

Who Motivates My Participation in Virtual Interorganizational Communities of Practice: Self, Peers, or the Firm?

Completed Research Paper

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Abstract

Virtual interorganizational communities of practice (IOCoPs) enable professionals in different organizations to exchange and share knowledge via computer-mediated interactions. Prior literature mainly focuses on internal motivating factors at the individual level. However, knowledge sharing requires social interactions thus influences from external entities play an important role in individuals' community participation. In this research, we study external motivating factors generated from two different channels: peer effects within and organizational influences outside the virtual community. We apply a novel econometric identification method to analyze a virtual IOCoP in the financial trading sector. We find that external motivating factors from online peers and offline organizations are influential in determining community participation. In addition, our results suggest that virtual IOCoPs and organizations are two complementary learning channels. Differentiating motivating factors across multiple levels enables us to shed new light on various mechanisms with which IOCoPs can engage collective learning and knowledge management across organizations.

Keywords: Interorganizational communities of practice, incentives to participate, peer effects, organizational influences, multilevel framework

Introduction

Knowledge is a key organizational asset that sustains firms' competitive advantages (Grant 1996). Understanding the creation, mobilization, and management of knowledge has been an enduring research theme in the management literature (Nonaka 1994) and information systems literature (Wasko and Faraj 2005). Most organizations do not possess all required knowledge within their formal boundaries, thus they need to acquire knowledge from outside organizations and individuals (Wasko and Faraj 2005). One potential channel to access expertise by peers from other organizations is interorganizational communities of practice (IOCoPs), where professionals belonging to different organizations are brought together in order to exchange, share, and learn from each other (Wenger et al. 2002). Recently, virtual IOCoPs have proliferated in business organizations due to the use of IT (Ardichvili et al. 2003; Moingeon et al. 2006).

Despite the wide use of virtual IOCoPs, little is known about their road to success (Ardichvili et al. 2003; Wenger et al. 2002). Theoretical mechanisms and empirical studies for IOCoP are still in their initial stages. Compared to communities of practice (CoPs), participation in virtual IOCoPs is outside of firm boundaries and purely autonomous and voluntary. Communal behavior such as knowledge sharing, trust, sense of belonging, and peer influences, which all impact sustention and success of the community, become more difficult through computer-mediated interactions than face-to-face ones (Cramton, 2001; Pan and Leidner, 2003). Furthermore, compared to a typical online community, virtual IOCoPs have two distinctive features: the common interests shared by community members are work-related, and participants in the community reveal their true personal and institutional identities. Thus, virtual IOCoPs face unique challenges and it is important to understand the incentives of participation and contribution in such communities.

At the peer level, learning and socialization are tied, and experience-based knowledge is exchanged and combined via social interactions in the community (Brown and Duguid 1991). Although the concept is not new, the methodology to empirically identify and estimate peer effects is a recent development (Bramoullé et al 2009). In particular, studies that scrutinize joint effect of personal attributes and peer influence often do so through the use of network autocorrelation models (Valente 2005). However, the phenomenon we study at the virtual IOCoP platform present challenges that cannot be accommodated by the current models. First, the individual attributes collected and the networks in which these individuals embedded are longitudinal. Second, there are possible unobserved individual level factors coming from the virtual platform correlating with observed attributes. These situations need a network autocorrelation model that accommodates both panel data and fixed effects. However, current network autocorrelation models do not fully support this kind data, which calls for extension in order to investigate factors affecting individuals' participation at virtual IOCoPs.

At the firm level, individuals apply knowledge obtained from virtual IOCoPs in their physical work environment. It is well known that organizations play a key role in articulating and amplifying knowledge developed by individuals (Nonaka 1994). However, it is not clear how organizations shape individuals' knowledge sharing and consumption behavior outside firm boundaries. Some argue that organizational characteristics provide context for individuals, and they can affect individual attitudes and behavior as a higher-level situational factor (John 2006). Others suggest that individuals could ignore contextual forces, and "the presence of contextual variables does not mean they will shape behavior" (Mowday and Sutton 1993, pp. 209). Thus it is intriguing to explore, in virtual IOCoPs where participation is purely autonomous and voluntary, whether individuals are still influenced by firms they are working for.

In this research, we conceptualize a multilevel framework to simultaneously explore motivational factors at the individual level, peer level and firm level in virtual IOCoPs. Cross-level designs focusing on interrelationships among individuals, network structures, and institutions are critical and just emerging in virtual community research. While multilevel analysis can provide a deeper and richer portrait of this new form of digitally mediated collaboration (Klein et al. 1999), such a framework is still rare in the IS field (Sarker and Valacich 2010). Using a rich and unique dataset from a virtual IOCoP on financial information exchange protocol, our study represents, to the best of our knowledge, the first to theorize and empirically analyze the incentives to participate and contribute in virtual IOCoPs from a multilevel perspective.

Our analysis yields several insights about motivations to participate in virtual IOCoPs. We find that individuals are primarily self-motivated to exchange and share knowledge in the virtual community. Peer effects in virtual IOCoPs are mostly negligible, contrary to those found in offline social networks. In other words, individuals' behavior is relatively independent from their peers in virtual IOCoPs. Moreover, contextual factors promoting an individual's quality of answers in fact hinder his peers' helpfulness. Finally, individuals' online behavior outside of firm boundaries is still subject to influences from their work environment in multifaceted ways. They can internalize some organizational influence while ignore others. Firms may also compete with virtual IOCoPs for their employees' time, efforts, and commitment.

The remainder of this paper is structured as follows. Section 2 reviews related literature on motivational factors in online communities and identifies the research gap. Section 3 develops hypotheses and section 4 describes our empirical setting and data used for econometric analysis. Section 5 is devoted to model development. Section 6 presents results and analysis. Section 7 summarizes our findings.

Literature Review

A stream of literature has examined motives of individuals for participating and contributing in online communities. Table 1 lists these motives at three different levels suggested in prior studies that are closely related to our research. While these papers have investigated factors motivating individuals' participation in various types of online communities, it is clear that none of them has explored factors at all three levels in a single study. Moreover, studies at the peer level and firm level are rather limited.

Research	Online Community	Motives		
		Individual Level	Peer Level	Firm Level
Ahn et al. 2013	A large Internet site devoted to a common interest	Utility of posting; Individual posting stock; Weekend effect	Expectation regarding the participation of others	None
Constant et al. 1996	A large organizational computer network	Earn respects; Enjoy helping others; Enjoy solving problems	None	Part of job to help; Fair to help; Organizational citizen; Firm reward; Important firm problem
Hennig-Thurau et al. 2004	Several Germany websites and opinion platforms	Concern for others; Positive self-enhancement; Social benefits; Economics incentives	None	None
Nov 2007	Wikipedia	Fun; Ideology; Values; Understanding; Enhancement; Protective; Career; Social	None	None
Roberts et al. 2006	OSS developers	Intrinsic motivation; Extrinsic motivation	None	Paying the participants
Shah 2006	OSS developers	Need; Fun, enjoyment	None	None
Shriver et al. 2013	A sports-based online community	Tenure; Past contribution	Friendship requests	None
Wasko and Faraj 2005	A network supporting a professional legal association	Reputation; Enjoy helping; Structural capital; Cognitive capital; Relational capital	None	None
Xia et al. 2012	P2P sharing networks	Benefits from the network; Benefits to the network	None	None
Zhang and Zhu 2011	Chinese Wikipedia	Tenure; Social participation	Group size; Percentage of blocked contributors	None

From Table 1 we see that motivational factors at the individual level have been researched extensively. We classify these factors into three categories. The first is the capability-based perspective, which considers whether individuals have the ability to contribute. Examples include cognitive capital or tenure (Shriver et al. 2013; Wasko and Faraj 2005; Zhang and Zhu 2011). The second is the utility-based perspective, which identifies various benefits offered by the community being valuable to individual participants. For instance, participants can learn knowledge, earn respect, advance their careers, or simply have fun from community activities (Ahn et al. 2013; Constant et al. 1996; Nov 2007; Wasko and Faraj 2005). The third is the pro-social perspective, where people contribute in order to benefit others, the community, or the society as a whole (Constant et al. 1996; Hennig-Thurau et al. 2004; Wasko and Faraj 2005; Xia et al. 2012). Our study intends to integrate factors from all three perspectives when examining motives at the individual level.

A few studies analyze influence from other community members. They mainly consider aggregated performance from all other participants. For example, Zhang and Zhu (2011) find that shrinking group size reduces social benefits, which negatively affects individuals' contribution levels in Chinese Wikipedia.

Ahn et al. (2013) suggests that individuals' contribution depends on whether they believe others will engage as well. Aral (2011) takes into consideration of the social network structure to analyze online user behavior. Other than the combined impact from all other users, it is interesting to see whether friends or the peer group formed through online conversation would matter. Shriver et al. (2013) study how friendship requests affect individuals' blogging behaviors. One experimental method has been introduced to examine peer effects on product diffusion in online networks (Bapna and Umyarov 2015). However, our study is different, as we want to explore whether friends' online behavior is directly related to an individual's own behavior *after* social ties are established. In other words, is it true that individuals tend to behave like their online peers who directly interact with them? To answer this question, we modify the methodology proposed by Bramoullé et al. (2009) in order to identify both endogenous and exogenous peer effects. The extended linear-in-means model takes into consideration interactions among peers structured through a social network (Bramoullé et al., 2009). While the new approach has been used to empirically estimated peer effects in offline settings (Bramoullé et al 2009; De Giorgi et al. 2010), its application in virtual world is very limited. We also extend the method to analyze panel data and address fixed effects.

Most research leaves out firm level factors. It is understandable since many communities are not work related. Constant et al. (1996) study several incentives provided by the firm for an online community formed within an organization. It is unclear whether firms can exert similar influence in IOCoPs beyond their boundaries. Roberts et al. (2006) explores monetary incentives provided by firms in the OSS community. We want to find out various firm level factors that encourage the employees' participation in IOCoPs.

Hypotheses

Communities of practice have been well studied in literature and practice (Jubert, 1999; Lave and Wenger 1991; McDermott, 2000; Lesser and Storck 2001; Wenger et al., 2002; Thompson, 2005; Roberts, 2006). In particular, IOCoPs have received great scholarly attention (Brown and Duguid 1991; Wenger et al. 2002; Huang et al. 2002) and are generally analyzed either at the individual level or at the organizational level. However, little research has been developed that links different levels of analysis. Further, the virtual form of IOCoPs remains even less studied. We argue that virtual IOCoPs are a unique form of community that embraces the interplay between virtual and real-world facets of a group, and the interplay between the individuals, peers, and organizational factors. Based on extensive literature review and data available for analysis, we propose hypotheses at three different levels respectively. In addition to the total amount of knowledge shared by an individual, we investigate knowledge consumption and knowledge contribution separately. These two distinct types of knowledge sharing are both desirable in virtual communities (Kankanhalli et al. 2005; Ridings et al. 2006). We also assess both quantity as well as quality of knowledge contributed by an individual (Wasko and Faraj 2005).

Individual Incentives

Research from diverse disciplines has addressed individual incentives in participation and contribution in virtual communities. As we have discussed in the prior section, those factors can be clustered into three categories: capability constraints, utilitarian motives, and pro-social orientation.

Individuals' community participation is constrained by their relevant capabilities. In virtual IOCoPs, participants from different organizations exchange information and knowledge related to their work or professional practice (Wemger et al. 2002). In order to engage meaningfully in community activities, they need to understand the common area of expertise, and be capable to use shared language and vocabulary. Without adequate skills or abilities, individual participants cannot participate in the community. It takes time for individuals to accumulate experience, master relevant expertise, and understand norms of their specialized fields (Wasko and Faraj 2005). Thus, longer tenure helps individuals to participate more actively in the virtual IOCoP.

In addition to self-interests, individuals are also encouraged by their pro-social behavior (Kollock 1999, Subramani and Peddibhotla 2003). A body of work in IS finds abundance empirical evidence from various forms of virtual communities. Specifically, our dataset allows us to examine structural capital. People centrally located in the community have higher level of structural capital, since they have more direct ties

with other individuals (Wasko and Faraj 2005). Those people tend to participate more as they “are more likely to understand and comply with group norms and expectations” (Wasko and Faraj 2005, pp. 41). More social ties with other members suggest more social interactions, which help individuals form habit of cooperation. Therefore, we hypothesize the following motives at the individual level:

H1: Individuals’ level of participation in a virtual IOCoP is positively related to their (a) tenure in the community; (b) informational benefits received from the community; and (c) structural capital.

Peer Effects

By joining research from both sociology and economics, social economics recognizes the importance of social interactions in shaping individual behavior and group outcomes (Durlauf and Young 2001). Individual characteristics alone cannot fully explain aggregate behavior in groups, such as fashion (Bikhchandani et al. 1992), obesity (Trogon et al. 2008), and participation in retirement plans (Saez and Duflo 2003). The reason is that “the feedback loop created by the dependence of an individual’s choice on the choice of others can lead to a social multiplier and multiple equilibria” (Soetevent 2006, pp. 194).

Albeit their importance, it is quite challenging to empirically identify peer effects. The reason is that three different effects could simultaneously exist that might explain why individuals behave similarly in the same group (Manski 1993). The first is endogenous peer effect, where an individual’s behavior is influenced by the behavior of his peers. The second is exogenous or contextual peer effect, where an individual’s behavior is influenced by the exogenous characteristics of his peers. The third is correlated effect, where individuals behave similarly because they are alike or face similar environments. Among these three effects, only endogenous and exogenous peer effects represent the impact of real social interactions. However, isolating them from correlated effect is difficult due to a simultaneity problem (Soetevent 2006).

Based on spatial econometrics, Bramoullé et al. (2009) propose an extension of the linear-in-means model to empirically identify endogenous and exogenous peer effects. The prerequisite is that social interactions among individuals are known to researchers, and a directed social network can be constructed and factored into econometric estimations. In addition, correlated effects are assumed to be fixed within groups. Bramoullé et al.’s approach is general enough to distinguish peer effects in most networks. It has been applied by researchers in social networks where ties are defined by using face-to-face interactions, such as recreational service choices in US high schools and middle schools (Bramoullé et al 2009), college major decisions in Bocconi (De Giorgi et al. 2010), and academic achievement in primary schools in Uruguay (De Melo 2011). In those offline networks, peer effects are positive and significant, indicating that individuals’ choices are affected by their peers’ behavior and exogenous characteristics.

In this paper we extend Bramoullé et al.’s identification strategy to explore whether peer effects exist in virtual IOCoPs. In virtual communities, peers communicate with each other through online conversations and social ties are formed via a digitally mediated platform. Similar to offline settings, online peers share common interests in discussion topics and exchange related information and thoughts. So we expect that peer effects exist in virtual IOCoPs. However, there are differences between online peers and offline peers. Online peers rely on text-based communication, which is a less rich medium than face-to-face communication (Daft and Lengel 1984). The interactions are not synchronized and frequent, nor are their conversations exclusive among themselves, since messages exchanged among peers are broadcasted to all other community members. Consequently, the strength of ties among peers is much weaker due to lower emotional intensity, lower intimacy, and less amount of time spent on interpersonal interactions online (Granovetter 1973). Therefore, it is important to empirically test peer influence in an online setting, and compare the results to prior findings in offline settings.

H2: Individuals’ level of participation in a virtual IOCoP is positively related to (a) endogenous peer influence (b) exogenous peer influence they receive.

Organizational Influence

Knowledge exchanged in IOCoPs is used for job-related activities and as a good means to increase professionals’ marketability and employability. Since knowledge utilization happens in the organization, it is possible that the context of the organization might shape individuals’ behavior of accessing and creating

such knowledge in the IOCoP (Mowday and Sutton 1993). In our research, organizations can be differentiated in terms of their consortium membership status and organizational knowledge. These two firm-level differences could help explain individuals' participation behavior in virtual IOCoPs.

The virtual IOCoP we study in this paper discusses messaging standards for electronic securities transactions, which are developed by the standard consortium, Fix Protocol Limited (FPL), in the financial service industry. As a neutral and independent industry association, FPL is open for any firm who is interested in becoming a FPL member to influence and promote the development and use of its standards. Compared with non-member organizations, member firms have stronger beliefs in the value of the standards, and identify more with the shared mission to enhance interoperability for global financial trading (Zhao et al. 2011b). Employees from member organizations tend to share these beliefs via sense-making in their organizational life (Bloor and Dawson 1994). Thus, individuals from member firms are more likely to develop a stronger sense of membership in the virtual IOCoP organized and hosted by the consortium (Blanchard and Markus 2004).

H3: Individuals from a consortium member company participate more actively than those from a non-member company.

The other dimension of firm-level characteristics is organizational knowledge, which is distinct from yet interdependent of individual knowledge (Bhatt 2002). Organizations possess knowledge in their routines and repertoires (Nelson and Winter 1982). They can also create knowledge through socialization, combination, externalization, and internalization (Nonaka et al. 1992). An organization can deepen its employees' knowledge through formal job-specific training as well as informal social interactions among employees. Some knowledge is informal, situated, experience-based, and can be effectively exchanged and combined via social interactions (Lave and Wenger 1991). If an organization has more individuals possessing diverse expertise, its employees have better chances to collaborate, share knowledge with one another, and use a collective learning approach to empower themselves. Therefore, we hypothesize that:

H4: Individuals' level of participation in IOCoP is positively related to their organization's knowledge.

Data

Empirical Setting

The IOCoP examined here is an online discussion forum created and hosted by FPL, a non-profit industry consortium responsible for defining, managing, and promoting usage of the Financial Information eXchange (FIX) protocol as an enabler for electronic financial trading. The FIX protocol is a standardized language for the automated trading of financial instruments. They are specifications around which software developers can create commercial or open-source software, and they enable firms to transact in an electronic, transparent, cost efficient, and timely manner. The FIX protocol is the de facto standard for pre-trade and trade communication in the global equity markets, and is expanding across the foreign exchange, fixed income, and derivative markets. It is gaining increased attention within the financial exchanges community, as over three quarters of all exchanges surveyed supported a FIX interface, with the majority handling over 25% of their total trading volume via the FIX protocol¹. Exchanges that have adopted the standard include American Stock Exchange, NASDAQ, Irish Stock Exchange, Korea Exchange, London Stock Exchange Group, and many others. It is open and free, and developed by voluntary efforts from member firms in FPL.

FPL was established in 90's by several founding firms, including Fidelity Investments and Salomon Brothers, to promote adoption of the protocol. It engages both financial institutions and IT vendors to develop the specifications. Membership dues collected by the consortium enables it to manage and expand the use of the FIX protocol, and develop and maintain its website. On its website, FPL hosts discussion forums, which are open for both member and non-member firms.

The most active online discussion forum in FPL is the General Q/A forum, which is selected as the IOCoP to study in the paper. It is the most active and successful online forum hosted by FPL and has existed since 1997. The volume of posts in the community is fairly stable during the 12-year study period. Due to

¹ <http://www.fixtradingcommunity.org/pg/main/who-uses-fix/fix-version>, last accessed on September 8th, 2016.

its work-related nature, the community's activity level appears lower than a typical online community as only professionals that work with the FIX Protocol would exchange knowledge in the community. Although not mandatory, participants are encouraged to disclose their own names as well as their companies' names in order to promote mutual trust and open culture in the community². As one member wrote in his post that: "...Your name and company indicate that you would like to stay anonymous. There is nothing to be afraid of and you will probably get more feedback if you are willing to share your identity."



In this online discussion forum, information is organized by message threads. The first message in each thread typically is a question asked by one participant, and the following messages in the same thread are answers or further discussion contributed by other participants. For each message, we can see the posting participants' identification information, posting time, and the full content of each individual message. Figure 1 shows an example of the message threads in the General Q/A forum of FPL.

Variable Description

In order to have reasonable size of observations for online messages, and consequently sufficient estimation precision, the time period or temporal unit is set as a *year*. The response variable in this study is users' participation level in the IOCoP, which is assessed by both the quantity and quality of participation. To accurately assess the *volume* of participation in a given year, we examined two distinct yet equally important types of behavior in virtual communities (Zheng et al. 2013): number of questions asked (# of questions), and answers provided (# of answers). # of questions represents active knowledge consumption³, while # of answers represents knowledge contribution.

We used helpfulness of answers contributed (Helpfulness) to quantify the quality of participation. Following Wasko and Faraj (2005), we reviewed and rated messages that answered the posted questions as very helpful (received a score of 4), helpful (received a score of 3), somewhat helpful (received a score of 2), and not helpful (received a score of 1). Helpfulness scores were averaged in a given year for each individual. If an individual did not provide any answer to others in a given year, she received a Helpfulness score of zero. We used two human raters to evaluate the helpfulness of all the answering messages. An inter-rater reliability check using Cohen's weighed kappa (Cohen 1968) was 0.724, indicating a substantial inter-rater agreement (Landis and Koch 1977). All rating discrepancies were jointly reviewed and reconciled.

The individual-level variables include tenure, informational benefits, and degree centrality. Tenure measures how long an individual has participated in the virtual IOCoP and reflects her cognitive capital (Wasko and Faraj 2005). Informational benefits reflect the average quality of answers an individual receives during a time period. High quality answers help individuals solve technical questions and learn from others. Degree centrality reflects an individual's structural capital in the network (Wasko and Faraj 2005), and is measured by the weighted number of unique individuals that a focal person is connected with in the conversation network, where the weight is the total number of posts sent and received between the focal individual and the peers. Such weights can be considered as a measure for the strength of ties.

Based on the aforementioned discussion, we include two organizational-level variables. Member is a dummy variable indicating whether an individual's organization is a member of the FIX Trading

² Over the years, only 15% of participants did not disclose any company information.

³ Passive knowledge consumption (i.e., message browsing behavior) cannot be captured in our dataset.

Community in a given year. It was coded based on membership records provided by the standard body management. Number of unique individuals from the same organization answering questions in the IOCoP in a given year is used as a proxy to measure organizational knowledge. The rationale is due to “the role of the individual as the primary actor in knowledge creation and the principle repository of knowledge...is essential to piercing the veil of organizational knowledge and clarifying the role of organizations in the creation and application of knowledge” (Grant 1996, pp. 121).

We also control for additional heterogeneities at three different levels. At the individual level, we control for one-timer, which indicates whether an individual only participates in the IOCoP for one-time period and never comes back. One-timer is not retained by the community, and is less likely to participate actively due to lack of identity or emotional attachment to the community (Blanchard and Markus 2004). At the peer level, we control aggregated peer contribution from the entire community, measured by the total number of posts in the virtual IOCoP in a year. At the organizational level, we control for different organizational affiliations. Our IOCoP has three types of individuals: the first type comes from IT vendors who develop standards-compliant systems; the second type works for software user organizations who adopt the standards for the automated trading of financial instruments with other financial institutions. IT vendors and user organizations represent the supply and demand sides of the standards and have different motivations to develop and use the standards (Zhao et al. 2011b). The third type consists of self-represented individuals, who either claim themselves as self-employed or do not disclose employer information in the IOCoP. Two dummy variables, IT vendor (1 indicating the organization is an IT vendor; 0 otherwise) and software user (1 indicating the organization is a software user of the FIX protocol; 0 otherwise), are used to differentiate three types of organizational affiliations.

Table 2: Notations of the Econometric Model	
y_{it}	Value of response variables of individual i in year t
\mathbf{y}_t	An $n \times 1$ vector of response variable for all individual in year t .
x_{it}	An $1 \times K$ vector of the observable characteristics of individual i in year t .
\mathbf{X}_t	An $n \times K$ matrix of individual observable characteristics in year t .
G_{ij}	Individual i 's response to j 's original post, $G_{ij} = 1/n_{it}$ if individual i responds to j 's original post in year t ; 0 otherwise.
n_{it}	The total number of individuals to whom i responds in year t , same as the degree of i .
G_t	An $n \times n$ matrix describing the post conversations between individuals
η_i	Individual level fixed effects of individual i , correlated with x_{ti} .
η	An $n \times 1$ vector of the individual level fixed effects for all n individuals.
α	Coefficient of the intercept term
β	Coefficient of endogenous peer effects
γ	Coefficient of participant's own characteristics
δ	Coefficient of exogenous peer effects

Table 1 shows the variable description. We use data in from 2001 to 2012. The primary purpose is to ensure the variation in the key constructs (e.g., information benefits, member, and organizational knowledge) in the years of data. The variation in early years' data is low and may leads to the model estimation problem. Overall, 1803 unique individuals from 957 organizations have posted 6698 messages over the 12 years.

Econometric Analysis

Model

We extend Bramoullé et al.'s model (2009) to study individuals' FPL forum participation decision, when such decision might be associated with both endogenous attribute and peer effects from the neighbors in the network. Notations and variable descriptions are provided in Table 2.

The structural model for a focal virtual IOCoP individual i in year t is characterized as:

$$y_{it} = \alpha_i + \beta \frac{\sum_{j \in P_{it}} y_{jt}}{n_{it}} + \gamma x_{it} + \delta \frac{\sum_{j \in P_{it}} x_{jt}}{n_{it}} + \eta_i + \varepsilon_{it}, \quad E(\varepsilon_{it} | x_{it}, \alpha_i) = 0$$

where y_{it} is the decision made by individual i in year t . x_{it} is a $1 \times K$ vector of individual observable attributes, including both individual-level attributes and organizational influences for i . Each individual i has a peer group P_{it} who has conversations in the virtual IOCoP at time t , with a size of n_{it} . β captures the endogenous peer effect from the network, and δ captures the exogenous peer effect. Since we have a panel dataset describing individuals' attributes and decisions in different years, we also include fixed effects η_i to capture the unobserved factors common to each individuals across the different years. This assumption allows for correlation between the unobserved attributes of individuals (*e.g.* years of experience in the industry) and observed attributes (*e.g.* years of IOCoP participation). Individuals' observed attributes are assumed to be strictly exogenous conditional on the fixed effects.

The model in matrix notation can be described as:

$$\mathbf{y}_t = \alpha_t \mathbf{1} + \beta \mathbf{G}_t \mathbf{y}_t + \gamma \mathbf{X}_t + \delta \mathbf{G}_t \mathbf{X}_t + \boldsymbol{\eta} + \boldsymbol{\varepsilon}_t \quad (1)$$

$$E(\boldsymbol{\varepsilon}_t | \mathbf{X}_t, \mathbf{G}_t, \alpha_t) = 0$$

In this study we investigate three online behaviors about individuals, number of questions asked, number of answers provided, and average helpfulness of answers by a focal individual in year t . The specification of these behaviors as response variables is shown below.

$$\mathbf{X}_t = \boldsymbol{\mu} + \mathbf{e}_t$$

$$(\boldsymbol{\eta}, \mathbf{e}_t) \sim \text{MVN}(\mathbf{0}, \boldsymbol{\Omega})$$

$$\boldsymbol{\Omega} \sim \text{InvWishart}(\boldsymbol{\Sigma}_\Omega, d_\Omega)$$

where \mathbf{y}_t is an $n \times 1$ vector of response variables in each time period.

$$\mathbf{y}_{t_QUES} = \alpha_t \mathbf{1} + \beta \mathbf{G}_t \mathbf{y}_{t_QUES} + \gamma \mathbf{X}_t + \delta \mathbf{G}_t \mathbf{X}_t + \boldsymbol{\eta} + \boldsymbol{\varepsilon}_t \quad (2)$$

$$\mathbf{y}_{t_ANS} = \alpha_t \mathbf{1} + \beta \mathbf{G}_t \mathbf{y}_{t_ANS} + \gamma \mathbf{X}_t + \delta \mathbf{G}_t \mathbf{X}_t + \boldsymbol{\eta} + \boldsymbol{\varepsilon}_t \quad (3)$$

$$\mathbf{y}_{t_HELP} = \alpha_t \mathbf{1} + \beta \mathbf{G}_t \mathbf{y}_{t_HELP} + \gamma \mathbf{X}_t + \delta \mathbf{G}_t \mathbf{X}_t + \boldsymbol{\eta} + \boldsymbol{\varepsilon}_t \quad (4)$$

$\mathbf{1}$ is an $n \times 1$ vector of ones. \mathbf{G}_t is an $n \times n$ matrix describing the post conversations between individuals in

the IOCoP, with $G_{ij} = \frac{1}{n_{it}}$ if individual i responds to individual j 's original post in year t , and 0 otherwise; n_{it} is the total number of individuals to whom i responds in year t . Since \mathbf{G}_t describes directed relationships between individuals, it is an asymmetric matrix. $\boldsymbol{\eta}$ is an $n \times 1$ vector of the individual level fixed effects for all n participants. Covariates \mathbf{X}_t can be represented as mean $\boldsymbol{\mu}$ with time-variant error \mathbf{e}_t . $\boldsymbol{\eta}$ and \mathbf{e}_t follow a multivariate normal distribution with parameters $\mathbf{0}$ and $\boldsymbol{\Omega}$. $\boldsymbol{\Omega}$ follows an inverse Wishart distribution with parameters $\boldsymbol{\Sigma}_\Omega$ and d_Ω .

In order to estimate the model, we need to eliminate fixed effects within each year. Thus we de-mean both the outcome and attributes for each observation in year t . This is achieved by multiplying the both sides of equation 1 with a term $\mathbf{Q}_t = I_t - \frac{1}{n_t} \mathbf{1}_t \mathbf{1}_t^T$, where I_t is an identity matrix of size $n_t \times n_t$; n_t is the number of individuals in the IOCoP in year t ; $\mathbf{1}_t \mathbf{1}_t^T$ is the cross-product of the all-one vector of size n_t . Thus equation (1) can be transformed into:

$$\mathbf{Q}_t \mathbf{y}_t = \beta \mathbf{Q}_t \mathbf{G}_t \mathbf{y}_t + \gamma \mathbf{Q}_t \mathbf{X}_t + \delta \mathbf{Q}_t \mathbf{G}_t \mathbf{X}_t + \mathbf{Q}_t \boldsymbol{\eta} + \mathbf{Q}_t \boldsymbol{\varepsilon}_t \quad (5)$$

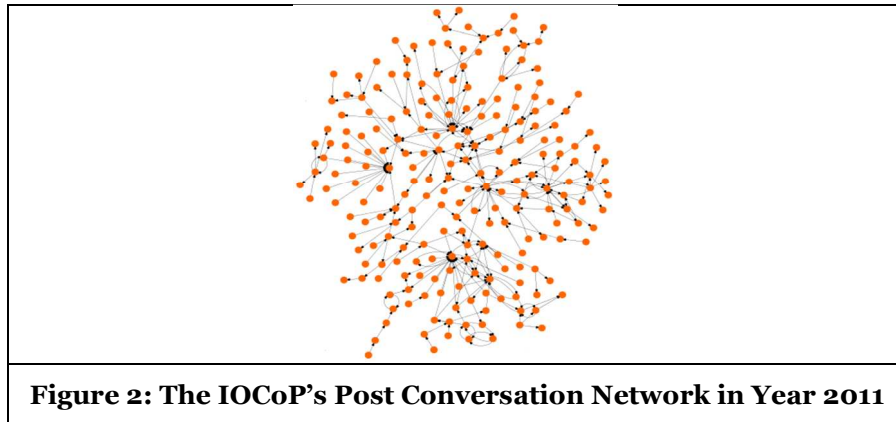
$$\mathbf{Q}_t \mathbf{y}_t = \mathbf{Q}_t (I_t - \beta \mathbf{G}_t)^{-1} (\gamma I_t + \delta \mathbf{G}_t) \mathbf{X}_t + \mathbf{Q}_t (I_t - \beta \mathbf{G}_t)^{-1} \boldsymbol{\eta} + \mathbf{Q}_t (I_t - \beta \mathbf{G}_t)^{-1} \boldsymbol{\varepsilon}_t \quad (6)$$

where equation (6) is a reduced form of equation (5).

Bramoullé et al. (2009) show that peer effects can be identified when the matrices \mathbf{I} , \mathbf{G} , \mathbf{G}^2 , and \mathbf{G}^3 are linearly independent. When such independence stands, the attributes of an individual's indirect neighbor two hops away (the neighbor's neighbor) and further can serve as instruments for the outcomes of the individual's direct neighbor, thus the reflection problem is solved. Bramoullé et al. (2009) specify a

sufficient condition for identification - the diameter of the network in which the nodes embedded is greater than or equal to three. In our context, it means the maximal distance between any two individuals in the conversation network is greater than or equal to three. In our model, identification comes from both the existence of indirect ties (ties of three hops away or more) and the direct ties of the network.

Figure 2 shows an example of FPL forum conversation network using data from year 2011. An arc from node i to node j represents that participant i responds to participant j 's post in that year. From the topology of the network we can easily find that there are path between nodes with distance greater than or equal to three. Furthermore, the linear independence among matrices \mathbf{I} , \mathbf{G} , \mathbf{G}^2 , and \mathbf{G}^3 is also quantitatively confirmed for each year. Thus the identification condition by Bramoullé et al. (2009) is satisfied.



Results

In Table 3, we report the results for the impacts of own characteristics, endogenous peer effects, and exogenous peer effects on an individual's participation behavior. Within the own characteristics and exogenous peer characteristics variables, we cluster the results into two levels, individual level and firm level, respectively. Note that the set of exogenous peer characteristics corresponds exactly to one's own characteristics. According to the identification conditions specified by Bramoullé et al. (2009) and the Bayesian models by LeSage and Pace (2009), we are able to obtain asymptotically optimal estimates of the peer effects.

At the individual level, participants receiving more information benefits tend to ask fewer questions. A plausible explanation is that they receive high quality answers in their first try; therefore there is no need to post follow-up questions to obtain the desired answers. Degree centrality, as a proxy for structural capital, plays a positive and statistically significant role in participation and quality of knowledge contribution. Participants who are more influential (high centrality) in the conversation network overall tend to post more, ask more questions and provide more answers. Among the posts by central participants, there are more than three times the answers than questions. Posts by influential participants are on average more helpful than others. Surprisingly, such participants are also shown to be slightly less helpful than average. One timers are shown to have negative impacts on either volume or quality of participation, suggesting that one timers are less committed to the community. H1(a), and (c) are confirmed, while H1(b) is rejected.

Endogenous peer effects are significant and positive in all three model estimations, suggesting that peers' participation behavior has a positive impact on the participation of the focal individual, in terms of both quantity, as measured by the number of questions and answers, and quality, as measured by helpfulness of the answers. Thus, H2(a) is supported in all dimensions of participation. Compared to endogenous peer effects, exogenous peer effects vary based on the dimensions of the participation, thus H2(b) is partially supported. In addition, coefficients of exogenous peer effects are in general smaller than those of endogenous peer effects. These findings suggest that, one's participation behavior is more influenced by peers' actions than by peers' characteristics.

Table 3: Main Model Estimation Results			
Variables	(1) # of Questions	(2) # of Answers	(3) Helpfulness
Individual Level Characteristics			
Tenure	-0.46*** (0.17)	0.27*** (0.092)	0.025** (0.012)
Information benefit	0.19*** (0.042)	0.27 (0.17)	0.018*** (0.0021)
Degree centrality	0.16*** (0.049)	0.50** (0.23)	0.014*** (0.0028)
One-timer	0.42*** (0.080)	0.082*** (0.027)	0.26*** (0.045)
<i>Organizational Level</i>			
Member	-0.21*** (0.082)	1.7*** (0.31)	1.3*** (0.39)
Organizational Knowledge	-0.11*** (0.032)	-0.40*** (0.15)	0.15*** (0.019)
IT Vendor	-0.41** (0.17)	1.3*** (0.29)	0.063** (0.029)
Software user	1.1 (0.76)	-1.5*** (0.37)	-0.011*** (0.0042)
Endogenous peer effects			
	0.33** (0.16)	0.40** (0.20)	0.62*** (0.24)
Exogenous peer effects (individual level)			
Tenure	0.030*** (0.011)	0.047*** (0.011)	0.029** (0.012)
Information Benefit	0.022 (0.014)	0.070 (0.043)	0.13*** (0.019)
Degree centrality	0.011 (0.0065)	0.038*** (0.0090)	-0.036*** (0.011)
One-timer	0.017 (0.011)	0.15 (0.093)	0.061 (0.039)
<i>Organizational Level</i>			
Member	0.048*** (0.017)	0.19 (0.17)	0.087** (0.040)
Organizational Knowledge	0.071*** (0.026)	0.046 (0.031)	0.0059 (0.025)
IT Vendor	-0.12 (0.077)	0.24** (0.11)	0.060** (0.029)
Software user	0.016 (0.010)	0.46** (0.22)	-0.030 (0.019)
Year fixed effects			
Aggregated peer contribution	0.0040 (0.0028)	0.0037 (0.010)	0.0088 (0.013)
Observations	2,024	2,024	2,024
Adj. R ²	0.42	0.40	0.65
*** p<0.01, ** p<0.05, * p<0.10, standard errors in parentheses.			

Organizational factors have significant influences on individuals' participation in the virtual IOCoP. Individuals from a member organization ask fewer questions and provide more answers. The answers provided by such participants are shown to be more helpful, indicating participants from member organizations play a positive role in the knowledge contribution to the forum, both in terms of quality and quantity. H3 is supported in terms of quality and quantity of the knowledge contribution. We found participants whose organizations possess richer internal resources and institutional knowledge tend to ask less, answer less, while the answers provided are on average more helpful. This finding suggests that participants from such organizations have a lower incentive to seek and share knowledge externally, however, the knowledge contributed are of higher quality. H4 is supported in terms of quality of the knowledge contribution. Individuals from vendor organizations exhibit a similar pattern to those from

member organizations. Individuals from software user organizations show an opposite pattern – they tend to answer less and the quality of their answers is lower. This clear contrast in behavior indicates the differential influences of their organizational factors.

Robustness Check

In this section we provide some alternative specifications for the main model. Table 4 reports the estimation results of the four models excluding exogenous peer effects. The rationale for this specification is that, while peers’ actions are observable in virtual communities, their contextual factors that correspond to the exogenous peer effects, such as the propensity of tenure, and organizational knowledge, may be unobservable to other members, therefore having no impact on one’s participation behavior. As a robustness check, we run a separate set of models explicitly excluding exogenous peer effects. As shown in Table 4, the estimates for coefficients of own characteristics are overall consistent with those in the main model, and the estimates for endogenous peer effect remain insignificant.

Variables	(1) # of questions	(2) # of answers	(3) Helpfulness
Own Characteristics			
<i>Individual Level</i>			
Tenure	-0.47** (0.21)	0.31*** (0.082)	0.030** (0.013)
Information benefit	0.18*** (0.041)	0.40 (0.30)	0.015** (0.0074)
Degree centrality	0.14*** (0.0064)	0.52** (0.26)	0.015*** (0.0036)
One-timer	0.40*** (0.079)	0.072** (0.035)	0.26*** (0.037)
<i>Organizational Level</i>			
Member	-0.22** (0.092)	1.9*** (0.35)	0.78** (0.36)
Organizational knowledge	-0.083*** (0.024)	-0.17*** (0.057)	0.25*** (0.076)
IT Vendor	-0.53*** (0.20)	1.4*** (0.40)	0.043*** (0.017)
Software user	1.1 (0.81)	-1.6*** (0.38)	-0.019*** (0.0053)
Endogenous peer effect	0.37*** (0.096)	0.41*** (0.090)	0.50** (0.24)
Year fixed effects			
Aggregated peer contribution	0.0064 (0.0084)	0.0045 (0.0048)	0.0084 (0.012)
Observations	2,024	2,024	2,024
Adj. R ²	0.41	0.31	0.63
*** p<0.01, ** p<0.05, * p<0.10, standard errors in parentheses.			

Additionally, we experiment with three alternative model specifications. The first experiment deals with the definition of firm membership. Instead of using a binary variable “Member” to indicate whether one’s firm is a member of FPL in a given year as in the main model, we use membership tenure to measure the firm membership status. *Membership tenure* is defined as the number of years a firm has been a member of FPL. The assumption is that, the tenure status of a firm as a member in the community may have different influences on its employees’ participation behavior. The more senior a firm is as a member, the more communal activities we expect to observe from its employees. The second experiment deals with the measure of the firm-level variable on the organizational knowledge “ORGKN”. While in the main model we use the total number of participants from a firm responding to questions in a given year as the measure for ORGKN, in the alternative model, we use the accumulative number of active participants from a firm responding to questions up to a given year. The rationale is that the organizational knowledge usually can be carried over time. The knowledge shared in previous years may be retained within a firm and adds to the overall body of knowledge of an organization. The third experiment deals with the measure of an individual’s structural capital. Rather than degree centrality, in the alternative specification, we use betweenness centrality of a participant to measure one’s structural capital. *Betweenness centrality* is defined as the number of shortest paths that passes through a focal node in a

network; it is an alternative measure of a node's centrality (Freeman 1977). In our setting, betweenness is computed as the number of pairs that are connected through the focal person in the conversation network. Only the shortest path between pairs is considered when calculating the betweenness centrality. Overall, the results from the three sets of experiments are very similar to those reported in our main model, and our results are robust to all the alternative specifications we have examined.

Discussion and Future Research

Our findings at the individual level are in general consistent with prior research. Participants tend to be more active if they are centrally located in the social network, and continue being active in the community. User retention is vital since one-time participants submit less number of posts and quality of answers is also lower. However, we find that helpfulness of answers decreases slightly as a participant stays longer in the community. This may be due to the fact that individuals with longer tenure tend to have stronger emotional bonds with other members in the virtual community (Blanchard and Markus 2004), and they may post some messages for entertainment and socialization, rather than providing concrete contents. In addition, these longtime participants may have less desire to establish or prove their credibility and reputation in the community via posting high quality answers. One unexpected finding is that participants who received more information benefits ask fewer questions, and exhibit no difference in participation in term of overall posting, answers, and quality of the answers. It suggests that information benefits received by individuals do not in turn promote more participation in terms of either quantity or quality, and participation in our virtual IOCoP is not driven by utilitarian incentives.

Peer Spillovers in the Virtual IOCoP

The economic and sociology literature has long recognized the peer spillovers in offline social networks, where individuals' preferences, expectations, and constraints can be shaped and affected in the process of interacting with their peers (Jackson 2006; Manski 2000). To investigate whether peer effects exist in the virtual environment, we apply a novel identification strategy in our dataset. We find evidence of both endogenous and exogenous peer effects, complementing to prior findings in the offline environment (De Giorgi et al. 2010; De Melo 2011; Lin et al. 2010). Our results suggest that peer effects matter even in the presence of electronic weak ties formed via virtual social interactions (Constant et al. 1996). According to Granovetter's seminal paper (1973, pp. 1361), "the strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services with characterize the tie". In our case, peers are geographically dispersed, may not know and interact with each other outside the virtual IOCoP, and focus their discussion topics on standard specifications, a non-personal subject matter. Consequently, the interpersonal ties between them are weak. However, electronic weak ties do not prevent individuals from influencing others to behave similarly. In addition, individuals are affected by certain exogenous characteristics of their online peers. By differentiating two types of peer effects, we find that endogenous peer effects are in general more influential than exogenous peer effects in our virtual IOCoP. It is understandable, as imitating peers' actions requires less cognitive efforts than recognizing and reacting to peers' contextual factors, such as their organizations' membership status.

Most peer effects are positive with only one exception: peers' degree centrality negatively affects a focal individual's quality of knowledge contribution. One possible explanation is that diffusion of responsibility could happen (Leary and Forsyth 1987). When an individual is connected with peers that are centrally embedded in the social network, she might feel that those peers can get help from their other friends. Consequently, the focal individual may feel less responsible to provide high quality answers.

Influences from the Organizations

We find that organizational contexts are important, which can simultaneously encourage as well as hinder individuals' participation in virtual IOCoPs. It is well known that organizations can influence their employees' participation in virtual communities through monetary incentives (Roberts et al. 2006). Our results further demonstrate that even without strategic involvement, organizations can still shape their employees' behavior in virtual IOCoPs where participation is autonomous and self-determined.

Individuals from member organizations of the FIX Trading Community ask fewer questions and provide more and better answers than those from non-member organizations. As a consortium-based standard body, the FIX Trading Community relies on private resource provision from member organizations to develop the open standards (Markus et al. 2006; Zhao et al. 2011b). Thus, being a member of the FIX

Trading Community signals an organization's strong interest in and commitment to the technical specifications developed and promoted by the consortium. Member organizations also have greater influence in the standard consortium, since they can decide how standards should evolve by participating in the consortium committees and working groups, and exercising their voting rights (Zhao et al. 2011a). By observing their organizations' membership status, individuals tend to share their organizations' beliefs in the standards and recognize their organizations' influence in the consortium. Consequently, it is easier for these individuals to build community identity in the virtual IOCoP initiated and hosted by the consortium, leading to more active participation.

Other than the membership status, organizational affiliations also affect individuals' participation in the virtual IOCoP. IT vendors are expected to prove their technical capabilities and improve their visibility in the marketplace in order to attract more customers to use their systems or services. We find that employees from IT vendors ask fewer questions and provide more and higher quality answers. It suggests that individuals' behavior is aligned with their organizations' interests.

We find an unexpected yet interesting result at the organizational level with regard to organizational knowledge. Individuals create fewer contents but with higher quality, if their organizations have more institutional knowledge. Volume of content creation is important for a virtual IOCoP since it ensures necessary social interaction frequency in order to build shared emotional connection in the community (Blanchard and Markus 2004). Less volume from individuals in certain organizations suggests constraints presented by their organizational context (Peters et al. 1985). The constraints could be attributed to complementarity or competition between the work environment and the virtual community. Virtual IOCoPs are a complementary channel for individuals to access knowledge that is not available within their organizations. They also provide individuals a complementary professional community in addition to the ones naturally formed within their organizations (Nonaka 1994; Constant et al. 1996). Individuals communicate less in the virtual IOCoP when they can easily interact with their colleagues working within their organizations. However, they are able to post higher quality answers, since organizational knowledge can be transferred to individuals and empower them to do so (Bhatt 2002; Nonaka 1994).

Implications for Research and Practice

Our contribution to the literature is fourfold. First, this study is among the first to investigate virtual IOCoPs by disentangling motivating factors of individual participation across three different levels: self, peers, and organizations. A virtual IOCoP depends on individual participants from different organizations, and focuses on work-related knowledge exchanged via digitalized social interactions. Thus, self-driven, peer effects and organizational influence could simultaneously exist. It is critical to differentiate motivational factors across levels in order to understand various mechanisms community organizers can use to encourage collective learning. Second, we are the first to analyze peer effects from both endogenous and exogenous dimensions in the virtual environment, and demonstrate their differing impacts on individual participation in virtual IOCoPs. Third, we reveal nuances of organizational influence faced by individuals working in the virtual IOCoP. Organizational influences are internalized by individuals. Moreover, it is important to realize that the work environment and the virtual IOCoP are substitutes for individuals' time, effort and commitment. More knowledge available at work discourages individuals' volume of participation in virtual IOCoPs. Last but not least, we confirm prior studies about the importance of individual-level incentives and suggest a strong micro foundation of knowledge management in the virtual IOCoP. Individuals' role in learning and knowledge creation is well recognized within an organization (Grant 1996; Simon 1991), and our study confirms that such a role can also be found in the inter-organizational setting.

Our findings provide community founders several important insights into better design and management of virtual IOCoPs. Due to peer spillovers, retaining active contributors in the virtual community is crucial. Those individuals not only contribute by themselves, they also encourage their peers to do the same through their actions. Our results draw attention to the important role of long-time community participants. Individuals tend to contribute more knowledge if they have been in the virtual IOCoP for a longer time. Moreover, their seniority is observable to other online peers, who are motivated to participate more actively in the community. Attracting and retaining individuals from member organizations of the standard consortium is beneficial to our IOCoP, as member organizations are also the backbone organizations in the virtual world. Our research also demonstrates the importance to quantify individuals' participation level in virtual IOCoPs from multiple perspectives. Knowledge consumption and provision

are indeed two different types of behavior. Factors hindering knowledge consumption, such as tenure and organizational membership status, can motivate knowledge provision. Knowledge contribution quantity differs from knowledge contribution quality. For instance, while organizational knowledge limits an individual's volume of participation, it encourages higher quality answers.

From an organization's standpoint, virtual IOCoPs are a compliment to the formal divisionalization of expertise within it. Organizations can enhance organizational learning and innovation capabilities by allowing individuals to participate in these communities. Organizations may leverage this digital platform to gain competitive advantages and increase marketability by actively encouraging employees to use virtual IOCoPs as an alternative learning channel to access external knowledge and expertise.

Limitations and Future Research

As an initial attempt to develop and validate a multilevel model of virtual IOCoPs, this study has several limitations that, in turn, offer opportunities for future research. Data available through the virtual IOCoP and public sources are limited. For example, since we deal with many private firms (e.g., many specialized IT vendors), additional organizational data, such as size and financial performance, is not publicly available. Also, we can only observe active knowledge consumption and contribution based on posted messages. However, we cannot identify individuals' browsing behavior, which represent their passive knowledge consumption in the community. Although our study yields interesting findings about virtual IOCoPs, our focus on a single IOCoP in the financial security sector raises concern about the generalizability of the findings. We submit that our results can be generalized to other industries, as the inter-organizational setting and digitalized knowledge sharing platform are common features.

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