts' (Personal correspondence, 20130104). The 'genuine identity' feature of Weibo offers entrepreneurial activists an opportunity to build a serious nationwide community around a specific issue, which is difficult to achieve on homeowners' forums because anonymity can lead to unaccountable and irrelevant postings. Furthermore, micro-blogging services are conducive to information sharing (Scanfeld, Scanfeld, & Larson, 2010; Small, 2011), and the easy integration of micro-blogging and blogging enables members of the issue-network to articulate their thoughts seriously (Personal correspondence, 20130104). Therefore, networking and communication on micro-blogging sites can function as an important complement to and extension of offline networking efforts, which may be facilitating the 'scale shift' of homeowner collective action in contemporary urban China.

Weibo: a platform of networking and information sharing

Micro-blogging services are a type of social media through which users broadcast public messages of 140 characters, known as *tweets*, to provide frequent and immediate updates on their activities, opinions, and status (Zhang & Pentina, 2012). Sina Weibo (www.weibo.com), the Chinese counterpart of Twitter, is the leading micro-blogging service in China. The number of registered users reached 300 million in February 2012.[10] On Sina Weibo, user A may choose to follow any other user B, which leads to the formation of a *follower relation*. Within the dyad, A is a follower of B and B is a friend of A. A set of follower relations and the set of Weibo users connected by these relations form a *follower network*.

Follower relations are fundamental to information dissemination on Weibo. The tweets from all users whom one follows are gathered together and displayed in a single reverse-chronological list for consumption. When a user finds an interesting tweet posted by another user and wants to share it with his/her own followers, he/she can retweet it by simply clicking the 'retweet' button. *Retweeting* has become the key mechanism for spreading information on micro-blogging services

(Suh, Hong, Pirolli, & Chi, 2010), and the *retweet network* of 'who retweets whom' can be constructed from the actual retweeting relations between a set of users.

One feature worth mentioning is that Sina Weibo encourages identity verification, either as an individual or an organization. Once the identity is verified, a symbol of '*V*' and the real identity are displayed in the profile. Verified users are perceived as more credible because only those of relatively distinguished social status are qualified for the service. For example, if a user wants to register as an educator, he/she should be at least an assistant professor in a university or a senior teacher in a top high school at the provincial level.

Previous studies on Weibo network and information diffusion

Formation of follower relations

It has already been pointed out that Weibo (because of its convenience, inexpensiveness, trustworthiness and wide geographical reach) is a new but important platform facilitating the formation of nation-wide public networks among homeowner associations. But what factors influence the formation of follower relations is an under-researched question, with only a few studies in the literature on social media (Lampe, Ellison, & Steinfield, 2007; Lewis, Kaufman, Gonzalez, Wimmer, & Christakis, 2008; Zhang & Pentina, 2012). Therefore, the authors draw on literature of social networks (Rivera, Soderstrom, & Uzzi, 2010) for guidance.[11] Extant studies suggest that actor attributes, existing relations (e.g. balancing mechanism), and proximity mechanisms contribute to the formation of social ties.[12] However, unlike social network studies that pay attention to assortative mechanisms when explaining the effects of actor attributes, this study argues that actor attributes facilitate follower relation formation because they increase the trustworthiness of the followed.

When user A follows B on Weibo, it implies that A trusts B to provide relevant information. B has the incentive to fulfil such trust because the continuation of the follower relation with A contributes to B's online social influence. This conception fits Hardin's encapsulated-interest concept of trust (Hardin, 2002). In this theory, trust and trustworthiness are linked, and it is the trustworthiness of the trusted that gives rise to trust and trust relationships (Hardin, 1996, 2002; Nannestad, 2008). Therefore, the attributes of the followed that signal trustworthiness are expected to be positively associated with the formation of follower relations.

A user's online activities provide a basis to assess his/her trustworthiness as well as the relevance of the provided information. Therefore, online activities are expected to be associated with online network size. Previous studies have demonstrated that the more time a student spends on Facebook, the larger is that student's Facebook friendship network (Lampe et al., 2007; Lewis et al., 2008). A study in China has found that time spent on Weibo significantly increases the (log of the) number of followers (Zhang & Pentina, 2012). Therefore, the authors propose:

> *H1a*: Active micro-blogging users are more likely to form follower relations.

This study extends previous research by examining the effect of 'identity verification', a unique service provided by Sina Weibo, on follower relations. The effect of 'identity verification' on follower-relation formation has not been empirically tested. Nevertheless, previous studies have found that the public display of online social networks (Donath & Boyd, 2004), or the inclusion of many verifiable elements in a user profile, increase the reliability of the signals of that user's identify, and reduce the transaction costs of being found, thus facilitating the formation of online connections (Lampe et al., 2007). Similarly, identity verification on Weibo functions as a

signal of trustworthiness because verification requires a user to verify his/her mobile phone number and submit other supporting documents. Verified identity is not only more difficult to manipulate than other profile fields – it is also implicitly endorsed by Sina Weibo itself. In addition, a verified user usually has high social status and a good reputation, and many are professionals whose expertise is helpful for others. All these characteristics increase their chance of being followed. Therefore, it is expected that:

H1b: Verified users are more likely to be followed by other users.

Driven by a balancing mechanism, an actor has the tendency to befriend those who nominate him/her as a friend, leading to mutual friendships (Bruggeman, 2008). The same phenomenon is also found in online social networks. Wimmer and Lewis' (2010) study of Facebook friendships in the United States finds a strong and significant effect of reciprocity. A web-based experiment with randomly selected Twitter users confirms that mutuality is a significant factor in predicting users' desire to form new ties (Golder & Yardi, 2010). The Weibo system likewise facilitates mutual friendships. Whenever a user is followed, Weibo automatically sends a private message to notify him/her of the new follower, so he/she can easily inspect the profile of the new follower and decide whether to reciprocate the friendship. Therefore, it is expected that:

H1c: Reciprocity is an important predictor of follower relation formation.

Proximity mechanisms (Rivera et al., 2010), in terms of geographical distance and boundaries, might also be at work. A study in the United States has shown that Internet use facilitates participation in local communities and supports affective networks outside local communities (Stern & Dillman, 2006). A longitudinal study in Canada found that the Internet only somewhat alters the way people maintain social relations, and that distance still matters (Mok, Wellman, & Carrasco, 2010). Recent studies on the geographical properties of Twitter networks have reached a similar conclusion – that geographical distance and national boundaries influence the formation of Twitter ties, leading to a substantial proportion of ties being formed in the same metropolitan area (Takhteyev, Gruzd, & Wellman, 2012), and users tending to establish connections with others from the same continent (Java, Song, Finin, & Tseng, 2007).

Previous studies have focused on large geographical scales (nations or continents); it is less clear whether geographical proximity at the sub-national level is relevant. In fact, geographical proximity seems not only a matter of geographical distance, but also of shared interest in local issues. As a study of transnational activism points out, even global issues are rooted in local settings – the Internet cannot replace personal connections to build stable coalitions across borders (Gillana & Pickerill, 2008). Since social relations are driven by the issues at stake, it is reasonable to argue that the more local the issues, the more likely social connections are to be geographically bounded. Because homeowner action/activism is highly localized, and because socio-political contexts vary among provinces (Chung, 2008; Yip & Jiang, 2011), it is expected that:

H1d: Follower relations within the same province are more likely to be observed than pure chance.

Nevertheless, as previously suggested, micro-blogging services enable cross-province networking better than do other online communication methods. Since cross-province networking capacity is micro-blogging services' relative advantage over previous online platforms as well as offline lateral networks, it will be revealing to examine the following question:

RQ1: How prevalent are cross-province follower relations?

Follower relations and information diffusion on Weibo

Determining the channel(s) of information diffusion is crucial to understanding to what extent and how Weibo follower networks can develop into issue-based collective action. Information diffusion on micro-blogging services intertwines closely with follower relations, and follower networks can be seen as information networks (Barash & Golder, 2011) because tweets posted by user A are by default displayed on the front pages of A's followers. Moreover, information diffusion happens through retweeting when A's followers pass A's tweets to their own followers, delivering information beyond A's immediate followers (Kwak, Lee, Park, & Moon, 2010). In this study, *information diffusion* refers to retweeting, and a *retweet network* is composed of a set of users and the retweeting relations among them.[13]

As fundamental a role as follower relations play in the information diffusion process, the relationship between follower networks and retweet networks is, to a large extent, under-researched. Only a few studies have shed light on the retweeting process. A study of retweets on Twitter reveals that a tweet is more likely to be retweeted if the author is followed by many, is following many, or has been a Twitter user for a long time (Suh et al., 2010). Another study reveals that a large number of retweets only go through one- or two-hop chains (Kwak et al., 2010), which implies that if there is a correlation between the follower network and the retweet network, the correlation is modest at best. Thus, this study proposes:

> *H2a*: Follower network positively correlates with retweet network, but the correlation coefficient is small.

Studies of the relationship between the indegree of the follower network (number of followers) and retweets result in inconclusive findings. A study of user influence on Twitter found only moderate correlation between indegree and retweets (Cha, Haddadiy, Benevenutoz, & Gummadi, 2010). The conclusion, echoed by other scholars (Kwak et al., 2010), was that indegree reveals very little about the influence of a user. On the contrary, Wu and colleagues found that the attention of ordinary Twitter users is mainly concentrated on elite users. In the process of two-step diffusion, information is first passed to intermediaries and then passed to ordinary users through those intermediaries. On average, intermediaries have more followers than do randomly sampled users (Wu, Hofman, Mason, & Watts, 2011). This implies that the number of followers might be an important determinant of information diffusion on micro-blogging services. Based on previous studies, this study hypothesizes:

> *H2b*: The number of followers from within the studied follower network has moderate power in predicting/explaining retweets.

Previous studies have concentrated on the effect of the total number of followers (from the entire social networking site) on retweetability; they have not differentiated followers who are interested in the focal issue from those who are not. This narrow focus on total number of followers fails to reveal the relative contributions of these two types of followers to the retweetability of messages pertinent to a particular issue. In other words, extant studies implicitly conceive all followers as homogenous, which is questionable in that micro-blogging users are driven by multiple motives (Zhang & Pentina, 2012), and that flows of information are fragmented and circulated mainly within the same category of users (Wu et al., 2011). To extend our understanding of the online dynamics of social groups who share a similar concern, this research highlights the distinction between (a) the number of followers who belong to the studied follower network and (b) the number of followers from outside the network, which invites the following questions:

RQ2a: Does the number of followers from outside the studied follower network have an effect on retweetability of messages pertinent to homeowner associations?

RQ2b: If followers from both inside and outside the studied network influence retweetability, what are the relative contributions of these two types of followers?

Data and methods

This study applied social network analysis techniques to examine the proposed hypotheses and questions. Social network analysis techniques differ from those of standard statistical analysis by focusing on both actors (nodes) and relations (Bruggeman, 2008; Wasserman & Faust, 1994). Social network analysis was congruent with the foci of this study because both follower relations and information diffusion were relational. A network is a set of actors (*nodes*) connected by a set of relations (*edges*). These relations can be binary or valued – binary relations indicate the presence/absence of relations, whilst valued relations provide information about the strength of relations.

Data collection

This article focused on a group of Sina Weibo users with a shared interest in homeowner associations. The authors selected the Weibo user y*eweihui tongxun* (Homeowner Association Communication, *YWHTX* thereafter) and defined its followers as the studied group. This method clearly defined the network boundary, enabling the construction of a whole network and the application of whole network analysis techniques to explore the formation of follower relations, which would have been very difficult to untangle with ego-network data.[14] It also provided an effective way to answer questions RQ2a and RQ2b by differentiating in-group and out-group followers.

The choice of *YWHTX* was carefully considered. The authors had conducted 'virtual ethnography' (Hine, 2000) by following *YWHTX*'s status updates for about six months. Its screenname, self-description, active followers and tweets all clearly demonstrated its particular concern for homeowner associations. In fact, *YWHTX* was an individual activist who advocated homeowner associations through micro-blogs, weblogs and offline seminars. On Sina Weibo, he broadcast news about homeowner actions in various cities, acted as an intermediary between homeowners and experts, and organized discussions about salient issues of homeowner associations (Personal correspondence, 2013).

The authors also consulted researchers and homeowner activists, who all recommended *YWHTX*. It was reasonable to infer that, by and large, the followers of *YWHTX* could be seen as a concerned group for homeowner associations. Though the findings from this group might not readily be generalized to all Weibo users, they can provide preliminary conclusions and shed light on the implications of Weibo for homeowner collective action.

The authors took advantage of Weibo's open API[15] and used the Python SDK[16] to collect data. Data were collected in June and July 2012. At that time, *YWHTX* had 1840 followers. The follower relations between each pair of users were collected to construct a follower network, which was a binary-directed network with edges running from followers to the followed. In this network, *indegree*[17] was the number of followers.

The latest 100 tweets of *each Weibo user* were also collected.[18] Though not comprehensive, analysis of the latest 100 tweets was still indicative and had an advantage – it reduced the chance of retweeting relations happening prior to the formation of the studied follower network. Using these tweets, the authors were also able to construct a *retweet network* among the 1840 users. In this retweet network, nodes were users and edges were information volume (number of retweets) running from a) users who first originally posted the tweets to b) users who reposted those tweets. First, 92808 tweets retweeted from other users were selected from a total of

140,923 tweets.[19] That pool was then narrowed to 10,918 relevant tweets, which mentioned 'home-owner association', 'homeowner', 'property management', 'real estate developer', or 'property rights'.[20] Third, the original author of each tweet was traced and identified. Then, the retweet network was constructed.

Finally, Weibo users' gender, province, identity verification, total tweets, and date of account registration were also collected.

Analysis methods

In addition to descriptive statistics, an exponential random graph model was used to examine the effects of the above-mentioned factors on the formation of follower relations. In this model, the log-odds of a follower relation were modelled in an exponential form analogous to logistic regression (Goodreau, Kitts, & Morris, 2009; Hunter, Handcock, Butts, Goodreau, & Morris, 2008; Robins, Pattison, Kalish, & Lusher, 2007). The exponential random graph model was specified as follows:

$$\text{logit}(Y_{ij} = 1) = \theta_{\text{edge}} + \sum_{A} \theta_{A}[\delta g_{A}(y)],$$

where Y_{ij} was the follower relation between two distinct users of i and j, $g_{A}(y)$ was a network statistic dependent on the network of y, and $\delta g_{A}(y)$ was network statistic change when Y_{ij} was toggled from zero to one. Parameter θ_{A} represented the change in the log-odds that a particular follower relation was formed if the formation of this relation increased the corresponding network statistic by one, all else being equal (Goodreau, Handcock, Hunter, Butts, & Morris, 2008). When a model posited an endogenous process of relation formation, Markov-Chain Monte Carlo maximum-likelihood estimation (MCMCMLE) was required to obtain the appropriate estimates (Hunter et al., 2008; Goodreau et al., 2009). The MCMCMLE was implemented in the R package of *ergm* (Handcock et al., 2012).

The authors also used *sna* package (Butts, 2010) to conduct QAP (quadratic assignment procedure) tests (Krackardt, 1987) to ascertain the significance level of the correlation between two networks.

Empirical findings

Description of follower network

The 1840 Weibo users were dispersed across 34 provinces.[21] Among them, 27.1% were from Beijing, 15.27% from Guangdong, and 11.2% from Shanghai. Users from these three provinces (municipalities) accounted for more than half of the studied population, a disproportionately large number, given that Internet users in these three areas were only 17.9% of all the Internet users in China (CNNIC, 2012). One explanation is that housing and property management markets are more developed and homeowner actions are more common in these three cities. A majority (71%) of these 1840 Weibo users were male. 13.2% were verified users, who were media workers, scholars and researchers, lawyers, NGO staff, homeowner association representatives, and homeowner activists (Table 1).

There were 24,737 edges in the follower network (Table 2). The average degree was 13.4 and the network density was 0.0073. Indegree and outdegree were highly correlated, and the correlation coefficient (0.771) was larger than that of the Twitter network (Java et al., 2007). According to the standard deviations, indegree was less dispersed than outdegree, implying that a handful of users were each followed by many. The dyadic reciprocity, which was the ratio of mutual to non-null dyads, was 0.432. The tie reciprocity, which was the proportion of reciprocated edges, was

Table 1.   Distribution of Weibo users in the follower network ($N = 1840$).

Province	Number of users (%)
Beijing	497 (27.1)
Guangdong	281 (15.27)
Shanghai	206 (11.2)
Others	856 (46.5)

Gender	Number of users (%)
Male	1306 (71.0)
Female	534 (29.0)

Identity verification	Number of users (%)
Verified	242 (13.2)
Not verified	1598 (86.8)

0.603. These two reciprocity scores were higher than (Kwak et al., 2010; Wu et al., 2011) or similar to (Java et al., 2007) that of Twitter networks. High reciprocity indicated a large number of mutual friendships.

About 27.3% (6743) of edges connected users from the same province. About 72.7% were cross-province relations, which were more prevalent than cross-country relations (25%) in Twitter networks (Takhteyev et al., 2012). It seems that as the geographical boundaries were defined on a smaller scale, cross-boundary connections became more prevalent. In all, we concluded that cross-province follower relations were quite common (RQ1).

It was obvious that intra-province relations were disproportionately concentrated in Beijing, where homeowner activism is more vibrant and politically participatory (Chung, 2008, pp. 52–57). This might imply that intra-boundary relation formation was not only constrained by geographical distance, but also driven by the social fabric in the offline world.[22]

Determinants of follower relations

The exponential random graph model simultaneously estimated the effects of user attributes,[23] proximity and network structure (Table 3). The explanatory terms included edges, the main

Table 2.   Structural characteristics of the follower network.

Property	Value
Nodes	1840
Total edges	24,737
Average degree	13.4
Density	0.0073
Degree correlation	0.771
SD of indegree	35.15
SD of outdegree	34.77
Mutuality	7462
Asymmetric dyad	9813
Reciprocity (non-null dyads/edges)	0.432/0.603
Number of cross-province edges	17994
Number of intra-province edges	6743
Edges within Beijing	3867
Edges within Guangdong	1086
Edges within Shanghai	417

Table 3. Exponential random graph model of follower network.

	Coefficient	Standard error	Exp(coef)
Edges	−6.614**	0.018	0.0013
Network structure effect			
Reciprocity	6.102**	0.024	446.750
Proximity effect			
Same province	0.586**	0.011	1.797
Actor's attribute effect			
Identity verification of the followed	0.983**	0.014	2.672
Active in tweeting	0.333**	0.008	1.395
Male	0.201**	0.009	1.223
AIC	219,809		

Note: This model was estimated by MCMCMLE using the following settings: burn-in = 2,100,000,000, interval = 1,500,000, and MCMC sample size = 4000.
**p-value < 0.001.

attribute effect of active in tweeting,[24] main attribute effect of identity verification for indegree, province homophily, reciprocity and main attribute effect of gender.[25] Gender was included as a control variable because a study of Facebook has shown that women have more online friends (Lampe et al., 2007). However, the effects of gender are inconclusive (Lewis et al., 2008; Zhang & Pentina, 2012).

The results showed that men were more active in networking. Being male increased the log-odds of follower relation formation by 0.201. This result contradicted previous studies, which was found to be insignificant (Lewis et al., 2008; Zhang & Pentina, 2012) or negative effects (Lampe et al., 2007). This result could be explained by the issue at stake. According to the authors' field-work observations in Shanghai, members of homeowner associations were mainly male, and men generally had higher levels of interest in this particular issue. This speculation needs further investigation.

The odds of forming a follower relation involving an 'active' user, who tweeted more frequently than 'average' users, were 1.395 times the odds between two inactive users. This confirmed hypothesis *H1a*. More importantly, users with verified identities were more likely to be followed by others. The odds of verified users being followed were 2.6 times that of ordinary users, thus confirming hypothesis *H1b*. A user's 'authentic' identity enhanced the trustworthiness of the tweets he/she posted, which was especially important when his/her followers used the micro-blogging service for information seeking. In addition, identify verification on Weibo (with its rigid qualification requirements) favoured celebrities, and thus most verified users possessed high social status and professional expertise. Information from these distinguished professionals and experts (e.g. lawyers and journalists) was valuable for those who are interested in homeowner associations.

The reciprocity effect was highly significant and its magnitude was very large (coefficient = 6.102). This result implied that user A following B increased by 6.1 the log-odds of B reciprocating the follower relation and forming a mutual friendship. Thus, hypothesis *H1c* was confirmed. This network structure effect was larger than any other effect in the model, which justified the use of an exponential random graph model.

A proximity mechanism was also at work. The odds of forming a follower relation between two users from the same province were 1.797 times the odds between two users from different provinces. In other words, despite the prevalence of cross-province relations, intra-province relations were more likely observed than pure chance, which confirmed hypothesis *H1d* and was consistent with the finding in Takhteyev et al. (2012).

Table 4.   QAP (product-moment) correlation between retweet network and follower network.

	Transposed follower network
Log-transformed of weighted retweet network	0.134
Dichotomized retweet network	0.132

Note: All p-values are <0.005. p-values were based on QAP tests (1000 permutations).

Retweet network structure

This section focused on tweets diffusion *within* the studied follower network. In the data set, 4439 tweets were retweeted between 2261 pairs of users. These tweets were originally tweeted by 320 users (information sources), which only accounted for 17.4% of the 1840 users in the studied network. Furthermore, most of the tweets came from a few users. Retweets originating from the top 10 most popular sources accounted for 42.5% of the total.

These tweets were retweeted by 563 users (disseminators), almost twice as many as the sources (320). The 10 most popular disseminators only retweeted 593 tweets (13.3%). This implied that the information was from a handful of users, and was disseminated to a relatively large number of users. Users who played the role of information sources were not necessarily active in retweeting. Only one of the top 10 popular sources was on the list of the most active disseminators. Tweets diffusion seemed likely to be a unidirectional process with little reciprocity, which was corroborated by low degree correlation (0.331) in the retweet network. Geographically, the majority of tweets were circulated *across* provincial borders. Analysis revealed that only 1511 (34%) tweets were reposted by users from the same province, whilst 2928 (66%) tweets were reposted by users from different provinces.[26]

Intuitively, if A followed B, it was more likely that tweets spread from B to A. To examine the correlation between the follower and the retweet networks, the follower network had to be transposed first. The edges weights of the retweet network were log-transformed because the distribution was skewed. The correlation coefficient was 0.134, and highly significant. Alternatively, the retweet network was converted into a binary network using the cutting point of 1. The resultant correlation was 0.132 and was also significant (Table 4). Thus, hypothesis *H2a* was supported.

Both correlation coefficients were small. One explanation was that tweets might travel through multiple users before reaching their destinations, but our retweet network represented the source and destination rather than the detailed diffusion paths. It was revealing to explore the lengths of geodesics[27] in the follower networks between the source and destination users. The result (Table 5) showed that 44.2% of tweets were retweeted by the followers of a source user. Another 44.9% of tweets were retweeted by the followers of followers of a source user. Only 2.3% of tweets travelled indirectly through someone outside the studied group to users in this group, which lent support to the method of defining the studied population.

Table 5.   Geodesics between tweet sources and destination users in the follower network.

Geodesics	Number of tweets reposted from source and destination users (%)
1	999 (44.2%)
2	1016 (44.9%)
3	180 (8%)
4	15 (0.7%)
Infinite (no direct path)	51 (2.3%)

Follower network and retweets

The chances of tweets being retweeted varied according to the network position of their senders. Based on the 13,510 tweets relevant to homeowner associations, the authors calculated *average number of retweets* for *each* user.[28] That is,

$$Y_i = \sum_{j=1}^{m} R_{ij},$$

where Y_i is the *average number of retweets* for user i and R_{ij} is the number of times the tweet j posted by user i was retweeted. This variable roughly measured how widely a user's tweets had been circulated.

An ordinary least squares (OLS) regression was conducted to explore the determinants of retweets. The log of the *average number of retweets* was regressed on gender, identity verification, log of number of tweets per day, months since account registration, province, log of number of followers from within the studied network (indegree), and log of number of followers from outside the network.[29]

The results (Table 6) showed that tweets from those whose identity was verified seemed more likely to be retweeted (coefficient = 0.36 in model 1), but its magnitude was attenuated when the log of the indegree was included (coefficient = 0.24 in model 2), and became insignificant when the log of number of followers was included (model 3). One interpretation was that identity verification only influenced retweetability indirectly through increasing a user's number of followers.

If a user tweeted frequently, his/her tweets were *less* likely to be retweeted. Since frequency of tweet updates was mainly driven by self-expression rather than information-seeking or citizenship behaviour (Zhang & Pentina, 2012), those who frequently posted tweets might be less useful for those interested in homeowner associations, causing their messages to be less likely to be retweeted. Once the total number of followers was taken into consideration (model 3), the time since account registration had a negative effect on retweetability, which suggested that the longer someone had been a member of Weibo, the less likely his/her tweets were to be retweeted. Gender had no significant effect. Geographically, tweets posted by users from Beijing were more likely to be retweeted, and this effect was significant even when the log of indegree and the number of followers from outside the studied network were included.

The number of followers from the studied network highly correlated with the average number of retweets in the expected direction (the coefficient of log of number of indegree was 0.15 in model 2 and 0.14 in model 3). Tweets from users who had a large number of followers in the studied network were circulated more widely. When log of indegree was included, R^2 increased by 0.0915, from 0.0605 to 0.152. It suggested that the explanatory power of indegree was much stronger than all user attributes in model 1. Therefore, hypothesis *H2b* was supported.

With regard to question RQ2a, the number of followers from outside the studied network was also a contributory factor. However, its explanatory power was relatively weak, as R^2 only increased by 0.018, from 0.152 to 0.170. Regarding question RQ2b, we concluded that the number of followers interested in homeowner associations, rather than the followers from outside the studied follower network, substantially influenced how widely a tweet related to homeowner associations was circulated on Weibo.[30]

Discussion and conclusion

This study argues that Weibo should be conceived as a space for virtual organizational infrastructure building, where micro-bloggers network, exchange experience and information, and conduct reflexive interactions. In this way, Weibo both links activists into a common contentious front and serves

Table 6.   OLS regression of average number of retweets.

Independent variables	Model 1		Model 2		Model 3	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
(Intercept)	0.60**	0.06	0.39**	0.06	0.22**	0.07
Gender (male = 1)	−0.00	0.05	−0.06	0.04	−0.07+	0.04
Verified user	0.36**	0.06	0.24**	0.06	0.11+	0.06
Months since registration	−0.00	0.00	−0.00	0.00	−0.01**	0.00
Log of number of tweets per day	−0.05+	0.03	−0.09**	0.02	−0.18**	0.03
Province: Beijing	0.18**	0.05	0.11*	0.05	0.10*	0.05
Province: Guangdong	−0.04	0.06	−0.07	0.06	−0.07	0.05
Province: Shanghai	−0.03	0.07	−0.02	0.07	−0.02	0.06
Log of indegree			0.15**	0.01	0.14**	0.01
Log of number of followers outside the studied network					0.07**	0.02
N	1012	1012	1012			
R^2	0.0605	0.152	0.17			

Notes: Dependent variable is log of average number of retweets. Only those who had tweeted prior the data collection process were included. 'Other provinces' was the reference group.
$+p < 0.10.$
$*p < 0.05.$
$**p < 0.01.$

as a breeding ground for mobilization. This conception requires scrutiny not of collective incidents, but of issue-networks, which can better shed light on Weibo's long-term implications for collective action and activism in China, in particular to whether Weibo has the potential to mitigate the afore-mentioned problem of localization and lack of networks between activists in different provinces. In addition, given the dearth of literature on this issue, the findings of this paper also contribute to the study of inter-organizational relations between homeowner associations.

This study finds that the follower network significantly correlates with the retweet network, lending support to the argument that networking on micro-blogging sites facilitates the exchange of information and reflexive interactions. Cross-province follower relations and information diffusion are prevalent on Sina Weibo (72.7% and 66%, respectively). This finding is quite interesting, given that homeowner collective action in urban China is usually confined to specific neighbourhoods (Zhu & Ho, 2008), and that neither existing offline lateral networking efforts of homeowner associations (Yip & Jiang, 2011) nor homeowner online forums (Huang et al. 2011) have the capacity to build effective cross-province organizational infrastructure. It highlights Weibo's unique feature of easy networking, not commonly found in previous online communication platforms. On the other hand, it supports the argument that micro-blogging services function as complements of and/or substitutes for offline networks by providing activists in general and homeowner activists in particular from different provinces a space to share updated information, experience and knowledge. This is of great significance, given that officially recognized offline lateral networks between activists, NGOs, and homeowner associations in particular are lacking because of the unfavourable political conditions. Even if city-level lateral networks are officially recognized by authorities, micro-blogging services still have a role to play in bridging networking efforts among various cities and/or provinces. Overall, Weibo is a valuable platform for activists to enlarge the geographic scale of their networking efforts.

Meanwhile, this study cautions against drawing sweeping conclusions – geographic proximity at the sub-national level is still at work, in that intra-province follower relations are much more likely to be formed than relations between two randomly selected users. Considering the

localized nature of homeowner associations and homeowner activism, the effect of geographical proximity on follower relations implies that, even in the Web 2.0 age, collective action remains strongly influenced by provincial regulations and political contexts. Thus, whether geographical proximity at various levels plays a role in less localized issues needs further investigation. This finding also complements previous studies (Java et al., 2007; Takhteyev et al., 2012) by demonstrating that geographical proximity works on a much smaller scale than a nation or a continent.

This study also finds that circulation of tweets pertinent to the issue at stake (e.g. homeowner associations and homeowner activism in this study) is strongly influenced by the number of followers from within the issue-network, and only weakly predicted by the number of followers from outside such a network. It suggests that only when a message is congruent with the interest of the potential audience can it draw the attention of a large number of users and set viral diffusion into motion. Therefore, enlarging the issue-specific network through consensus-building and heightening the salience of the issue at stake will be primary tasks for online activists.

User attributes which provide a basis for assessing the trustworthiness of a user contribute to the formation of follower relations on Weibo. Specifically, those who tweet in a frequent manner and have their identity verified are more likely to be followed. Among the user attributes examined in this paper, identity verification exerts the strongest effect. Identity verification is also a contributory factor to information diffusion: on average, tweets posted by verified users are circulated more widely, but verified identity seems to influence diffusion only indirectly through fostering follower relations. These findings lend support to Garrett's argument that people will not indiscriminately disseminate information (Garrett, 2006). Indeed, Weibo users tend to follow and disseminate information from those who are credible, trustworthy and professional. In other words, Weibo users have the capacity to distinguish, listen to and disseminate information that is trustworthy and helpful by making good use of the signals afforded by micro-blogging services. This study contributes to the literature by highlighting the trustworthiness of content generators, whilst previous studies mainly focused on the styles of framing or the content of messages (Pu & Scanlan, 2012; Suh et al., 2010). Future studies need to assess the relative importance of these two factors.

The information processing strategy of micro-blog users and the significance of identity verification in the formation of follower relations and information diffusion present opportunities as well as dilemmas for online activists in the context of China, where the authorities actively censor social media.[31] Online activists need to be as trustworthy as possible to widen the circulation of and win support for their claims. Often, they need to disclose their identities and professional credentials, but in doing so, they expose themselves to governmental surveillance. Tight state control together with the importance of verified identity in determining one's online influence may lead to a pessimistic conclusion – that micro-blogging services may not have the power to change China's 'self-imposed censorship and de-politicized politics' (Ho, 2008) in the near future. This invites a question for future studies – how does state pressure influence information diffusion on Weibo?

The limitations of this study are related to methodological issues in using online data. Therefore, highlighting these limitations can provide implicit guidance for future studies. As one referee pointed out, the studied follower network might consist of property managers, real estate developers and/or government officials, which causes sample selection problems. The authors examined followers' self-descriptions, excluded 46 property managers and real estate developers, and then re-ran most analyses. The results were almost the same. However, it should be acknowledged that the sample selection problem was still not fully addressed because self-description is not an accurate indicator. More generally, data 'crawled' from Sina Weibo are self-reported, self-selected, and often incomplete. For example, incomplete data preclude the authors from examining other attributes of Weibo users like age, education, income, occupation and use motivations.

Researchers using online data need to evaluate its reliability, validity and representativeness. Future studies should combine online network data and traditional data sources (e.g. surveys) to present a more comprehensive picture. In the exploration of tweets diffusion, this study focused on how user attributes influence the average circulation of tweets posted by that user and did not take the content of tweets into consideration. This also invites further examination. Finally, though this study has demonstrated the presence of the network structure effect of reciprocity, it has not examined high-ordered network structures such as transitivity because of computational constraints.

Acknowledgements

Notes

1. Collective action is defined as any action taken by two or more people in order to improve home-owners' conditions.
2. http://news.sohu.com/20070126/n247846747.shtml, accessed on 1 July 2012.
3. http://citynews.eastday.com/csdb/html/2011-01/13/content_35673.htm, accessed on 1 July 2012.
4. http://www.sywy.net.cn/, accessed on 1 August 2012.
5. http://wzwx.66wz.com/system/2012/05/14/103166040.shtml, accessed on 1 August 2012.
6. http://jsnews.jschina.com.cn/system/2011/12/19/012324855.shtml, accessed on 1 August 2012.
7. http://news.cnwest.com/content/2012-10/14/content_7421913.htm, accessed on 1 August 2012.
8. http://www.zj.xinhuanet.com/video/2013-01/11/c_114337566.htm, accessed on 1 August 2012.
9. http://zjnews.zjol.com.cn/05zjnews/system/2012/12/04/018990587.shtml, accessed on 1 August 2012.
10. http://news.xinhuanet.com/tech/2012-02/29/c_122769084.htm, accessed on 1 August 2012.
11. Some argue that Twitter networks are not social networks because they exhibit low reciprocity and highly skewed degree distribution (Wu et al., 2011). On the contrary, others show that levels of reciprocity are moderate or high, and that levels of reciprocity increase when confined to users from one continent (Java et al., 2007). Zhang and Pentina (2012) reviewed the previous literature on Twitter and concluded that Twitter is used to satisfy the needs of both information and social connection. As revealed in the empirical section, when indegree is confined to a group of users with shared interest, the follower network exhibits a relatively high level of reciprocity and is much closer to social networks. Therefore, the general theory of social networks can still shed some light on follower relation formation.
12. This study does not claim to exhaust all possible factors. First, 'crawling' data directly from a micro-blogging site is constrained by what exists on that site, a situation not unlike secondary data analysis. Second, teasing out the effects of actors' attributes and proximity from that of existing relationships is computationally intensive. It is extremely hard to include high-ordered network structure effects in the exponential random graph model for a network of size 1840.
13. More details on the construction of the retweet network can be found in the data and methods section.
14. An ego-network consists of ego ('focal' node) and nodes to which the ego has a direct connection. Many existing studies have explored ego-networks but cannot untangle the formation mechanisms of follower relations.
15. http://open.Weibo.com/
16. http://open.Weibo.com/wiki/SDK
17. The *indegree* of a node is the number of head endpoints of edges adjacent to that node.
18. Data collection process was constrained by the API limit, and the current study opted for a less comprehensive but feasible choice.
19. Only retweets were relevant because original tweets not retweeted by others did not contribute to the valued edges, and tweets retweeted by others were included as the retweeted of others.

20. Keywords were selected in a trial-and-error manner by examining 300 randomly-sampled tweets. They were intended to be inclusive enough to select most tweets relevant to homeowner associations and homeowner actions, whilst restrictive enough to exclude irrelevant tweets.
21. Seventy-three users did not report their locations.
22. The observed pattern might simply be the result of the research design because the influential user whom we used to define the studied follower network was located in Beijing. We could not assess which interpretation was more appropriate.
23. Exploratory analysis showed that *time since account registration* was insignificant once *reciprocity*, *geographical proximity* and *active in tweeting* were included in the model. Because the model estimation was computationally intensive, *time since account registration* was not included in the final model.
24. *Average number of tweets per day* was calculated first. It was dichotomized with the cutting point equal to the mean value. Those greater than the cutting point were coded as active in tweeting. Dichotomization had to be used to estimate the model with an average personal computer; otherwise, the computation would have been beyond the capacity of a personal computer.
25. It took about five days to obtain a final model with an average personal computer (2.3 GHz and 4G RAM).
26. Further analysis showed that tweet diffusion within a province was more likely than pure chance (*p*-value of QAP test < 0.001), but the correlation between the retweet network and geographical network, which was an undirected network with edges being 1 when both users were from the same province, was only 0.04.
27. The geodesic is the number of relations in the shortest possible diffusion path from one actor to another. Here, we assumed that tweet diffusion followed the most 'efficient' follower relations.
28. It was based on the *total* number of retweets contributed by users inside and outside the studied network.
29. Number of retweets, number of tweets per day and number of followers were log-transformed because their distributions were skewed.
30. The authors also used log of total number of followers as an independent variable without splitting followers into two parts. The R^2 of this alternative model is 0.113, which was lower than that in model 3.
31. http://www.bbc.com/news/technology-17313793, accessed on 1 August 2012.

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