

6-20-2015

## Sustainability of a Virtual Community: Integrating Individual and Structural Dynamics

Gee-Woo Bock

*SungKyunKwan University*, gwbock@skku.edu

Manju K. Ahuja

*University of Louisville*, Manju.ahuja@louisville.edu

Ayoung Suh

*City University of Hong Kong*, ahysuh@cityu.edu.hk

Lee Xian Yap

*DBS Bank, Singapore*, leexian@gmail.com

Follow this and additional works at: <https://aisel.aisnet.org/jais>

---

### Recommended Citation

Bock, Gee-Woo; Ahuja, Manju K.; Suh, Ayoung; and Yap, Lee Xian (2015) "Sustainability of a Virtual Community: Integrating Individual and Structural Dynamics," *Journal of the Association for Information Systems*, 16(6), .

DOI: 10.17705/1jais.00400

Available at: <https://aisel.aisnet.org/jais/vol16/iss6/3>

This material is brought to you by the AIS Journals at AIS Electronic Library (AISeL). It has been accepted for inclusion in Journal of the Association for Information Systems by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact [elibrary@aisnet.org](mailto:elibrary@aisnet.org).

# Journal of the Association for Information Systems

JAIS 

Research Article

## Sustainability of a Virtual Community: Integrating Individual and Structural Dynamics

**Gee-Woo Bock**  
Sungkyunkwan University  
gwbock@skku.edu

**Manju K. Ahuja**  
University of Louisville  
manju.ahuja@louisville.edu

**Ayoung Suh\***  
City University of Hong Kong  
ahysuh@cityu.edu.hk

**Lee Xian Yap**  
DBS Bank, Singapore  
leexian@gmail.com

### Abstract

*This study investigates how virtual communities retain active members and maintain sustainability as they grow in size. By integrating the individual and structural dynamics of a virtual community, this study develops a multi-level research model that explores how structural factors (i.e., membership and clique sizes) at the community level interact with individual factors (i.e., the extent of use of collaborative tools, the strength of emotional ties, and shared information resources) to predict an active member's intention to stay. We tested the proposed cross-level hypotheses using survey data collected from 164 participants and 15 virtual communities. The results of this study emphasize the need to consider individual and structural dynamics simultaneously to understand virtual communities' sustainability. Results indicate that membership size does not directly influence an active member's intention to stay but that it exerts an indirect effect by strengthening the positive relationship between the extent of use of collaborative tools and shared information resources. This study supports the notion that, because members form cliques, the strength of emotional ties among individuals in a virtual community does not decrease despite an increase in membership size. Notably, the results suggest that, in a virtual community, a large clique size may weaken the relationship between the strength of emotional ties and the intention to stay.*

**Keywords:** Virtual Community, Sustainability, Communicative Ecology Theory, Multi-level Modeling.

---

\* Corresponding author

\*\* Hock Hai Teo was the accepting senior editor. This article was submitted on 31st October 2011 and went through three revisions.

# Sustainability of a Virtual Community: Integrating Individual and Structural Dynamics

## 1. Introduction

Virtual communities (VCs) are online social networks that have become increasingly popular avenue for people with common interests, goals, or practices to interact and share information and knowledge (Chiu, Hsu, & Wang, 2006). Given that VCs' sustainability and survival largely depend on ongoing member participation and voluntary contributions, these communities must retain active members who contribute by posting or offering commentaries for other members (Wang, Butler, & Ren, 2013). If most community members consume the resources of a community but do not contribute to it, a VC's sustainability will be threatened (Butler, 2001).

Empirical evidence shows that many initially active VCs fail to retain their active members and become obsolete over time (Preece, 2001; Boyd & Ellison, 2007; Phang, Kankanhali, & Sabherwal, 2009), such as SixDegrees.com, which launched in 1997 and grew quickly. However, it was shut down in 2000 because it failed to retain active members (Boyd & Ellison, 2007). Bebo, which has a younger user profile (principally school-aged children), has reportedly lost a significant number of users—24 percent in April 2009 (Hou, Chen, Shang, & Chern, 2012). Given this situation, we need to understand how a VC can successfully maintain active membership as it grows in size. This issue is especially crucial for managers who run VCs and practitioners who design and develop them. Despite this growing problem, however, solutions remain unclear.

One can broadly categorize existing research on VCs' sustainability into two independent streams (Appendix A explains more fully). The first stream examines individual dynamics in VCs and focuses mainly on identifying the factors that influence individuals' ongoing participation in and contribution to them (e.g., Teo, Chan, Wei, & Zhang, 2003; Lin, 2008; Chung & Lee, 2009; Hsiao & Chiou, 2012). The second stream focuses primarily on VCs' structural dynamics and investigates how their network characteristics evolve over time (e.g., Butler, 2001; Buriol, Castillo, Donato, Leonardi, & Millozzi, 2006; Otto & Simon, 2008; Panzarasa, Opsahl, & Carley, 2009; Faraj, Jarvenpaa, & Majchrzak, 2011; Wang et al., 2013). We observe that these two streams have not informed each other. That is, the studies on individual dynamics in VCs have paid little attention to the structural factors that may modify individual behavior, and research that concentrates on VCs' structural dynamics has not adequately considered how components at the individual level (such as technological, social, and cognitive dimensions) can contribute to VCs' sustainability. These two independent scholarly streams have led to fragmented and equivocal research findings that do not provide a clear picture of *why* and *how* a VC can remain sustainable as it grows. As such, we need to examine the interplay between them for insights about managing VCs' sustainability. Accordingly, we integrate individual and structural dynamics to provide a more complete understanding of VCs' sustainability in this paper.

To this end, we draw on communicative ecology theory (Foth & Hearn, 2007) to establish a holistic framework and gain a better understanding of the interplay between individual dynamics at the micro level and structural dynamics at the community level. In particular, to examine the interaction between individual and structural dynamics, we focus on the opposing forces of membership size, which create push-and-pull effects on a VC's sustainability. On the one hand, large VCs are considered beneficial for active members in that they can share more information resources and provide more social support compared with small VCs (Asvanund, Clay, & Krishnan, 2004; Butler, 2001). Additional resources encourage active members to continue contributing to a VC (Wang et al., 2013). On the other hand, large VCs tend to struggle in maintaining active membership because an increase in network size increases information overload, causes social loafing problems (Kraut, 2003), and weakens the bond among VC members (Hsiao & Chiou, 2012). Large VCs also incur greater costs in terms of moderating the communities and maintaining the quality of posts and the depth of interactions (Gu, Konana, Rajagopalan, & Cheh, 2007). This problem, in turn, diminishes a VC's overall value to its active members (Jones, Ravid, & Rafaeli, 2004; Ridings, Gefen, & Arinze, 2002; Ridings & Wasko, 2010).

Research has yet to address the issue of how one can resolve the positive and negative forces that exert two opposing effects of the membership size on VC sustainability. In this study, we deliberate

over an evolutionary tendency that is frequently observed in VCs as they grow in size: the formation of *cliques*. A clique is a subset of a network in which actors are more closely and intensely tied to one another than they are to the other members of the entire network (Scott, 2000). Clique formation has been regarded as an emergent individual strategy for coping with the negative effects of an increase in network size (Ganley & Lampe, 2009; Ridings & Wasko, 2010; Hsiao & Chiou, 2012). Despite the progress made in research, however, we know little about how structural factors, such as membership and clique sizes, interact with individual dynamics as VCs endeavor to retain active members. One can empirically investigate how to retain active members by examining the intention of active members to stay in a VC (Zhou, Fang, Vogel, Jin, & Zhang, 2012; Hsiao & Chiou, 2012). Accordingly, this study addresses the following questions:

**RQ1:** *What are the individual factors that influence an active member's intention to stay in a VC?*

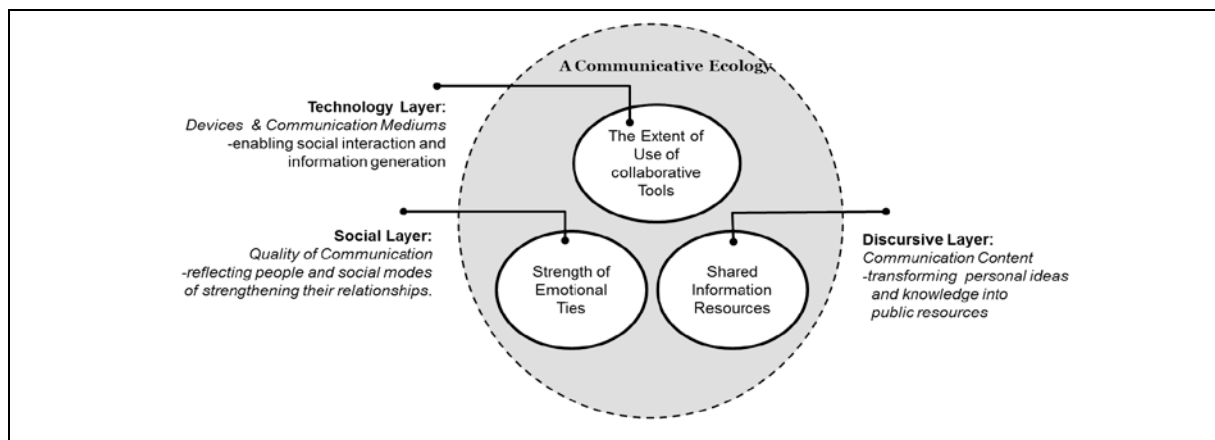
**RQ2:** *How do structural factors (e.g., membership and clique sizes) moderate the effect of the individual factors on an active member's intention to stay?*

In this study, we address both individual and structural factors at the individual and community levels, respectively, and examines the interaction effect between the two levels; thus, a single-level model that treats different levels as if they co-occur at a common level would be inadequate (Hox, 2002). To construct our research model, we employ the cross-level moderator model that Kozlowski and Klein (2000) propose. The model suggests that the relationship among low-level constructs are changed or moderated by a characteristic of the high-level entity in which they are both embedded. With the multi-level model, we identify significant implications for academia and industry by developing a cross-level theory that can be applied to other types of online ecologies in explaining how individual dynamics can be shaped by structural factors at a higher level (for academia) and by providing managers or companies with insights and prescriptive guidelines on designing a sustainable online ecology (for industry).

## 2. Theoretical Development

### 2.1 Individual Dynamics in Virtual Communities

One can regard a VC as a communicative ecology, which Foth and Hearn (2007, p. 9) define as “the context in which communication processes occur”. Communicative ecology theory (CET) posits that new media and information technologies can influence the communicative content and social interactions in a virtual environment. CET enables researchers to take a holistic approach to understanding the dynamic interrelationships among social interactions, discourse, and communications technology in digital environments (Foth & Hearn, 2007; Seol, Lee, Yu, & Zo, 2012).



**Figure 1. Conceptual Framework of a Communicative Ecology (Adapted From Seol et al., 2012)**

As Figure 1 shows, CET proposes that a communicative ecology comprises three layers: technological, social, and discursive. The technological layer comprises devices and media that connect people and enable communication and interaction among them (Seol et al., 2012). Accordingly, the technological capabilities provided by (or embedded in) VCs support communication and information exchange. These capabilities include thread posting, real-time chat, private messaging, polling tools, communal calendars/scheduling, social network applications, and the creation of avatars for interaction among users. In contrast to traditional communities that mainly operate through direct reciprocation and personal familiarity, VCs possess capabilities that provide a fundamentally different environment in which individual members can realize the benefits of technologies by collaborating with other members (Wasko, Faraj, & Teigland, 2004; Kang, Lim, Kim, & Yang, 2012). Collaborative IT features provide many ways to facilitate contributive activities, such as reviewing and managing content, recombining information and knowledge, and bouncing novel ideas off other users (Faraj et al., 2011). Hence, we use the phrase “the extent of use of collaborative tools” to represent VCs’ technological dimension.

A VC’s discursive layer represents communication content and captures the extent to which members can exchange their private information resources, and this process accumulates public resources to facilitate members’ access to timely, relevant, and valuable information. This layer is critical to sustaining a VC because members can benefit from such available resources (Chiu et al., 2006; Wasko & Faraj, 2005). Research also points out, however, that available information resources alone do not necessarily imply a benefit for members, especially if a VC focuses on increasing the pool of information (Gu et al., 2007). This discrepancy is attributed to the fact that a high volume of information may increase a member’s search time and information-processing costs, which escalates the difficulty of converting available information resources into benefits (Butler, 2001). Information resources are converted into VC benefits only when members can easily search for and access valuable information when they need it. Therefore, we determine that “shared information resources” represent VCs’ discursive layer.

The social layer comprises people and social modes that represent the quality of the communication and interpersonal relationships among community members (Seol et al., 2012). A VC’s sustainability depends on the formation of social bonds and relationships (Ren, Kraut, & Kiesler, 2007; Ridings et al., 2002). When strong relationships exist, members are more likely to return regularly to a VC and, therefore, sustain the community; as time passes, these members construct a shared history and consequently further strengthen their ties and their loyalty to the VC (Wasko, Teigland, & Faraj, 2009; Ren et al., 2012). As such, we consider the “strength of emotional ties” to represent the social layer that determines VCs’ sustainability.

## 2.2. Virtual Communities’ Structural Dynamics

One of CET’s assumptions is that the structural features of a communicative ecology shape individual dynamics and so serve as contextual factors rather than directly regulating individuals’ social behavior. In a VC, the structure evolves as individuals join and leave the network and as social relationships are created and served (Panzarasa et al., 2009; Wang et al., 2013). A VC’s structural dynamics can be captured by examining its change in size. First, as membership in a VC increases, so does the resource pool of the community and, consequently, the potential of the VC to attract more members (Butler, 2001; Grewal, Lilien, & Mallapragada, 2006; Koh, Kim, Butler, & Bock, 2007). As Dunbar (1996) argues, however, an individual’s capacity to maintain social ties is limited. Increasing the number of partners with whom one interacts decreases that individual’s quality of interactions among VC members and negatively affects member participation and involvement levels (Hsiao & Chiou, 2012; Ridings et al., 2002; Ridings & Wasko, 2010).

Scholars have also argued that, as the membership in a VC grows, members tend to congregate in cliques or small subgroups of active participants who engage with and respond to only one another (Wasko et al., 2009; Panzarasa et al., 2009). Forming a clique, even in a large VC, enables individual members to strengthen their emotional bond with their communities through subgroup activities. The issue that arises then is how clique size influences active members’ perceptions of the values their

VCS present. Active members may develop stronger social ties with their co-participants in a small clique than in a large clique. Nevertheless, if the attachment to other clique participants is excessively strong, attachment to the VC as a whole may diminish (Ganley & Lampe, 2009).

In sum, the effect of a VC's size is neither simple nor unidirectional, and the evolving roles of IT in managing VC size are unclear. Although previous studies have acknowledged that a VC's structural dynamics should be considered when explaining the individual dynamics in such a community, no empirical study has examined how membership size clique sizes influence individual dynamics in VCs. Therefore, the answers to the research questions formulated in the current study are critical in determining how to help VC organizers manage diffused relationships as a VC grows and how to enhance their ability to retain active members over time.

### 3. Research Model and Hypotheses

Figure 2 illustrates our research model, which predicts an active member's intention to stay. We conceptualize intention to stay as the willingness to participate in and continue using a relevant VC on the basis of information systems (IS) continuance behavior, which occurs after IS use becomes a routine activity (Lin & Lu, 2011; Bhattacharjee, 2001).

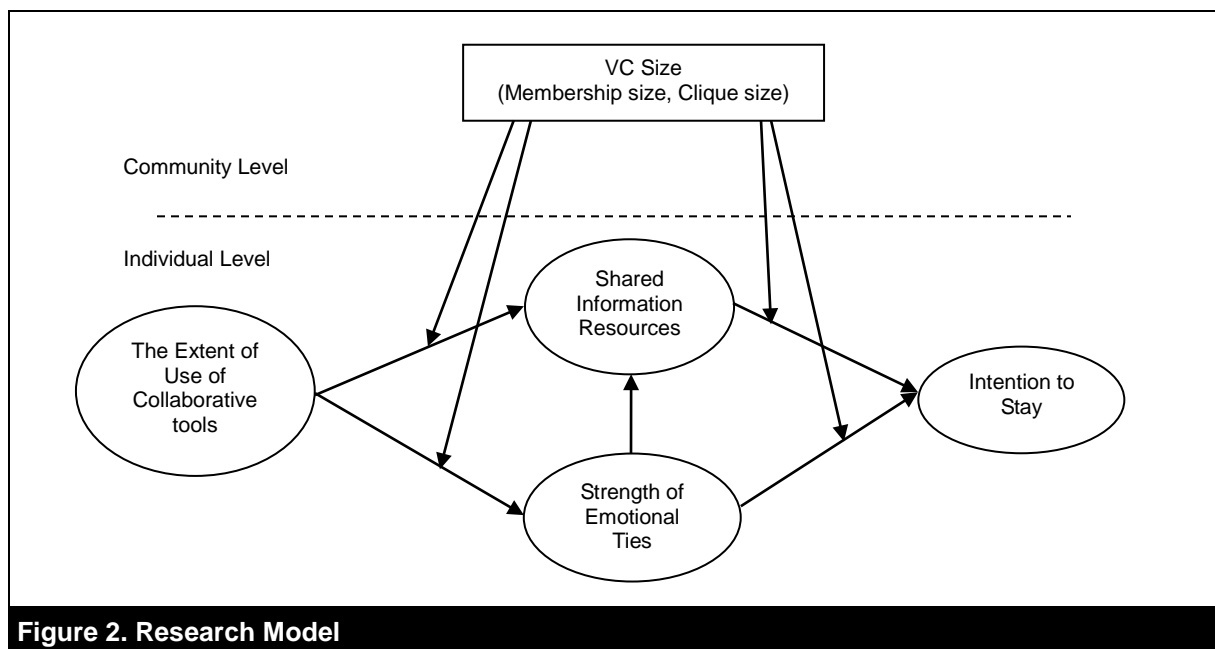


Figure 2. Research Model

#### 3.1. Explaining an Active Member's Intention to Stay

Communication in a VC depends on the existence of an IT infrastructure that enables members to add to, recombine, modify, and integrate the information resources that others have contributed (Faraj et al., 2011). CET holds that the patterns and modes of IT use can modify and shape an individual's activities in a communicative ecology. Diverse collaborative IT features, such as discussion forums, document sharing, real-time chats, group scheduling, and archives for multi-media materials, allow active members to create, organize, transmit, store, and retrieve information more effectively and to ensure the visibility of their contributions to a VC's audience (Ma & Agarwal, 2007; Phang et al., 2009). Also, embedded network applications enable people to gather diverse perspectives from multiple sources and enter into a dialogue to discuss issues of common interest to create information resources (Langlois, Elmer, McKelvey, & Devereaux, 2009). Accordingly, we infer that frequently using collaborative tools enables one to extensively share information resources

**H1:** *The extent to which one uses collaborative tools is positively associated with how extensively they share information resources in a VC.*



The frequency of interaction among members is a major determinant of the extent to which active members build social relationships with one another in a VC (McKenna, Green, Gleason, 2002). Through private messages, chats, or discussions in forum threads, VC members exchange additional socio-emotional information and are afforded opportunities to build social connections, which foster fondness and trust (Ren et al., 2007). Moreover, current technological developments enable VCs to adopt diverse IT features that facilitate collaborative interaction: examples of such features are social gadgets that support private communication, online social games, group polling/scheduling systems, and social network applications, all of which facilitate reciprocal and mutual support for other members' needs (Wellman & Gulia, 1999). These features strengthen the emotional ties among members.

**H2:** *The extent to which one uses collaborative tools is positively associated with the strength of their emotional ties to one another in a VC.*

Strengthening emotional ties with other members of a VC increases individual feelings of attachment to the community and enables members to increase the depth, breadth, and efficiency of the information that they share (Wasko et al., 2004). In VCs where strong emotional ties exist, members are more likely to trust one another, and this trust diminishes the uncertainty of their exchanges and enhances their ability to cooperate in the pursuit of their interests (Gargiulo & Benassi, 2000). In addition, when strong relationships exist, personal reputation and the peer-review process serve as powerful mechanisms that prevent low-quality contributions and free riding (Roberts, Hann, & Slaughter, 2006) and stimulate members' willingness to share their information resources (Chiu et al., 2006). This situation, in turn, increases the benefits that all members perceive from the shared information resources in a VC (Blanchard & Horan, 1998; Blanchard & Markus, 2004).

**H3:** *The strength of one's emotional ties with other members is positively associated with how extensively they share information resources in a VC.*

Active members voluntarily create content, promote communities, manage infrastructure, and facilitate interaction among participants (Butler et al., 2007). Because a VC can acquire resources, exist, and function only through the time and effort exerted by active members, retaining such members is critical to a VC's success and survival (Wang et al., 2013). According to CET, active members are likely to want to stay in a VC that is characterized by multitudinous resources that offer timely, relevant, and reliable information. CET suggests that, under these circumstances, members benefit from staying in the VC and that they will be committed to remaining active to acquire the aforementioned resources. For example, when active members post messages and share valuable information with all the other members of a VC, they are more likely to be motivated to contribute resources that contain relevant information (Wasko et al., 2004). This positive feedback loop between resource availability and an active member's motivation to share helps ensure that valuable information resources remain available, which influences an active member's intention to stay in the VC. Therefore, we posit that active members are more likely to stay in a VC when a high level of shared information resources exists.

**H4:** *The extent to which one extensively shares information resources is positively associated with their intention to stay in a VC.*

The strength of emotional ties refers to the extent to which an individual feels emotionally close to other members of a VC. It encompasses the amount of energy, emotional intensity, intimacy, commitment, and trust that connect individuals (Wasko et al., 2009). Individuals willingly contribute to their community when they feel strongly attached to it and to its members—an attachment that is integral to sustaining a VC (Ren et al., 2007, 2012). Such strong emotional ties inspire attachment to both a community as a whole and to other members in it. In particular, many scholars regard social support and emotional closeness as the most important motivations for active members to continue contributing to their VCs (Chiu et al., 2006). Hence, strong emotional ties with others in a VC are likely to encourage active member to stay in the community (Podolny & Baron, 1997). From this perspective, we posit that an active member's intention to stay in a VC depends on the strength of the emotional ties that the individual perceives in the VC.

**H5:** *The strength of one's emotional ties with other members is positively associated with their intention to stay in a VC.*

### 3.2. The Moderating Effect of the Size of a Virtual Community

CET holds that the contextual factors of an ecology shape individual dynamics in a VC. A VC's network constantly grows and changes (Faraj et al., 2011; Wang et al., 2013) and thereby possibly modify the underlying mechanisms that drive the ongoing contributions of active VC members. As the network of a VC grows, more people rely on the extent of use of collaborative tools to search for, access, and exchange information; to respond to others; and to generate new information. Contributing to a VC is possible only through IT-based interactions in a VC; therefore, as the membership size increases, collaborative tools play a greater role in reducing communication costs and facilitating information sharing by connecting dispersed people electronically (Sproull & Faraj, 1995). When a VC has many participants, many members will likely possess the information that other members seek. Accordingly, active members can realize more benefits from the shared information resources via collaborative tools when interacting with numerous VC members than when interacting with only a small number of people. Therefore, we posit that the larger the membership size of a VC, the more positive the relationship between the extent of use of collaborative tools and shared information resources.

**H6:** *The extent to which one uses collaborative tools is more strongly associated with how extensively they share information resources as the membership size of a VC increases.*

The effects of the extent of use of collaborative tools on strengthening emotional ties can also be altered by a VC's membership size. The strength of the social ties in a collective is constrained by the number of social ties involved (Lin, 2006) because the strength of these ties erodes in accordance with the increase in membership size (Astley, 1985). As the membership size of a VC increases, users are more likely to communicate with an increased number of members and to form additional ties with these members through computer-mediated communication. Although collaborative tools enable individual members to build social relationships with others without face-to-face contact and, consequently, to increase the strength of emotional ties to a certain extent, this positive effect on the strength of emotional ties is likely to be weakened eventually as the number of ties increases. Accordingly, the effect of the extent of use of collaborative tools on the strength of emotional ties is likely to decrease as membership in a VC grows.

**H7:** *The extent to which one uses collaborative tools is less strongly associated with the strength of their emotional ties as the membership size of a VC increases.*

As a network grows in size, members tend to form cliques in which tightly knit individuals interact with others who have similar attributes and views (Watts & Strogatz, 1998; Wasko et al., 2009; Panzarasa et al., 2009). By forming cliques, VC members are embedded in densely connected subgroups on the basis of shared experiences, interests, or location; in the subgroups, they are connected, in turn, to one another by the shortcuts created when individuals in one subgroup also belong to other subgroups (Panzarasa et al., 2009). Therefore, even when the membership size of a VC increases, members remain emotionally attached to the VC as a whole. Nevertheless, an increase in the local redundancy of ties often comes at the expense of global connectivity (Watts & Strogatz, 1998). As a clique begins to grow, the clique participants may begin to engage in behaviors (e.g., such as increasingly focusing on socializing with those in the clique who have similar interests) that reduce the egalitarian spirit that many other VC members value (Ganley & Lampe, 2009). Empirical research shows that some clique members have even set up separate websites to communicate exclusively with their clique participants (e.g., Ridings & Wasko, 2010). In summation, while clique formation may help VC members maintain their emotional ties to a VC, the influence of the strength of emotional ties on their intention to stay in the VC may decrease as the number of clique participants increases.



**H8:** *The strength of one's emotional ties is less strongly associated with their intention to stay in a VC as the size of a clique increases.*

The formation of cliques increases a network's information transmission capacity (Shilling & Phelps, 2007). If a clique has many participants, they commonly participate in specific thread topics. This participation provides a unique opportunity for active members to exchange information that those outside the clique cannot often access (Ganley & Lampe, 2009). Because the participants in a clique tend to be closely connected by similar interests, preferences, or purposes, they are more likely to contribute valuable information and knowledge to others in it. Therefore, active members may perceive the benefits from the shared information resources in a VC as more salient as the size of a clique increases.

**H9:** *The extent to which one extensively shares information resources is more strongly associated with their intention to stay in a VC as the size of a clique increases.*

## 4. Method

### 4.1. Multi-level Approach

Because we examine a multi-level phenomenon that involves both individual-level (i.e., the extent of use of collaborative tools, strength of emotional ties, shared information resources, intention to stay) and community-level factors (i.e., membership and clique sizes), we adopted a multi-level approach that considers both individual- and community-level variables simultaneously. Many scholars consider multi-level models to be appropriate for research designs wherein nested data are used or data on participants are organized at more than one level (Luke, 2004). To adhere to the multi-level approach, we analyzed our data in Hierarchical Linear Modeling (HLM) version 6.02, which is gaining increased acceptance in IS literature (Kang et al., 2012; Mithas, Ramasubbu, Krishnan, & Fornell, 2006).

### 4.2. Scale Development

We adapted most of the measurement scales for the research constructs in this study from earlier studies that have proven them to be reliable and valid. To measure the extent of use of collaborative tools, we adopted the concept of breadth and depth of IT use that Massenti and Zmud (1996) propose. Accordingly, we asked individuals (see Section 4.3) questions regarding how diverse the IT functions they use for collaboration are and how heavily they rely on the IT functions for collaboration. We adapted the items for shared information resources from several measurements (namely, Rindfleisch, Burroughs, & Denton, 1997; Greisdorf & Spink, 2000) and modified them. The items mainly explore individuals' perceptions on the availability and relevance of information resources. To measure the strength of emotional ties, we adapted items from the measure of relationship strength that Barnes (1997) developed. We adapted the items for intention to stay from items that measure behavioral intention in the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980) and modified them. Appendix B provides the research constructs, related literature, and all the questionnaire items. The total number of registered users in a VC represents the membership size of the VCs we analyzed. To assess clique size, one of the authors joined all the VCs studied and observed the clique size in these communities. The average number of members in a clique ranged from 7 to 164 (see Appendix C). For further analysis, we transformed the data by taking the natural log of both the VCs' membership and clique sizes<sup>1</sup>.

<sup>1</sup> For a given period, one of the authors of this study participated as a member in the VCs that we surveyed and identified the subgroups (cliques) that formed in accordance with the members' interests, regions, tastes, subjects of interest, etc. For example, a VC where fish lovers can discuss aquarium-related topics has dozens of subgroups and was formed in accordance with the species of fish in which the members are interested. We also found that a VC where brides and brides-to-be can discuss wedding preparations and beauty tips that had several subgroups that formed in accordance with the members' living areas so that they could participate in offline meetings. The cliques were formed by creating distinct subcategories with specific titles (subgroup names) in a VC or by initiating their own discussion threads. Through this approach, the members created different subgroups in a VC. We used the size of the subgroups that were formed to represent subcategories in the VCs.

### 4.3. Data Collection

To select the sample, we searched the Web and selected suitable VCs<sup>2</sup> on the basis of the following criteria: the VCs had to be based on a special interest, be active (contain posts less than two months old), and provide statistics for the number of registered members. We then sent e-mail messages to the administrator of each VC to seek permission to conduct the survey. On the basis of the received responses, we eliminated some VCs that did not meet the criteria, which left a final sample of 15 VCs (refer to Appendix C for a list).

Next, one of the authors joined all the VCs as a member. That author posted a new topic in all the VCs to seek help from the members in completing the online survey. The author also sent private messages to administrators that asked them to complete a general survey about VCs. We collected a total of 164 responses from the members of the 15 VCs. Table 1 lists the respondents' demographic information. The sample contains respondents that fall under a wide range of age groups and nationalities. Given that this study focuses on how to retain active members in VCs, the response rate should actually be based on active membership because active members are the ones who contribute to the resources in a VC. In most VCs, active members follow a power law distribution (Phang et al., 2009) that indicates that the majority of users are lurkers who never contribute (Nielsen, 2006). Researchers (Nielsen, 2006) have calculated many different percentages for different VCs (e.g., 1%, 0.7%, 0.1%, and 0.003%). Appendix C shows the estimated number of active members based on the estimation of 1% of the total number of registered users. This was the most conservative estimation of the number of active members. Considering that only a small fraction of users extensively participate and account for most contributions, our response rate adequately ensures the validity of the research.

---

<sup>2</sup> In the interest of defining the boundary conditions of this work, we note that we focus on social VCs that are characterized by social interaction among VC members. A range of VCs that are classified by level of social communication exists. Some VCs are highly social oriented, whereas others are content oriented. Interestingly, research has shown that social interactions also exist in content-oriented VCs, such as Wikipedia. As Viegas, Wattenberg, Kriss, and van Ham (2007) indicate, the active members of Wikipedia interact in order to plan, coordinate, and resolve the problems they encounter in the website's talk pages. Editors discuss paragraphs that need reworking and sections that should be added or trimmed. Ren et al. (2012) also point out that Wikipedia has a site where active members can interact with one another, which enables members to build strong attachments to Wikipedia. To a smaller extent, therefore, our findings are also applicable to content-oriented VCs. However, VCs that do not offer any interaction among members are beyond the scope of this research.

**Table 1. Demographic Information of Respondents**

Measures	Values	Freq	Percent	Measures	Values	Freq	Percent	
Gender	Male	125	76.2	Contribution Frequency	> Once a day	105	64.0	
	Female	39	23.8		Once a day	33	20.1	
<b>Total</b>		<b>164</b>	<b>100.0</b>		5-6 times a week	12	7.3	
Age group	13 or below	2	1.2		3-4 times a week	8	4.9	
	14-19	39	22.6		1-2 times a week	1	0.6	
	20-29	91	55.5		2-3 times a month	3	1.8	
	30-44	28	17.1		Once a month	1	0.6	
	45 or above	6	3.7		< Once a month	1	0.6	
<b>Total</b>		<b>164</b>	<b>100.0</b>		<b>Total</b>		<b>164</b>	<b>100.0</b>
Education level	Primary	2	1.2		Australia	1	0.6	
	Secondary	21	12.8	Belgium	1	0.6		
	College	34	20.7	Canada	2	1.2		
	Tertiary	94	57.3	China	1	0.6		
	Others	13	7.9	England (U.K.)	12	7.3		
<b>Total</b>		<b>164</b>	<b>100.0</b>	Great Britain (U.K.)	3	1.8		
Years of membership	< 2mth	3	1.8	Indonesia	4	2.4		
	2-6mth	24	14.6	Ireland	1	0.6		
	6-12mth	33	20.1	Malaysia	4	2.4		
	1-2yrs	45	27.4	Netherlands	1	0.6		
	> 2yrs	59	36.0	New Zealand	1	0.6		
<b>Total</b>		<b>164</b>	<b>100.0</b>	Others	1	0.6		
Most frequently used communication medium	Email	2	1.2	Scotland (U.K.)	1	0.6		
	Polling	3	1.8	Singapore	115	70.1		
	Post message	137	83.5	Sri Lanka	1	0.6		
	Private message	22	13.4	Thailand	1	0.6		
				United Kingdom	8	4.9		
				United States	5	3.0		
<b>Total</b>		<b>164</b>	<b>100.0</b>	Venezuela	1	0.6		
<b>Total</b>		<b>164</b>	<b>100.0</b>	<b>Total</b>		<b>164</b>	<b>100.0</b>	

## 5. Results

The reliabilities of our constructs all registered a value higher than 0.7 and so were satisfactory. To verify construct validity, we conducted exploratory factor analysis using principal axis factoring with direct oblimin rotation. All items were loaded on each distinct factor, and the factor loadings for all the items were greater than 0.7. Table 2 shows the results of the reliability and factor analyses. Subsequently, we tested common method bias (CMB) to reinforce remedial approaches and prevent detrimental effects from self-report measurement. We adopted the procedure that Pavlou, Liang, and Xue (2007) suggest<sup>3</sup>. On the basis of the test results, we conclude that little risk of CMB exists.

<sup>3</sup> First, we performed principal components factor analysis to examine the existence of a factor that explains the majority of common variance. If a substantial amount of common method variance is present, either (a) a single factor will emerge from the factor analysis or (b) one general factor will account for the majority of the covariance in the independent and criterion variables (Podsakoff & Organ, 1986, p. 536). The results from this test reveal that the amount of variance explained by the identified four factors was evenly distributed with average 20.1 percent. Second, we conducted a partial correlation analysis in which we added the highest factor identified as a control variable to examine its effect on the dependent variable. The analysis results show a very weak contribution of the control variable to the intention to stay.

**Table 2. The Results of Reliability and Factor Analysis**

	Code	Cronbach's $\alpha$	Factor 1	Factor 2	Factor 3	Factor 4
Strength of emotional ties	SET3	0.920	<b>.878</b>	.183	.148	.074
	SET4		<b>.857</b>	.142	.186	.132
	SET5		<b>.792</b>	.222	.279	.154
	SET2		<b>.788</b>	.212	.240	.195
	SET1		<b>.712</b>	.292	.144	.307
Shared information resources	SIR5	0.890	.257	<b>.791</b>	.183	.226
	SIR4		.321	<b>.779</b>	.211	.145
	SIR1		.125	<b>.768</b>	.111	.309
	SIR2		.189	<b>.761</b>	.027	.337
	SIR3		.158	<b>.711</b>	.311	.067
The extent of use of collaborative tools	UCT5	0.917	.217	.238	<b>.846</b>	.110
	UCT4		.207	.247	<b>.842</b>	.121
	UCT1		.227	.074	<b>.838</b>	.188
	UCT2		.183	.137	<b>.815</b>	.240
Intention to stay	ITS3	0.902	.188	.317	.212	<b>.838</b>
	ITS1		.215	.307	.245	<b>.836</b>
	ITS2		.220	.230	.183	<b>.800</b>
Eigen value			3.812	3.527	3.330	2.625
Percentage of variance			22.426	20.749	19.588	15.440
Cumulative variance			22.436	43.174	62.762	78.202

Extraction method: principal component analysis.  
Rotation method: direct oblimin. A rotation converged in 6 iterations.

## 5.1. Multi-level Modeling

Our research questions are of a multi-level type. First, we examined how the extent of use of collaborative tools, shared information resources, and the strength of emotional ties influenced an active member's intention to stay at the individual level. Second, we investigated how these individual-level relationships varied depending on membership and clique sizes. The succeeding multi-level modeling equations represent the final model that predicts intention to stay (model 6).

### 5.1.1. Level 1: Individual-level Equation

Given that the extent to which a member intends to stay in a VC is the dependent variable of interest in this research, we denote it at the individual level as  $Y_{ij}$ .  $\beta_{0j}$  represents the mean level of the dependent variable (i.e., intention to stay) at the individual level, and  $r_{ij}$  represents the residual within-group variance (Hox, 2002).

$$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{The extent of Use of collaborative tools}) + \beta_{2j}(\text{Strength of emotional ties}) + \beta_{3j}(\text{Shared information resources}) + \beta_{4j}(\text{Gender}) + \beta_{5j}(\text{Age}) + \beta_{6j}(\text{Education}) + \beta_{7j}(\text{Year-membership}) + r_{ij}$$

Note: gender, age, education, and year-membership are control variables at the individual level

### 5.1.2. Level 2: Cross-level Equations

Through cross-level modeling, we can examine how community-level variables moderate the relationship between individual-level predictors and a dependent variable. In the level-2 modeling,  $\gamma_{01}$  is the coefficient that captures the effect of a group variable on the within-group levels represented by  $\beta_{0j}$ ,  $\gamma_{ij}$  is the slope that relates a group variable to the slope terms from the level-1 equation, and  $u_{0j}$  and  $u_{1j}$  are the residuals at the group level (Hox, 2002; Kang et al., 2012). A significant variance in the slope terms indicates that the relationship among individual variables vary depending on the group-

level variable (Luke, 2004). This formulation below is the cross-level equation used to examine both the direct effect and moderating effects of membership size on an individual's intention to stay in a community. Because the membership and the clique sizes are characterized by different properties, we conducted HLM analysis twice. The first analysis treats membership size as a group variable and the second one regards clique size as a group variable.

$$\begin{aligned}\beta_{0j} &= \gamma_{00} + \gamma_{01}(\text{Membership Size or Clique Size}) + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11}(\text{Membership Size or Clique Size}) + u_{1j} \\ \beta_{2j} &= \gamma_{20} + \gamma_{21}(\text{Membership Size or Clique Size}) + u_{2j} \\ \beta_{3j} &= \gamma_{30} + \gamma_{31}(\text{Membership Size or Clique Size}) + u_{3j} \\ \beta_{4j} &= \gamma_{40} \\ \beta_{5j} &= \gamma_{50} \\ \beta_{6j} &= \gamma_{60} \\ \beta_{7j} &= \gamma_{70}\end{aligned}$$

Given the nature of our research model, we needed to check the mediating effects of the strength of emotional ties and shared information resources. As per Baron and Kenny (1986), therefore, we estimated the three regression equations for the mediation test (models 1–6)<sup>4</sup>. The results of the analyses for verifying mediation indicate that shared information resources and the strength of emotional ties partially mediated the relationship between use of collaborative tools and intention to stay.

Table 3 displays the results of the HLM analysis in which we used membership size as a community-level variable, and Table 4 lists the results of the analysis wherein we used clique size as a community-level variable. After controlling for gender, age, education, and year-membership at the individual-level, we found that these control variables did not exert a significant influence on the other research variables.

Hypothesis 1 addresses the relationship between the extent of use of collaborative tools and shared information resources. As model 1 in Tables 3 and 4 indicates, the extent of use of collaborative tools was positively related to shared information resources as we expected ( $\gamma_{10} = .24$ , S.E. = .04,  $p < .01$  in Table 3;  $\gamma_{10} = .28$ , S.E. = .04,  $p < .01$  in Table 4). Hypothesis 2 centers on the relationship between the extent of use of collaborative tools and the strength of emotional ties. Model 2 in Tables 3 and 4 indicate that the extent of use of collaborative tools positively influenced the strength of emotional ties ( $\gamma_{10} = .33$ , S.E. = .05,  $p < .01$  in Table 3;  $\gamma_{10} = .34$ , S.E. = .05,  $p < .01$  in Table 4). Thus, Hypotheses 1 and 2 were supported. Hypothesis 3 addresses the positive relationship between the strength of emotional ties and shared information resources. As we expected, the model 3 in Tables 3 and 4 show that the strength of emotional ties positively influenced shared information resources ( $\gamma_{20} = .31$ , S.E. = .07,  $p < .01$  in Table 3;  $\gamma_{20} = .31$ , S.E. = .07,  $p < .01$  in Table 4). Thus, Hypothesis 3 was supported. The results of the HLM analysis indicate that both shared information resources and strength of emotional ties significantly influenced the intention to stay, which supports Hypotheses 4 and 5 (see models 6 in Tables 3 and 4).

<sup>4</sup> First, we tested whether the independent variable (UCT) was correlated with the mediators (SIR and SET). Second, we verified whether the independent variable was correlated with the dependent variable. Finally, we determined whether the mediators affected the dependent variable (ITS) given that the independent variable is controlled because we established the effect of the mediators on the dependent variable. Full mediation occurs when the independent variable no longer exerts a significant effect when the mediators are included; partial mediation occurs when the independent variable continues to exert a significant but diminished effect. The results are as follows:

- 1) UCT significantly influenced SIR and SET (see models 1 and 2).
- 2) UCT significantly influenced ITS (see model 4).
- 3) The two mediators, SET and SIR significantly influenced ITS (see model 5), and UCT still had a significant but diminished effect on ITS (See model 6).



**Table 3. Results of HLM Analysis—The Membership Size as the Community Variable**

Level	Fixed effect		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
			Shared information resources	Strength of emotional ties	Shared information resources	Intention to stay	Intention to stay	Intention to stay
			Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)
Individual level	Intercept	Y <sub>00</sub>	<b>5.44***</b> (0.14)	<b>4.98***</b> (0.12)	<b>5.46***</b> (0.12)	<b>6.15***</b> (0.12)	<b>6.20***</b> (0.07)	<b>6.20***</b> (0.06)
	UCT	Y <sub>10</sub>	<b>0.24***</b> (0.04)	<b>0.33***</b> (0.05)	<b>0.14***</b> (0.05)	<b>0.30***</b> (0.05)		<b>0.15***</b> (0.05)
	SET	Y <sub>20</sub>			<b>0.31***</b> (0.07)		<b>0.21***</b> (0.07)	<b>0.14*</b> (0.08)
	SIR	Y <sub>30</sub>					<b>0.54***</b> (0.08)	<b>0.48***</b> (0.08)
	Gender	Y <sub>40</sub>	-0.05 (0.14)	0.10 (0.16)	-0.08 (0.13)	0.15 (0.16)	0.16 (0.15)	0.16 (0.14)
	Age	Y <sub>50</sub>	-0.02 (0.08)	0.08 (0.09)	-0.05 (0.07)	0.05 (0.09)	0.03 (0.08)	0.04 (0.08)
	Education	Y <sub>60</sub>	-0.03 (0.07)	0.13 (0.08)	-0.08 (0.07)	-0.03 (0.09)	-0.04 (0.08)	-0.03 (0.08)
	Year-Membership	Y <sub>70</sub>	-0.06 (0.05)	-0.01 (0.06)	-0.06 (0.05)	-0.04 (0.06)	-0.01 (0.06)	-0.03 (0.08)
Community level	MSize	Y <sub>01</sub>	0.05 (0.08)	0.08 (0.06)	0.03 (0.06)	0.08 (0.06)	0.05 (0.03)	0.05 (0.03)
Cross level	UCT x MSize	Y <sub>11</sub>	<b>0.05**</b> (0.02)	0.01 (0.02)	<b>0.05**</b> (0.02)	0.01 (0.02)		0.06 (0.18)
	SET x MSize	Y <sub>21</sub>			0.10 (0.05)		0.04 (0.04)	0.05 (0.04)
	SIRx MSize	Y <sub>31</sub>					-0.03 (0.04)	-0.05 (0.04)

Msize: membership size, \*p<0.1; \*\* P<0.05; \*\*\* P<0.01.

**Table 4. Results of HLM Analysis—The Clique Size as the Community Variable**

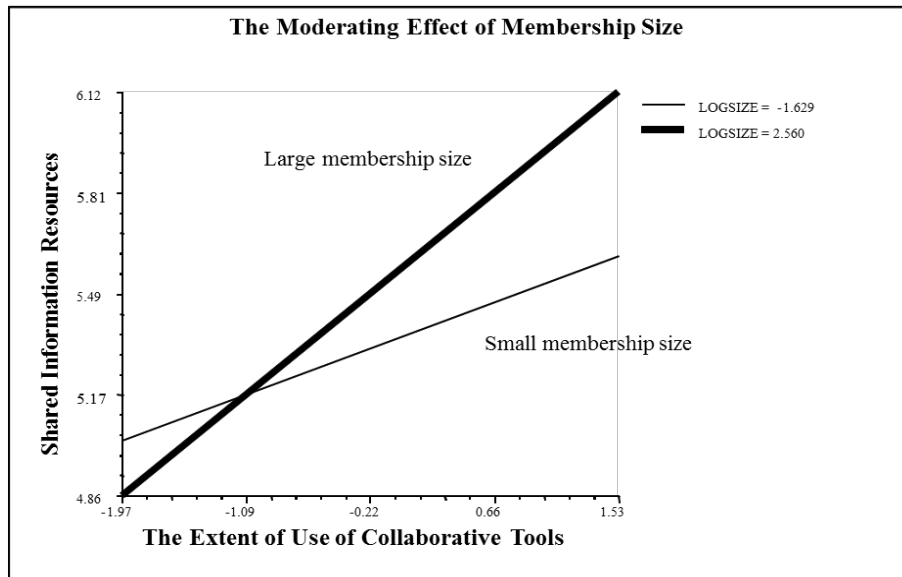
Level	Fixed effect		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
			Shared information resources	Strength of emotional ties	Shared information resources	Intention to stay	Intention to stay	Intention to stay
			Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)
Individual level	Intercept	$\gamma_{00}$	<b>5.47***</b> (0.11)	<b>5.00***</b> (0.12)	<b>5.48***</b> (0.09)	<b>6.17***</b> (0.11)	<b>6.24***</b> (0.06)	<b>6.24***</b> (0.06)
	UCT	$\gamma_{10}$	<b>0.28***</b> (0.04)	<b>0.34***</b> (0.05)	<b>0.17***</b> (0.05)	<b>0.31***</b> (0.05)		<b>0.13***</b> (0.05)
	SET	$\gamma_{20}$			<b>0.31***</b> (0.07)		<b>0.24***</b> (0.07)	<b>0.17**</b> (0.08)
	SIR	$\gamma_{30}$					<b>0.51***</b> (0.08)	<b>0.45***</b> (0.09)
	Gender	$\gamma_{40}$	-0.09 (0.14)	0.11 (0.16)	-0.13 (0.13)	0.14 (0.16)	0.15 (0.08)	0.15 (0.14)
	Age	$\gamma_{50}$	-0.00 (0.08)	0.10 (0.09)	-0.03 (0.08)	0.06 (0.09)	0.02 (0.08)	0.04 (0.08)
	Education	$\gamma_{60}$	-0.04 (0.08)	0.12 (0.08)	-0.09 (0.07)	-0.03 (0.09)	-0.04 (0.08)	-0.04 (0.08)
	Year-Membership	$\gamma_{70}$	-0.04 (0.05)	0.00 (0.06)	-0.04 (0.05)	-0.02 (0.06)	-0.01 (0.08)	-0.01 (0.06)
Community level	CSize	$\gamma_{01}$	-0.23 (0.15)	-0.05 (0.15)	-0.22 (0.12)	-0.17 (0.15)	-0.02 (0.08)	-0.05 (0.09)
Cross level	UCT x CSize	$\gamma_{11}$	0.07 (0.05)	0.05 (0.05)	0.04 (0.05)	0.01 (0.06)		0.05 (0.05)
	SET x CSize	$\gamma_{21}$			0.03 (0.09)		<b>-0.19*</b> (0.10)	<b>-0.15*</b> (0.08)
	SIRx CSize	$\gamma_{31}$					<b>0.22**</b> (0.11)	<b>0.19*</b> (0.10)

CSize: clique size, \*P<0.1 \*\* P<0.05; \*\* P<0.01.

Hypotheses 6 and 7 address the moderating effects of membership size with the extent of use of collaborative tools on shared information resources and the strength of emotional ties. The coefficient of  $\gamma_{11}$ , indicates that membership size positively moderated the effect of the extent of use of collaborative tools on shared information resources ( $\gamma_{11} = .05$ , S.E. = .02,  $p < .05$ ) (see model 1 in Table 3). The interaction effect of membership size with the extent of use of collaborative tools remained significant even after we incorporated the strength of emotional ties to the model to predict shared information resources ( $\gamma_{11} = .05$ , S.E. = .02,  $p < .05$ ) (see model 3 in Table 3). By contrast, membership size did not moderate the effect of the extent of use of collaborative tools on the strength of emotional ties (see model 2 in Table 3). Thus, Hypothesis 6 was supported, but Hypothesis 7 was not. HLM provides the graphic function that substantiates moderating effects by categorizing high-level and low-level membership sizes<sup>5</sup>. We plotted the significant cross-level interactions to illustrate their nature. Figure 3 shows that the slope of the line representing the relationship between the extent of use of collaborative tools and shared information resources had a steeper incline in the VCs that have a large membership size than in those with a small membership size<sup>6</sup>.

<sup>5</sup> We transformed the number of membership size in Figure 3 by taking log and mean centering (see footnote 6 below). Converting the number back to the original values, we estimated the original value for LOGSIZE = -1.629 to be about 32 and LOGSIZE = 2.560 to be about 2,200. The same conversions can be done for Figure 4 and 5 (LOGCLIQU = -1.124 to be about 3 and LOGCLIQU = 1.078 to be about 75). The values of high and low membership size in the figures were estimated only with the sample used in this study, and they do not represent actual membership size because the estimation should be variant on the sample mean.

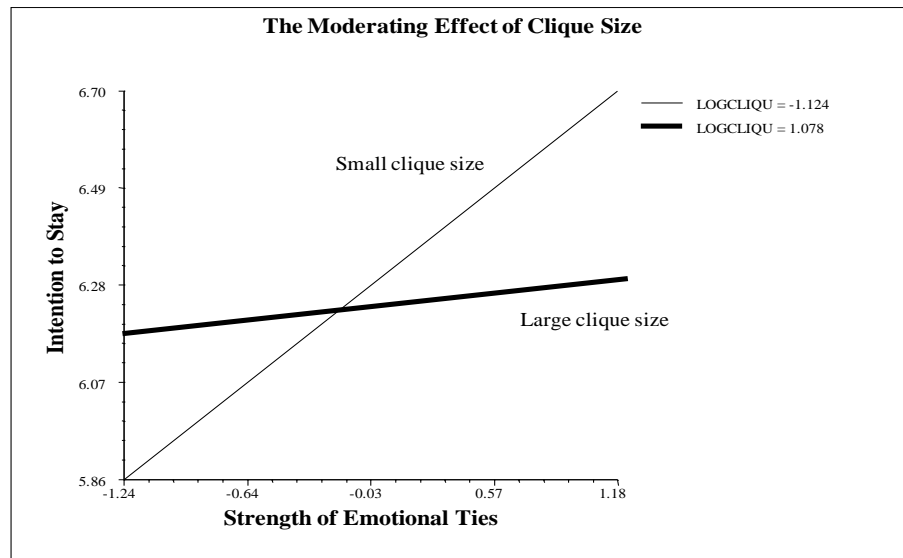
<sup>6</sup> In HLM analysis, the intercept is interpreted as the expected value of the outcome variable, at which all explanatory variables have the value zero. In many cases, however, "zero" may not be a possible value, and, as a consequence, the value of the intercept is meaningless. To resolve this problem, HLM performs a transformation of the X-variables that convert zero into a legitimate, observable value. The usual practice is to subtract the grand mean from all the values of explanatory variable—an approach called "centering on the grand mean" or "grand mean centering" (Hox, 2002, p. 56). Given that we subtracted the grand mean from all the values of membership size for which natural logs were taken, the transformed value of membership



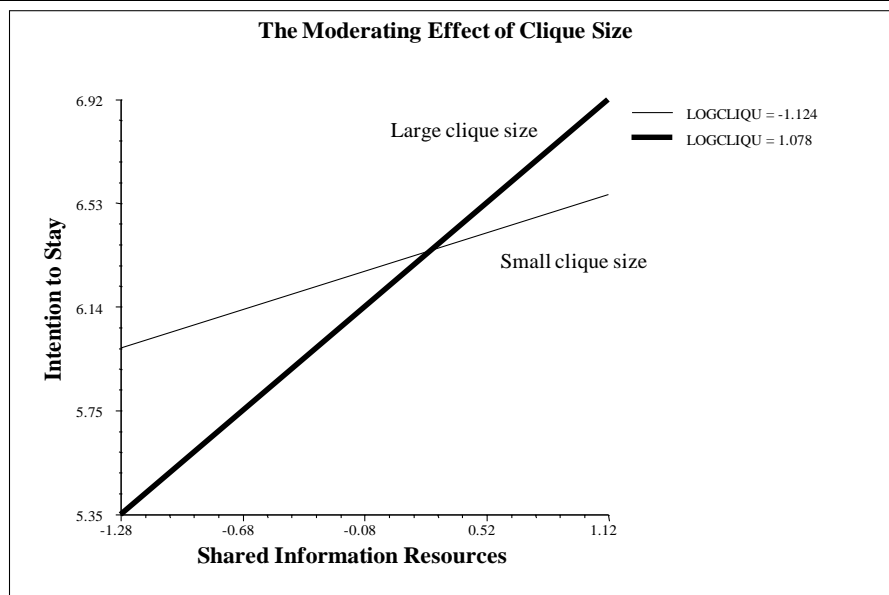
**Figure 3. The Moderating Effect of Membership Size on the Relationship between the Extent of Use of Collaborative Tools and Information Resources**

Hypotheses 8 and 9 address the moderating effects of clique size on the members' intention to stay in the VCs. The analysis results show that clique size moderated the effect of the strength of emotional ties on the intention to stay ( $\gamma_{21} = -.19$ , S.E. = .10,  $p < .1$ ) (see model 5 in Table 4) and that clique size moderated the effect of shared information resources on the intention to stay ( $\gamma_{31} = .22$ , S.E. = .11,  $p < .05$ ) (see model 5 in Table 4). These moderation effects remain significant when we added the extent of use of collaborative tools as a predictor of the intention to stay in model 6 of Table 4 ( $\gamma_{21} = -.15$ , S.E. = .08,  $p < .1$  and  $\gamma_{31} = .19$ , S.E. = .10,  $p < .1$ ). Thus, Hypotheses 8 and 9 were supported. Figure 4 indicates that the slope of the line representing the relationship between the strength of emotional ties and the intention to stay had a steeper incline in the VCs that have few clique participants than in the communities with more clique participants. Figure 5 shows that the slope of the line representing the relationship between shared information resources and the intention to stay had a steeper incline in the VCs with many clique participants than in those with fewer clique participants.

size would be negative when the size is smaller than the grand mean. Conversely, if membership size is greater than the grand mean, then its transformed value would be positive. The negative value in Figure 3 represents the value of small-sized membership groups. Because the value of membership size has been transformed by grand mean centering, the small-sized groups will have a negative value in the graph.



**Figure 4. The Moderating Effect of Clique Size on the Relationship between Strength of Emotional Ties and Intention to Stay**



**Figure 5. The Moderating Effect of Clique Size on the Relationship between Shared Information Resources and Intention to Stay**

## 6. Discussion and Implications

In this paper, we examine how VCs can retain their active members to grow sustainability. The results suggest that one should consider both VCs' individual and structural dynamics. At the individual level, our work shows how the three layers of a communicative ecology (technological, social, and discursive layers) interplay to help retain active members. We found that an active member's intention to stay was mainly determined by shared information resources and the strength of their emotional ties. Our findings demonstrate that, although the same pool of shared information resources may be available in different VCs, the strength of emotional ties can spell the difference between active members staying in or leaving a community. That is, social- and resource-related benefits co-exist and reinforce one another;

thus, disregarding one aspect of these benefits may negatively affect a VC's sustainability. In addition, the extent of use of collaborative tools is an antecedent to the two main beneficial aspects of a VC; such relationship highlights the essential role of collaborative IT functions.

At the community level, our work shows how structural changes influence individual dynamics in a VC. Our findings show that membership size significantly moderates the relationship between the extent of use of collaborative tools and shared information resources in a VC. We found that, as a VC's membership size increases, the extent of use of collaborative tools played a greater role in retaining active members by inducing more extensive sharing of information resources. The results indicate that the positive effects of membership size (e.g., a larger resource pool and more potential contributors) can outweigh its negative effects (e.g., information overload and free riding) as long as VC members actively use collaborative tools. That is, VCs can effectively harness the positive effects of membership size by facilitating the use of diverse collaborative tools that support active members who are willing to exchange and share their information resources.

We expected the positive influence of the extent of use of collaborative tools on the strength of emotional ties to diminish as membership size increases in a VC because a rise in network participants usually increases the number of ties one has to manage (Scott, 2000). Contrary to our expectations, we found that membership size did not reduce the positive effect of the extent of use of collaborative tools on the strength of emotional ties. This contradiction may be attributed to the fact that active members can form cliques to find ways of addressing their social needs as the membership size of their VC increases (Ren et al., 2007). In a clique in which participants are strongly connected, active members maintain the strength of emotional ties to the VC as a whole despite an increase in membership size (Ridings & Wasko, 2010). Our work empirically supports previous studies that consider clique formation as an individual emergent strategy for addressing the negative effects of membership size (Ganley & Lampe, 2009; Wasko et al., 2009; Panzarasa et al., 2009; Ridings & Wasko, 2010). The next issue that arises is what happens when cliques grow.

To address this question, we examined the moderating effect of clique size and found that, as clique size increased, the effect of shared information on intention to stay also increased, whereas the effect of the strength of emotional ties on the intention to stay decreased. Given that a clique is formed on the basis of VC members' own interests, preferences, or purposes, the existence of more clique participants engenders increased discussions and responses, which may stimulate active members' motivation to keep contributing to their VCs. Nevertheless, we also found that the effect of the strength of emotional ties on the intention to stay decreased as clique size increased. As we hypothesized, the results indicate that the social bonds with a VC are less likely to influence an active member's intentions to stay when a clique grows. This phenomenon stems from the tendency of active clique members to focus more strongly on internal socializing and the solidarity of clique participants as the clique grows. Accordingly, we argue that an increase in the number of ties in a clique may weaken the relationship between the strength of emotional ties to a VC as a whole and active members' intention to keep contributing to the VC.

This finding adds to the literature on VCs' sustainability by explaining how clique size influences an active member's intention to stay. Researchers have pointed out that, as an online group grows without cliques, active members tend to be overwhelmed by both the amount of information and the number of members and, thus, are more likely to end active participation (Jones et al., 2004; Wang et al., 2013). Wang et al.'s (2013) longitudinal analysis highlights the negative effects of membership size on the growth of online groups. Under this situation, Jones and Rafaeli (2000) assert that a "mega virtual public' cannot be sustained" (p. 221). This constraint is the reason why researchers suggest creating cliques when a VC grows excessively large (Jones & Rafaeli, 2000). However, little empirical research has been conducted to examine the effects of clique size. The current paper expands the literature that considers the sustainability of VCs by explaining how clique size influences an active member's intention to stay. Our findings suggest that members who have strong ties with their fellow clique participants retain their social attachment to a VC as a whole. This attachment implies that members do not necessarily leave a VC as it grows so long as they have strong relationships with the other members of their clique and benefit from the information resources shared



with other members in the VC. Therefore, we propose facilitating the formation of cliques as an effective coping strategy for addressing the possible negative effects of membership size on a weak emotional attachment to a VC. The effect of clique formation is consistent with the notion of a “small-world network” in a large VC (Panzarasa et al., 2009); in other words, the mechanisms that underlie strong ties are activated at the local level in a large VC because tightly knit networks are likely to produce strong social bonds and foster trust among members.

### 6.1. Limitations and Future Research

Despite this study's intriguing findings, readers should interpret the results with caution because of several limitations. First, although we believe that our efforts contribute to capturing the structural dynamics of a VC via the use of average clique size, VCs can vary significantly in clique size and level of social interaction. Future researchers may wish to use network analysis methods, such as SOCK (a sociometric analysis system), which provides more accurate information regarding clique size (Alba, 1972). A second limitation is that this study does not distinguish between two types of information resource: public, which even lurkers see, and private, which is restricted to interactions with selected individuals. Furthermore, this study does not differentiate between IT tools for creating public (posting) and private information. Future research would benefit from distinguishing between various types of resources and IT tools for more precise results. A third limitation is the possible positive bias in our data because we could administer a survey only to active members who may have had a relatively more positive experience than did those who had left the VCs. Future research could extend the study's generalizability by including data on people who ended their contributions or who left their VCs because of negative experiences. Fourth, although we addressed the moderation effect of clique size, this study takes a cross-sectional approach. Therefore, it does not fully capture the dynamic effects of VC and clique sizes. The changing structure of a VC is explained by either the mechanism of homophily (similarity of traits) or preferential attachment (Barabási, 2002); similar members coordinate their actions to achieve benefits collectively. In this sense, the process of clique formation relates to the herd behavior of individuals. Future research would benefit from examining herd behavior in the context of clique formation. A final limitation of our study is that some of the relationships may be recursive. For example, because the patterns of exchange that generate information resources in VCs serve to increase emotional ties, shared information resources can also affect emotional ties.

### 6.2. Implications for Research

This study provides several important key contributions to the IS literature on VCs. First, the study extends CET by developing an understanding of how individual and structural dynamics interact to retain active members in VCs. This extension can also be applied to a variety of computer-mediated environments, such as advertising, education, business, and communications, to enable researchers or practitioners to design a more sustainable communicative ecology.

Second, by explaining the moderating effects of membership size, our framework enables researchers to more effectively explain how some large VCs retain their active members and continue to grow but others lose their active members. This is a significant contribution to VC literature because the majority of previous work focuses only on the perspective of a single-level phenomenon (either the individual or the structural factors). Such a limitation prevents a more comprehensive understanding of VCs' sustainability. We describe the opposing effect of membership size on a VC's sustainability and why a large VC tends to struggle in maintaining active membership. Previous studies argue that, as a VC grows larger, it is better positioned to provide more information because of economies of scale; at the same time, however, it incurs greater costs in terms of moderating the community and maintaining the quality of postings and the depth of interactions (Gu et al., 2007). Therefore, membership size may exert negative effects on a VC's sustainability (Butler, 2001; Ridings & Wasko, 2010). Our work provides a possible explanation for this dilemma.

Third, this study develops an understanding of how clique size indirectly influences VCs' sustainability. That clique size significantly explains a VC's sustainability is one of the study's most important implications. Understanding the effects of clique size presents essential implications for researchers

who may be interested in better understanding why some large VCs survive and thrive as they grow and others do not. Although some previous studies argue about the role of clique formation in VCs (e.g., Ren et al., 2007; Ganley & Lampe, 2009), the arguments are at the conceptual level. Few studies have empirically observed how the influence of clique size contributes to explaining VCs' sustainability. A noteworthy finding is that clique size significantly moderated the relationship between the strength of emotional ties and the intention to stay in VCs. Our findings suggest that one can manage community expansion while maintaining the attractiveness of a community to its members by stimulating members to use an increasing number of diverse collaborative tools and by managing clique size. Clique size should be carefully monitored because a large clique may weaken the relationship between the strength of emotional ties and the intention to stay, although social attachments among clique participants can be connected to strong emotional ties to the VC as a whole. Future research should also seek to determine whether a tipping point at which a community divides into cliques exists. A further issue to be addressed, then, is what happens during different growth stages over time; namely, before and after the tipping point. Examining this and other aforementioned issues may prove valuable and fruitful for VC research.

We note that the findings reported here are not meant to imply that large cliques diminish the viability of a VC or that cliques should always remain small. We emphasize that a large clique may weaken the positive effect of the strength of emotional ties on the intention to stay. Recent research has argued for design features to support the formation of subgroups (e.g., Ren et al., 2012; Hsiao & Chiou, 2013). These efforts can nonetheless be costly if clique sizes are not managed and emotional bonds do not translate into increased retention of active members. Under this backdrop, we suggest that VC managers carefully monitor cliques to ensure that social attachment among clique participants is connected to strong emotional ties to the VC as a whole.

### 6.3. Implications for Practice

Our study's results provide practitioners with rich insights into how they can improve active members' intention to stay in VCs. First, our study advises the managers or designers of VCs to devise plans that leverage IT further to increase collaborative interactions and, thus, enable members to more effectively share information and build strong emotional ties with one another. One possible way of accomplishing this goal is by providing add-ons to the current IT platform to enable VC members to choose appropriate collaborative tools. Incorporating IT features that can foster collaborative interactions, such as digital maps, network applications, and game elements, will be helpful in diverting the effect of membership size in a positive manner. Our findings suggest that the positive effects of the extent of use of collaborative tools increase with a larger membership size. Accordingly, adopting an increasing number of diverse collaborative technologies will help VCs mitigate the negative effects caused by an increase in membership size.

Second, our study advises practitioners to promote members who have similar interests, needs, topics, or activities to form small cliques. Previous studies have suggested that allowing members to form and name subgroups fosters bond formation (Hsiao & Chiou, 2012; Ren et al., 2012). Flickr, Wikipedia, and Second Life have adhered to this approach (Ren et al., 2007).

Third, emotional ties can be encouraged by ensuring that member actions are visible to other members; such visibility can be achieved by limiting the size of a clique, although proposing a threshold figure is not the focus of this study. If the strong social ties to clique members do not extend to strong emotional ties to the VC as a whole, VC managers should consider strategically reducing clique sizes. Over time, as some cliques are found to be too large to foster social attachments among their members and too difficult to manage, VC managers can consider helping the cliques to split into smaller subgroups in order to reduce clique size.

## 7. Conclusion

Despite the enthusiastic adoption of VCs by practitioners in the fields of marketing, education, and medical services, little theoretical progress has been made in understanding how VCs should be managed for sustainability. Recent empirical work has been concerned primarily with either an

individual's motivation to participate in community activities or the static features of VCs, whereas the evolution of the structural patterns of a VC and the underpinning mechanics of retaining active members have been mostly overlooked. By employing a multi-level approach, we successfully integrated the individual and structural dynamics of a VC to predict an active member's intention to stay. Our work shows the theoretical and practical importance of examining not only changes in a VC's membership size, but also changes in clique size. By recognizing the impact of the push-and-pull effects of membership size and by understanding how clique formation plays a role in mitigating the possible negative effect of membership size, businesses and individuals can better achieve their goals of making their VCs sustainable.

## **Acknowledgements**

This paper was supported by Samsung Research Fund, Sungkyunkwan University, 2011, granted to the first author. It was also partly supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2013S1A3A2054667) awarded to the third author.

## References

- Ajzen, L., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs: Prentice Hall.
- Alba, R. A. (1972). Graph-theoretic definition of sociometric clique. *Journal of Mathematical Sociology*, 3, 113-126.
- Astley, W. G. (1985). The two ecologies: Population and community perspectives on organizational evolution. *Administrative Science Quarterly*, 30(2), 224-241.
- Asvanund, A. Clay, K., Krishnan, R., & Smith, M. (2004). An empirical analysis of network externalities in peer-to-peer music sharing networks. *Information Systems Research*, 15(2), 155-174.
- Barabási, A. (2002). *Linked: The new science of networks*. Cambridge, MA: Perseus Publishing.
- Barnes, J. G. (1997). Closeness, strength, and satisfaction: Examining the nature of relationships between providers of financial services and their retail customers. *Psychology & Marketing*, 14(18), 765-790.
- Baron, R. B., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173-1182.
- Bhattacharjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly*, 25(3), 351-370
- Blanchard, A. L., & Horan, T. (1998). Virtual communities and social capital. *Social Science Computer Review*, 16(3), 293-307.
- Blanchard, A., & Markus, M. L. (2004). The experienced "sense" of a virtual community: Characteristics and processes. *The DATA BASE for Advanced in Information Systems*, 35(1), 65-79.
- Boyd, D., & Ellison, N. (2007). Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication*, 13(1), 210-230.
- Butler, B. S. (2001). Membership size, communication activity, and sustainability: A Resource-based model of online social structures. *Information Systems Research*, 12(4), 346-362.
- Buriol, L., Castillo, C., Donato, D., Leonardi, S., & Millozzi, S. (2006). Temporal analysis of the wikigraph. In *Proceedings of the Web Intelligence Conference* (pp. 45-51).
- Chiu, C. M., Hsu, M. H., & Wang, T. G. (2006). Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. *Decision Support Systems*, 42(3), 1872-1888.
- Chung, C., & Lee, M. (2009). Understanding the sustainability of a virtual community: Model development and empirical test. *Journal of Information Science*, 35(3), 279-298.
- Dholakia, U., Bagozzi, R., & Pearo, L. (2004). A social influence model of consumer participation in network and small-group-based virtual communities. *Research in Marketing*, 21(3), 241-263.
- Dunbar, R. I. M. (1996). *Grooming, gossip, and the evolution of language*. Cambridge, MA: Harvard University Press.
- Faraj, S., Jarvenpaa, S., & Majchrzak, A. (2011). Knowledge collaboration in online communities. *Organization Science*, 22(5), 1224-1239.
- Foth, M., & Hearn, G. (2007). Networked individualism of urban residents: Discovering the communicative ecology in inner-city apartment building. *Information, communication & Society*, 10(5), 749-772.
- Ganley, D., & Lampe, C. (2009). The ties that bind: Social network principles in online communities. *Decision Support Systems*, 47(3), 266-274.
- Gargiulo, M., & Benassi, M. (2000). Trapped in your own net? Network cohesion, structural holes, and the adaptation of social capital. *Organization Science*, 11(2), 183-196.
- Greisdorf, H., & Spink, A. (2000). Recent relevance research: Implications for information professionals. *Online Information Review*, 24(5), 389-396.
- Grewal, R., Lilien, G. L., & Mallapragada, G. (2006). Location, location, location: How network embeddedness affects project success in open source systems. *Management Science*, 52(7), 1043-1056.
- Gu, B., Konana, P., Rajagopalan, B., & Cheh, H. M. (2007). Competition among virtual communities and user valuation: The case of investing-related communities. *Information Systems Research*, 18(1), 68-85.

- Ginsburg, M., & Weisband, S. (2004). A Framework for virtual community business success: The case of the international chess club. In *Proceedings of 37th Hawaii International Conference on System Sciences*.
- Hou, A., Chen, Y., Shang, R., & Chern, C. (2012). The post adoption switching of social network service: A human migratory model. In *Proceedings of 16th Pacific Asia Conference on Information Systems*.
- Hox, J. (2002). *Multilevel analysis: Techniques and application*. New Jersey, London: Lawrence Erlbaum Associates.
- Hsiao, C., & Chiou, J. (2012). The impact of online community position on online game continuance intention: Do game knowledge and community size matter? *Information & Management*, 49(6), 292-300.
- Jones, Q., & Rafaeli, S. (2000). Time to split, virtually: "Discourse architecture" and "community building" as means to creating vibrant virtual publics. *Electronic Markets*, 10(4), 214-223.
- Jones, Q., Ravid, G., & Rafaeli, S. (2004). Information overload and the message dynamics of online interaction space. *Information Systems Research*, 15(2), 194-210.
- Kang, S., Lim, K., Kim, M., & Yang, H. (2012). A multi-level analysis of the effect of group appropriation on collaborative technologies use and performance. *Information Systems Research*, 23(1), 214-230.
- Koh, J., Kim, Y., Butler, B., & Bock, G. (2007). Encouraging participation in virtual communities. *Communications of the ACM*, 50(2), 69-73.
- Kozlowski, S. W. J., & Klein, K. J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal and emergent processes. In K. J. Klein & S. W. J. Kozlowski (Eds.), *Multilevel theory, research and methods in organizations* (pp. 3-90). San Francisco: Jossey Bass.
- Kraut, R. (2003). Applying social psychological theory to the problems of group work. In J. M. Carroll (Ed.), *HCI models, theories, and frameworks: Toward a multidisciplinary science* (pp. 325-356). New York: Morgan Kaufmann.
- Langlois, G., Elmer, G., McKelvey, F., & Devereaux, Z. (2009). Networked publics: The double articulation of code and politics on Facebook. *Canadian Journal of Communication*, 34(3), 415-434.
- Leimeister, J. M., & Ebner, W., & Krcmar, H. (2005). Design, implementation, and evaluation of trust supporting components in virtual communities for patients. *Journal of Management Information Systems*, 21(4), 101-135.
- Lin, K., & Lu, H. (2011). Why people use social networking sites: An empirical study integrating network externalities and motivation theory. *Computers in Human Behavior*, 27(3), 1152-1161.
- Lin, N. (2008). A network theory of social capital. In D. Castiglione, J. Deth, & G. Wolleb (Eds.), *Handbook on social capital* (pp. 50-69). Oxford: Oxford University Press.
- Lin, H. (2008). Determinants of successful virtual communities: Contributions from system characteristics and social factors. *Information & Management*, 45(8), 522-527.
- Luke, D. A. (2004). *Multilevel modeling quantitative applications in the social sciences*. Newbury Park, CA: Sage.
- Ma, M., & Agarwal, R. (2007). Through a glass darkly: Information technology design, identity verification, and knowledge contribution in online communities. *Information System Research*, 18(1), 42-67.
- Massenti, B., & Zmud, R. W. (1996). Measuring the extent of EDI usage in complex organizations: Strategies and illustrative examples. *MIS Quarterly*, 20(3), 331-345.
- McKenna, K. Y. A., Green, A. S., & Gleason, M. E. J. (2002). Relationship formation on the Internet: What's the big attraction? *Journal of Social Issues*, 58(1), 9-31.
- Mithas, S., Ramasubbu, N., Krishnan, S., & Fornell, C. (2006). Designing websites for customer loyalty across business domains: A multilevel analysis. *Journal of Management Information Systems*, 23(3), 97-127.
- Nielsen, J. (2006). Participation inequality: Encouraging more users to contribute. *Jakob Nielsen's Alertbox*. Retrieved from <http://www.nngroup.com/articles/participation-inequality/>
- Otto, P., & Simon, M. (2008). Dynamics perspectives on social characteristics and sustainability in online community networks. *System Dynamics Review*, 24(3), 321-347.



- Panzarasa, P., Opsahl, T., & Carley, K. (2009). Patterns and dynamics of user's behavior and interaction: Network analysis of an online community. *Journal of the American Society for Information Science and Technology*, 60(5), 911-932.
- Pavlou, P. A., Liang, H., & Xue, Y. (2007). Understand and mitigating uncertainty in online exchange relationships: A principal-agent perspective. *MIS Quarterly*, 31(1), 105-136.
- Phang, C. W., Kankanhalli, A., & Sabherwal, R. (2009). Usability and sociability in online communities: A comparative study of knowledge seeking and contribution. *Journal of the Association for Information Systems*, 10(10), 721-747.
- Podolny, J. M., & Baron, N. (1997). Resources and relationships: Social networks and mobility in the workplace. *American Sociology Review*, 62(5), 673-693.
- Podsakoff, P. M., & Organ, D. W. (1986). Self reports in organizational research: Problems and prospects. *Journal of Management*, 12(4), 531-544.
- Preece, J. (2001). Online communities: Usability, sociability, theory and methods. In R. Earnshaw, R. Guedj, A. van Dam, & T. Vince (Eds.), *Frontiers of human-centred computing, online communities and virtual environments* (pp. 263-277). Amsterdam: Springer Verlag.
- Ren, Y., Harper, M. Drenner, S., Terveen, L., Kiesler, S., Riedl, J., & Kraut, R. E. (2012). Building member attachment in online communities: Applying theories of group identity and interpersonal bonds. *MIS Quarterly*, 36(3), 841-864.
- Ren, Y., Kraut, R. E., & Kiesler, S. (2007). Applying common identity and bond theory to design of online communities. *Organization Studies*, 28(3), 377-408.
- Ridings, C. M., Gefen D., & Arinze, B. (2002). Some antecedents and effects of trust in virtual communities. *Journal of Strategic Information Systems*, 11(3), 271-295.
- Ridings, C. M., & Wasko, M. (2010). Online discussion group sustainability: Investigating the interplay between structural dynamics and social dynamics over time. *Journal of the Association for Information Systems*, 11(2), 95-121.
- Rindfleisch, A., Burroughs, J. E., & Denton, F. (1997). Family structure, materialism, and compulsive consumption. *Journal of Consumer Research*, 23(4), 312-325.
- Roberts, J., Hann, I. H., & Slaughter, S. (2006). Understanding the motivations, participation, and performance of open source software developers: A longitudinal study of the Apache projects. *Management Science*, 52(7), 984-999.
- Shilling, M., & Phelps, C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, 53(7), 1113-1126.
- Scott, J. (2000). *Social network analysis: A handbook*. London: Sage.
- Seol, S., Lee, H., Yu, J., & Zo, H. (2012). Determinants of the successful usage of a firm's SNS page. In *Proceedings of 15th Pacific Asia Conference on Information Systems*.
- Sproull, L., & Faraj, S. (1995). Atheism, sex and databases: The net as a social technology. In K. Brian & J. Keller (Ed.), *Public access to the Internet* (pp. 62-81). Cambridge, MA: MIT Press.
- Teo, H., Chan, H., Wei, K., & Zhang, Z. (2003). Evaluating information accessibility and community adaptivity features for sustaining virtual learning communities. *International Journal of Human-Computer Studies*, 59(5), 671-697.
- Viegas, F. B., Wattenberg, M., Kriss, J., & van Ham, F. (2007). Talk before you type: Coordination in Wikipedia. In *Proceedings of 40th Annual Hawaii International Conference on System Sciences*.
- Wang, X., B., Butler, S., Ren, Y. (2013). The impact of membership overlap on growth: An ecological competition view of online groups. *Organization Science*, 24(2), 414-431.
- Wasko, M., & Faraj, S. (2005). Why should I share? Examining knowledge contribution in electronic networks of practice. *MIS Quarterly*, 29(1), 1-23.
- Wasko, M., Faraj, S., & Teigland, R. (2004). Collective action and knowledge contribution in electronic networks of practice. *Journal of the Association for Information Systems*, 5(11), 493-513.
- Wasko, M., Teigland, R., & Faraj, S. (2009). The provision of online public goods: Examining social structure in an electronic network of practice. *Decision Support Systems*, 47(3), 254-265.
- Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of "small-world" networks. *Nature*, 393(6684), 409-410.
- Wellman, B., & Gulia, M. (1999). Net surfers don't ride alone: Virtual communities as communities. In B. Wellman (Ed.), *Networks in the global village* (pp. 331-366), Boulder, CO: Westview Press.
- Zhou, Z., Fang, Y., Vogel, D., Jin, X., & Zhang, X. (2012). Attracted to or locked in? Predicting continuance intention in social virtual world services. *Journal of Management Information Systems*, 29(1), 273-305.

## Appendices

### Appendix A

**Table A-1. Summary of Two Research Streams Regarding the Sustainability of a VC**

Level	Summary	Category -Factors explored	Related literature
Individual level	While studies that emphasized individuals' motivations for joining VCs, researchers who addressed the sustainability of VCs have emphasized the importance of understanding why people stay and maintain their contribution over time in a VC.	<b>Technological</b> -Community adaptability, Information accessibility -Information quality, System quality -Intuitive user interface (usability) -IT infrastructure quality	Teo et al. (2003) Lin (2008) Guindburg & Weisband (2004) Koh et al.(2007)
	To understand sustained contribution to VCs, researchers have attempted to identify the factors that influence active members' ongoing contributions. Depending on the theoretical lens researchers employed, the results of studies suggest a range of factors to account for the variance in active members' ongoing contributions. Within the CET framework, the factors suggested from the prior literature can be categorized into three dimensions: technological, cognitive, and social.	<b>Discursive</b> -Information value (Purposive value) -Quality of content -Shared language, Shared vision	Dholakia, Bagozzi, & Pearo (2004) Leimeister, Ebner, & Krcmar (2005) Chiu et al. (2006)
		<b>Social</b> -Interpersonal interconnectivity, social enhancement -Reciprocity -Sense of belonging, Social usefulness, trust -Social identity -Social value	Chung & Lee (2009) Chiu et al. (2006) Lin (2008) Dholakia et al. (2004) Hsiao & Chiou (2012)
	Research gaps: Most prior literature limits its view to the theory development at the individual level. While researchers have acknowledged that contextual factors at a higher level may modify individual behavior, few studies explore how contextual factors at the community level modify individual dynamics observed at the individual level.		
Community level	Studies have described how the structure of networks changes over time and how structural changes influence the resources the networks generate. All VCs change in their network structure over time. The changing structure of a VC is explained by either the mechanism of homophily (similarity of traits) or preferential attachment (Barabási, 2002). Structural dynamics have been explained by two aspects: membership and clique sizes. Researchers argue that membership size of a VC has both positive and negative effects on its sustainability. As a VC grows in size, it can attract more members, but social loafing and free riding can increasingly be observed, which, in turn, decreases the perceived benefits for active members. Clique formation has been suggested as an effective emergent coping strategy to mitigate the negative effects of membership size. Thus, a VC's sustainability is predicated on the ability of its members to form cliques around their interests and preferences, which enables them to strengthen social ties with preferred members and maintain social bonds to the VC as a result.	Membership size	Butler (2001) Grewal et al. (2006) Koh et al. (2007) Otto & Simon (2008) Hsiao & Chiou (2012) Wang et al. (2013)
		Clique formation -While these studies describe the tendency for people to form cliques as a network grows, they did not empirically examine how clique size influences individual dynamics in a VC.	Ganley & Lampe (2009) Wasko et al. (2009) Panzarasa et al. (2009) Ridings & Wasko (2010)
	Research gaps: While researchers acknowledge that increases in membership size do not result in a linear increase in user contribution, little is understood about how membership size interacts with individual-level factors to predict an active member's intention to stay. Furthermore, although researchers invoke a need to explore the role of clique formation in sustaining a VC, few studies have empirically examined how clique size influences individual dynamics that explain a VC's sustainability.		

## Appendix B

Table B-1. Questionnaire Items

Construct	Item Code	Operational definition items
The extent of use of collaborative tools		Definition: it refers to how diverse IT functions individuals use and how heavily they rely on such IT functions for communication and information sharing with other members (Massenti and Zmud, 1996).
	UCT1	How often, in a week, do you use IT features like posting threads in your forum, or private messaging, real-time chat, or social network applications to communicate with other members in your VC? (Never—Very Often)
	UCT2	How often, in a week, do you use IT features like posting threads in your forum, or private messaging, real-time chat, or social network applications to share information with other members in your VC? (Never—Very Often)
	UCT3	How heavily do you rely on IT functions provided by posting threads in your forum, or private messaging, real-time chat, or social network applications in order to communicate with other members in your VC? (Not at All—Very Heavily)
	UCT4	How heavily do you rely on IT functions provided posting threads in your forum, or private messaging, real-time chat, or social network applications in order to share information with other members in your VC? (Not at All—Very Heavily)
Strength of emotional ties		Definition: it is the extent to the content or information exchanged, expertise leveraged, and knowledge shared in their virtual communities are available, relevant, and useful (Rindfleish et al., 1997; Greisdorf and Spink, 2000).
	SET1*	How often do you feel relaxed when communicating with members in your VC? How often do you feel welcomed when communicating with members in your VC? How often do you feel pleased when communicating with members in your VC? How often do you feel pleasantly surprised when communicating with members in your VC? How often do you feel comfortable when communicating with members in your VC? (Never—Very Often)
	SET2	I like the way I am treated by members in my VC.
	SET3	I am treated with respect by members in my VC.
	SET4	Members in my VC are very willing to listen to me.
	SET5	Members in my VC are very friendly towards me.
Shared information resources		Definition: it is the extent to the content or information exchanged, expertise leveraged, and knowledge shared in their virtual communities are available, relevant, and useful (Rindfleish et al., 1997; Greisdorf and Spink, 2000).
	INR1	Information that is of my interest is ____ in my VC. (Not Available—Overwhelming)
	INR2	Information contributed by members that is of interest to me is ____ in my VC. (Not Available—Overwhelming)

**Table B-1. Questionnaire Items (cont.)**

Construct	Item Code	Operational definition items
Shared information resources	INR3	Information in my VC helped me identify aspects of my problems that would otherwise have gone unnoticed.
	INR4	The information retrieved from my VC is/will be useful in resolving my current/future information need.
	INR5	The information retrieved from my VC is/ will be informative.
Intention to stay	Definition: It is the extent of the intention of members to participate and continue using the relevant VCs (Ajzen & Fishbein, 1980).	
	MER1	I intend to stay in my VC in the future (at least for the next six months or so).
	MER2	I intend to return to my VC (e.g., for information, communicating with other members) in the future (at least for the next six months or so).
	MER3	I plan to visit my VC regularly in the future (at least for the next six months or so).
<p>* Responses collected from the 5 emotion items were calculated to find the emotional tone of the relationship. The total scores were normalized to a scale of 1-7. With the normalized scores, score for emotional tone was calculated. The 5 questionnaires measuring emotions were therefore normalized into 1 item (SET1).</p> <p>** The scale used for each item measures "strongly disagree" to "strongly agree" unless otherwise stated in the above table.</p>		

## Appendix C

Table C-1. The List of VCs Surveyed

No.	Name of VC	No. of Responses	Average # of members in a clique	Estimated # of Active Members*	Total Number of Registered Members	Interest	Description
1	AquaticQuotient	4	7	35	3,529	Aquatic	A community for fish-lovers to discuss aquarium-related topics. It is a local VC.
2	Arofanatics	24	80	133	13,328	Arowana	A community for Arowana fish lovers. It is a local VC.
3	Bit-Tech	17	30	182	18,200	Technology	A community for technology discussion, including computer hardware and software. It is a non-local VC.
4	ChillCrab	4	45	147	14,730	Friends-finder	A friends-finder community which had personal profiles of each member. Through this community, members get to view others' profiles, and then decide whether to befriend him/her. It is a local VC.
5	Club Snap	4	30	127	12,723	Photography	A community which gathers people who loves photography. It is a local VC.
6	Hardware Zone	11	20	1,900	190,000	Hardware	A community for technology-savvy people who wish to discuss about computer hardware and know about the latest hardware, news and reviews. It is a VC based in Singapore, Malaysia and Philippines.

**Table C-1. The List of VCs Surveyed (cont.)**

No.	Name of VC	No. of Responses	Average # of members in a clique	Estimated # of Active Members*	Total Number of Registered Members	Interest	Description
7	iGuana Mobile	5	164	2,000	200,000	Mobile	A community for mobile users to discuss the different mobile phones, share logos, ring tones etc. It is a local VC.
8	KeepTouch	20	45	156	15,553	General	A general interest community, offering a place for members to exchange information in a wide range of topics. It is a local VC.
9	MAC User Group Singapore	7	25	47	4,722	MAC	A community for Mac PC users. It is a local VC.
10	Renault Car Club	4	15	30	3,021	Renault Car	A community for members to discuss about Renault Cars. It is a local VC.
11	sgForums	5	55	1,800	180,000	General	A general interest community, offering a place for members to exchange information in a wide range of topics. It is a local VC.
12	Singapore Brides	3	60	131	13,136	Bridal	A community for brides and brides-to-be to discuss about wedding preparations and other beauty tips. The site also provides recommendations for wedding banquets and others related stuffs. It is a local VC.
13	Singapore Palm User Group	27	30	98	9,800	PDA	A community for palm users or enthusiasts to discussion anything regarding PDAs. It is a local VC.
14	The Mouth Piece	19	28	42	4,218	Band	A community for people who play brass band. It is a non-local VC.



**Table C-1. The List of VCs Surveyed (cont.)**

No.	Name of VC	No. of Responses	Average # of members in a clique	Estimated # of Active Members*	Total Number of Registered Members	Interest	Description
15	VR-Zone	10	12	128	12,812	Hardware	A community for technology-savvy people to discuss about computer hardware. It is a local VC.

\* The number of active members is estimated based on the estimation of 1% of total number of registered users. Research (Nielsen, J. 2006) listed many different percentages for different VCs (e.g., 1%, 0.7%, 0.1%, and 0.003%). This estimation is to justify that the small number of respondents in each VC adequately represents the active VC members. The estimation of the number of active members is not used for our hypothesis test. Accordingly, even though we can use different percentages of active members for different VCs, it does not change the results of this study.

## About the Authors

**Gee-Woo BOCK** received the PhD degree in management engineering from Korea Advanced Institute of Science and Technology (KAIST), Seoul, Korea, in 2001. He was an assistant professor at the National University of Singapore (NUS) and a chief researcher at the department of strategic management in Samsung Economic Research Institute in Seoul before joining the NUS. He is currently a professor at the School of Business in Sungkyunkwan University (SKKU) in Seoul and an AE of I&M. His current research interests include knowledge management, social network services, online rumors, personalization and service systems in the healthcare and the tourism industries. His papers have been published in the *MIS Quarterly*, *CACM*, *IEEE TEM*, *EJIS*, *DSS*, *I&M*, *IJEC*, *JGIM*, *Data Base for Advances in Information Systems*, *Journal of Organizational Computing and Electronic Commerce*, *Journal of the American Society for Information Science and Technology*, *Journal of Information Science*, and others.

**Manju K. AHUJA** is Professor and University Scholar in the CIS Department at the College of Business, University of Louisville, Kentucky. Her publications have appeared in journals such as *MIS Quarterly*, *Management Science*, *Information Systems Research*, *Organization Science*, *Journal of Management*, *European Journal of Information Systems*, *Journal of MIS*, and many other outlets. She is currently a Senior Editor at *Management Information Systems Quarterly* and recently served as Division Chair of the Academy of Management's OCIS division. Her research interests include innovation and knowledge management related to IT, virtual communities and teams, computer-mediated work, effects of mobile technologies on work and life, and management of human resources in IT professions. She has received three National Science Foundation grants totaling \$1,095,000 for her research on IT workforce issues. Her research has been cited by publications such as *Wall Street Journal*, *Times of India*, *Strategy+Business*, and *Computerworld*.

**Ayoung SUH** is Assistant Professor of School of Creative Media and Department of Information Systems, City University of Hong Kong. She began her academic career in 2008 after attaining her PhD in Management Information Systems from Ewha Womans University, Seoul, Korea. Her research interests include virtual collaboration, virtual communities and teams, virtual identity, and the effects of game design elements in the workplace (gamification). Before joining CityU, she worked as Research Professor in the College of Business Administration at EWU (2008-2013). She was also a Visiting Professor at Sungkyunkwan University (2012-2013). Her papers are published in *Journal of Management Information Systems*, *Journal of Information Science*, *Computers in Human Behavior*, *Journal of Computer Information Systems*, and others.

**Lee Xian YAP** is a Vice President in DBS Bank in Singapore and worked as a consultant in Accenture before joining the bank. She graduated from the School of Computing in the National University of Singapore with Honor majoring Information systems. She presented her paper at ECIS 2005.