MIS Quarterly

RESEARCH ARTICLE

PLATFORM SPONSOR INVESTMENTS AND USER CONTRIBUTIONS IN KNOWLEDGE COMMUNITIES: THE ROLE OF KNOWLEDGE SEEDING[1]

Peng Huang
Robert H. Smith school of Business, University of Maryland,
College Park, MD 20742 U.S.A. {phuang1@rhsmith.umd.edu}

Ali Tafti
College of Business Administration, University of Illinois at Chicago, 601 S. Morgan St.,
Chicago, IL 60607 U.S.A. {atafti@uic.edu}

Sunil Mithas
Robert H. Smith school of Business, University of Maryland,
College Park, MD 20742 U.S.A. {smithas@rhsmith.umd.edu}

How should digital platforms engage with and invest in their online communities to shape innovation and knowledge contributions from members in their platform ecosystems? This is an important question because user contributions are important drivers of technological progress and business value. We examine the effect of platform sponsors' investments in online communities on user knowledge contributions, using fine-grained longitudinal data from a leading enterprise software vendor's community network. We focus on the sponsor practice of knowledge seeding, in which its employees provide free technical support by answering questions posted in discussion forums. We define user knowledge contribution as peer-evaluated, quality-weighted solutions that community members provide to help resolve the questions their peers raise. We show that the platform sponsor's investments in knowledge seeding have a positive, significant association with user knowledge contribution. We also find temporal and geographical variations in returns on the sponsor's knowledge investments. Specifically, returns (i.e., amount of user contribution that is stimulated) decrease with the age of the community, consistent with the observation that the most active contributors are lead users who tend to join the community early. In addition, returns vary across different countries, such that greater returns are realized when the investment is made in countries with higher levels of information technology (IT) infrastructure, partly because country-level IT infrastructure may be associated with greater absorptive capacity of these countries. We discuss the implications for research and practice.

Keywords: Digital platforms, platform ecosystems, open innovation, knowledge community, knowledge contribution, knowledge seeding, network of practice, enterprise software

> To make it work, we knew we'd have to put the people in our company on the front line before customers would engage. It would be 90% us and 10% them at first. But we knew if we did that, it would eventually be 10% us and 90% them.
>
> — Mark Finnern, an SAP community evangelist, commenting on the SAP Community Network (Hinchcliffe and Kim 2012, p. 9)

[1]Paul Pavlou was the accepting senior editor for this paper. Bin Gu served as the associate editor.

Introduction

As firms increasingly recognize the value of the collective wisdom and expertise of the crowd, many of them are embracing a more open model of knowledge creation and innovation management (Boudreau and Lakhani 2009; El Sawy et al. 2016; Ghazawneh and Henfridsson 2013; Nambisan et al. 2017). This open model of innovation is a departure from a relatively closed model of knowledge management, which focuses on managing the productivity of internal research and development (R&D) and other intangible resources (Kleis et al. 2012; Ravichandran et al. 2017; Tafti et al. 2015). For example, platform firms build virtual communities that extend beyond their boundaries to include various parties in their value ecosystems, such as customers who adopt their products and technologies, suppliers who provide component technologies, and partners who build complementary products and applications on top of their technology platforms (Gawer and Cusumano 2002; Parker et al. 2016; Porter and Donthu 2008). These Internet-enabled, open knowledge communities often use a series of collaborative technologies such as wikis, blogs, and discussion forums to facilitate the creation, diffusion, and sharing of knowledge among community members. These communities enable the rapid diffusion of best practices, strengthen customer relationships, gather inputs and feedback for new product and service developments, reduce support costs, and incubate user-driven innovations (Chen et al. 2012; Gruner et al. 2014; Jeppesen and Molin 2003).

A growing body of literature has investigated this form of knowledge management practice. For example, some argue that a community-based model of knowledge creation is conducive to producing variety in innovation, allows for critical evaluation of existing knowledge and innovation, and enables rapid detection and elimination of errors (Lee and Cole 2003). Others have shown that a variety of incentives drive community members' voluntary contribution behaviors, which include fun and enjoyment, a sense of belonging, the acquisition of knowledge, and the opportunity to establish reputation (Füller et al. 2007; Jeppesen and Frederiksen 2006; Spaeth et al. 2015).

Despite significant progress in the research of firm-sponsored open knowledge communities (Chen et al. 2012; Porter and Donthu 2008; West and O'Mahony 2008), there are at least two issues that challenge the current understanding of these knowledge communities. First, there are debates about whether the platform sponsor should take a proactive role in managing the virtual community it creates to influence community member behaviors. On the one hand, some researchers argue that a platform sponsor's effort is essential to stimulate member engagement (Porter and Donthu 2008; Porter et al. 2011). On the other hand, survey research suggests that the offering of incentives by the sponsoring firm is negatively related to members' contribution behaviors (Liu et al. 2014). Some point out that the sponsoring organization faces a tension between encouraging unrestricted outside participation and exerting control over the community (West and O'Mahony 2008). These debates highlight the need for empirical evidence to shed light on the effectiveness of efforts made by the sponsors to nurture their communities (Porter and Donthu 2008).

Second, much of the existing literature on managing virtual communities has not studied the role of heterogeneous user groups in the evolution of knowledge communities. User populations often differ in their capacities to make useful contributions. As a result, it is unclear whether the same management practices of the sponsoring firm may trigger different levels of response from different user groups. For example, prior research has shown that lead users are typically early adopters of products or services, have up-to-date knowledge with regard to the practice in question, and are the most active knowledge contributors to virtual communities (Franke et al. 2006; Jeppesen and Laursen 2009; Morrison et al. 2004; Urban and Von Hippel 1988; Von Hippel 1986). In the early stages, when a firm-sponsored knowledge community is being established, it may attract a disproportionally large fraction of lead users compared with when the community reaches a mature stage. Therefore, user knowledge contribution patterns may show significant temporal variations in response to the sponsor's management practices. Answers to these questions have managerial implications for the sponsoring firms because a better understanding of user contribution patterns from different user groups can help optimize their efforts to attract user engagement.

We address these questions by observing the sponsor's management practices and user knowledge contribution patterns from a leading enterprise software platform's global online community network and innovation platform. Such electronic networks of practice are becoming an important avenue for the diffusion of specialized domain knowledge among IT professionals (Huang et al. 2012). We assembled a unique longitudinal dataset over a period of seven years to conduct the empirical investigation. We focus on a particular form of the sponsoring firm's practice in nurturing its virtual knowledge communities—*knowledge seeding*, or *knowledge investment*—through which the sponsor's employees provide free technical support by answering questions posted by community members in the discussion forums. We define *user knowledge contribution* as the peer-evaluated, quality-weighted solutions that the community members provide to help resolve the questions their peers raise.

To preview our key findings, we show that sponsor knowledge seeding is significantly associated with subsequent user knowledge contribution. All else being equal, a 1% increase in the amount of knowledge seeding by the sponsor to support the community users from a country results in a 0.19% increase in user knowledge contribution from users in that country. We argue that this positive effect occurs because sponsor knowledge investment is conducive to building trust between community members and the sponsor of the community (Jarvenpaa et al. 1998; Porter and Donthu 2008), and enhances the community users' body of knowledge (Benbya and Van Alstyne 2011). Therefore, knowledge seeding increases both the community users' *propensity* and their *capacity* to contribute knowledge to the community.

Interestingly, we also find temporal and geographical variations in the returns on platform sponsor knowledge seeding. In particularly, the return on sponsor knowledge investment, in terms of the amount of user contribution it stimulates, decreases with the age of the community. We interpret this finding as being consistent with the observation that a large fraction of lead users join knowledge communities in their early stages because they are often early adopters (Jeppesen and Laursen 2009; Morrison et al. 2004; Morrison et al. 2000; Urban and Von Hippel 1988; Von Hippel 1986). In addition, when we examine sponsor knowledge investments received by the user groups at the country level, our analyses reveal that sponsor knowledge seeding yields varying returns across different countries; specifically, greater returns are realized when investments are made in countries with higher levels of information technology (IT) infrastructure. We attribute the effect to the greater absorptive capacity of countries that are enabled by advanced IT capabilities (Dedrick et al. 2013; Ko et al. 2005; Malhotra et al. 2005; Szulanski 1996), which leads to a greater user group capacity to make knowledge contributions.

Background and Theoretical Framework

Prior Literature

Recognizing the wisdom of the crowd, many organizations have used advanced information and communication technologies to build virtual communities that connect the various members of the platform ecosystem who are involved with their products and services. Sponsoring firms have used their community networks for a variety of purposes, such as brand building and promotions (Brodie et al. 2013; Gruner et al. 2014), soliciting ideas for new products and services development (Bayus 2013; Chen et al. 2012; Di Gangi and Wasko 2009; Di Gangi et al. 2010), providing support for product use (Moon and Sproull 2008), and facilitating the codification, diffusion, and sharing of product-related knowledge among users (Huang and Zhang 2016). For example, research shows that more firms are adopting a "crowdsourcing" approach to developing products and services in order to harness the "collective brain" of their customers through virtual customer communities (Chen et al. 2012; Ebner et al. 2009). Of particular interest are new types of firm-sponsored knowledge communities, such as networks of practice, where the accumulation and sharing of practice-related knowledge occurs primarily through computer-mediated communication technologies (Huang and Zhang 2016; Wasko and Faraj 2005). Studies have shown that networks of practice help solve problems quickly, facilitate the spread of best practices by harnessing expertise dispersed among community members, and create innovations with both high quality and great variety (Füller et al. 2007; Wenger and Snyder 2000).

Within the research domain of firm-sponsored knowledge communities, our study is related primarily to two broad streams of literature. The first stream of literature studies the behavior and motivation of users in firm-sponsored knowledge communities (Chen et al. 2012; Jeppesen and Frederiksen 2006; Nambisan and Baron 2010; Spaeth et al. 2015). For example, Nambisan and Barron (2010) show that customers' perceptions of their role as the sponsoring firm's innovation partner, their prosocial behavior, and their expected private rewards (e.g., self-image enhancement) lead to greater customer contribution to firm-sponsored customer communities. In addition, Jeppesen and Fredericksen (2006) identify a set of personal attributes that are associated with active contributors: They are usually hobbyists rather than professionals, they are often motivated by receiving recognition from the sponsoring firm, and most of them demonstrate lead-user attributes. Some researchers have noted that firm-sponsored online knowledge communities (Jeppesen and Frederiksen 2006; Wiertz and de Ruyter 2007) are very different from open-source software communities (Lakhani and von Hippel 2003; Lerner and Tirole 2002; Singh et al. 2011; Von Hippel and Von Krogh 2003; von Krogh et al. 2012). For example, Wiertz and de Ruyter (2007) point out that most open-source software communities are organized under the collective efforts of a group of individuals or nonprofit committees as independent development projects. In contrast, the members of firm-sponsored knowledge communities are typically part of the host company's platform ecosystem, which often consists of customers who have paid for the company's products and partners who have helped develop add-on products or services on top of the sponsoring firm's product platforms. As a result, members in these communities often desire recognition from the sponsoring firm (Jeppesen and Frederiksen 2006) and may derive career benefits from their participation activities (Huang and Zhang 2016). In addition, many of the firm-sponsored knowledge communities are used for peer support among customers, so the host company benefits in the form of reduced support costs and other valuable by-products (e.g., customer feedback, user-created innovation, stronger relationships) as a result of peer-to-peer problem solving.

The second stream of literature that is most relevant to our work is a small but emerging body of research that focuses on how organizations that sponsor online communities can foster user engagement (Liu et al. 2014; Porter and Donthu 2008; Porter et al. 2011). For example, Porter et al. (2011) show that three types of sponsor efforts are particularly effective in encouraging user participation: encouraging users to contribute high-quality content, cultivating connections among members, and creating enjoyable experiences for community users. Moreover, survey research by Porter and Donthu (2008) reveals that sponsor efforts to foster member embeddedness and to provide access to quality content build trust among virtual community users. Liu et al. (2014) report that a series of host-firm management practices, such as promoting user interaction and organizing offline activities, induce a higher level of user knowledge contribution through the mediating effect of social capital, while providing explicit incentives has a detrimental effect. Chen et al. (2012) find that both peer feedback and sponsoring-firm feedback encourage participants to contribute on Dell's IdeaStorm, an online platform that allows Dell's customers to provide ideas related to its products and services. Comparing autonomous (community-managed) open-source communities and sponsored open-source communities, West and O'Mahony (2008) analyze three community design decisions that community sponsors make—the organization of production, governance, and intellectual property—and conclude that managing the tension between providing unfettered opportunities for outside participation and retaining a controlling influence over the communities to ensure goal alignment is critical for user participation and community growth. In addition, recent studies have found that gamification—that is, using game mechanisms and techniques in nongame contexts—is increasingly adopted by online community sponsors as a means to stimulate greater user engagement (Kankanhalli et al. 2012), and empirical studies lend support to the effectiveness of such mechanisms (Cavusoglu et al. 2015; Li et al. 2012).

Hypotheses

Sponsor Knowledge Investments and User Knowledge Contributions

As we noted previously, prior research highlights the difficulty of building successful virtual communities and attracting sustained user participation (Porter et al. 2011). While some researchers have proposed that efforts from a community sponsor are a critical determinant of online community success (Kim 2000), empirical evidence is lacking with regard to the various types of efforts sponsors make and how effective they are (Porter and Donthu 2008).

We extend prior work by arguing that a particular form of sponsor effort—namely, *knowledge investment* made by the community sponsors, or *knowledge seeding*—is likely to stimulate greater user contribution to the open knowledge community. Community sponsors may make knowledge investments in a variety of ways, such as posting wiki articles and tutorials on virtual communities, sharing source code of some applications and tools, or providing free technical support by answering questions posted by knowledge seekers in the discussion forums.

We argue that user knowledge contribution to an online knowledge community is a function of two key factors: community users' *propensity* to contribute and their knowledge contribution *capacity*. We define *user contribution propensity* as a dispositional willingness to make useful knowledge contributions to the community. We define *user contribution capacity* as a user's ability to assemble appropriate practice-related knowledge and prior usage experience, conduct independent research and experimentation, and make a useful knowledge contribution to the community.

Why should sponsor knowledge investment influence community users' knowledge contribution? Consider first the effect of sponsor knowledge seeding on users' contribution propensity. Prior research suggests that the effectiveness of knowledge exchange is influenced by prosocial attitudes and organizational norms (Constant et al. 1996; Nambisan and Baron 2010). In particular, trust—the belief that the other party will refrain from opportunistic behavior and will not take advantage of the situation (Hosmer 1995)—is a precondition that needs to be developed to promote positive outcomes and sustain repeated interactions among virtual community members, who are typically a group of strangers (Ridings et al. 2002). The *social perspective* of trust emphasizes a moral obligation toward others, arguing that actions taken by one party in an exchange relationship often result in reciprocated actions by another party (Jarvenpaa et al. 1998). For example, a firm's benevolent action toward a customer may lead to a sense of moral obligation on the customer's part such that he or she will perform an act of reciprocity to restore equality in the relationship with the firm (Wulf et al. 2001). In contrast, the *rational perspective* of trust emphasizes self-interest and maintains that trust lowers transaction costs by reducing the need for self-protective actions in the event of the other party's opportunistic behavior, thereby facilitating risk-taking behavior (Jarvenpaa et al. 1998; Mayer et al. 1995).

We argue that sponsor knowledge investment is conducive to building trust between community members and the community sponsor, leading to a greater propensity of the members to contribute. This is because by sharing valuable knowledge in the public domain and, in some instances, committing resources to provide free technical support to community members, the community sponsor demonstrates that it genuinely cares about the well-being of the community members beyond its own profit-seeking motivations, therefore reinforcing community members' beliefs in the sponsor's benevolence (Porter and Donthu 2008). This, in turn, leads to community members' increased willingness to create value for the sponsoring firm by contributing their own knowledge to the community. In addition, the commercial context of a firm-sponsored community often creates a sense of insecurity in that community members may fear that their knowledge contribution may be misappropriated by the community sponsor for commercial use (Boudreau and Lakhani 2009; Lakhani and Panetta 2007; Lee and Cole 2003; Spaeth et al. 2015), which can hinder information sharing. When a sponsoring firm commits to sharing knowledge in the public domain and makes a consistent effort to help community members solve the issues they encounter in their daily work, the community members will view this commitment as a signal that the sponsor has a genuine interest in fostering the community and will not engage in opportunistic behavior that goes against the interests of the community members. As such, trust in the sponsor's integrity motivates community members to overcome their risk aversion and contribute knowledge to the community (Jarvenpaa et al. 1998).

Second, knowledge seeding enhances users' knowledge contribution *capacity*. A community sponsor's knowledge investments are likely to facilitate the diffusion of knowledge related to its products and services, thereby enhancing the body of knowledge the community users possess. Prior research has emphasized the role of learning as a key benefit of user participation in networks of practice (Brown and Duguid 1991; Wenger and Snyder 2000). Generating new knowledge, particularly in a community context, is an incremental and cumulative process (Prasarnphanich and Wagner 2009). Therefore, the extent of users' knowledge contributions to the community depends on their domain expertise and ability to discover existing knowledge, conduct independent investigations and experiments, recombine ideas shared by peer members, and find novel solutions. When the community sponsor makes knowledge investments to seed the community, there are more ways that the sponsor-contributed knowledge can be related to users' own experiences and recombined with existing users' knowledge to generate new ideas, leading to greater capacity of the community users to contribute their own knowledge. For example, Benbya and Van Alstyne (2011) show that to initiate a knowledge management community and elicit useful user contributions, it is important for the sponsor to seed the community with critical knowledge that solves the most pressing user problems.

Note that by providing knowledge seeding, the community sponsor may also risk undermining users' incentive to contribute their own knowledge, by creating a *crowding-out* effect. For example, in a study of an open-source software community, Kuk (2006) underscores that participation inequality—that is, participation that is concentrated on a few highly motivated members to the extent that they monopolize discussion—can crowd out others' contributions and ultimately be detrimental to knowledge sharing. However, the monopolization of discussion by a few prominent members is unlikely in communities with a large population, such as the one we study. Synthesizing prior work, we propose that a community sponsor's knowledge investments will increase both the community users' propensity and their capacity to contribute knowledge, and the positive impact of sponsor knowledge seeding will dominate the crowding-out effect. Because our unit of analysis is the user group in a country (see the "Methods" section), we hypothesize the following:

> H1: *In a firm-sponsored knowledge community, a greater amount of sponsor knowledge investment in a country's community users will stimulate a higher level of average user contribution from the country.*

How Returns on Sponsor Knowledge Investments Vary over Time

Although we argued in the previous section for a positive return on sponsor knowledge investment in terms of the amount of user knowledge contribution it stimulates, we also expect a temporal variation in the returns on sponsor knowledge investment. We argue that the return on knowledge seeding is likely to diminish gradually because of the changing composition of the members in the community over time. Prior research on knowledge communities has emphasized the role of lead users (Franke et al. 2006; Jeppesen and Laursen 2009; Morrison et al. 2004; Morrison et al. 2000; Von Hippel 1986). Lead users distinguish themselves in several respects: they are more likely to innovate, and they experience needs ahead of the mass market (Morrison et al. 2000; Urban and Von Hippel 1988). In the context of networks of practice, lead users usually have up-to-date knowledge related to the practice in question and thus have a higher propensity to contribute knowledge to the online communities (Jeppesen and Laursen 2009).

In addition, lead users tend to be early adopters of the product or service (Jeppesen and Laursen 2009; Morrison et al. 2004; Morrison et al. 2000; Urban and Von Hippel 1988; Von

Hippel 1986). Therefore, in the early stage, when a knowledge community is being established, we expect that the community will attract a disproportionally large fraction of lead users, who are early adopters of the technology and more likely to make knowledge contributions. As a result, sponsor knowledge investment is likely to stimulate stronger responses from these lead users and thus generate a higher rate of return. However, in later stages, when the community reaches a more mature phase, there will be a smaller fraction of lead users among the community members it attracts, and the community will consist of a larger fraction of late adopters with lower contribution capacities, leading to reduced average user knowledge contribution in response to sponsor knowledge investments. In summary, we propose the following:

> H2: *In a firm-sponsored knowledge community, the age of the community negatively moderates the return on sponsor knowledge investment (i.e., the positive effect of sponsor knowledge investment on stimulating average user contribution is smaller when the community is in mature stages).*

How Returns on Sponsor Knowledge Investments Vary by Geography

We also expect a variation in the returns on sponsor knowledge investment due to the absorptive capacity of the heterogeneous user populations in the community. Organizational learning occurs at different rates because organizations differ in their absorptive capacities, or their abilities to assimilate, and utilize new external knowledge (Cohen and Levinthal 1990; Lane and Lubatkin 1998; Zahra and George 2002a). Absorptive capacity is important for the long-term success of organizations because it strengthens, complements, and refocuses the organization's knowledge base (Zahra and George 2002a). Many have argued that the development of absorptive capacity is usually path dependent; that is, it requires investments in prior related knowledge (Lane and Lubatkin 1998; Roberts et al. 2012). For example, prior studies have emphasized that a firm's ability to assimilate externally generated knowledge is dependent on the firm's own R&D efforts and IT capabilities (Cohen and Levinthal 1989; Ravichandran et al. 2017; Saldanha et al. 2017).

We argue that a country's IT infrastructure is an important determinant of the collective absorptive capacity of the community user population from the country, particularly in the processes of assimilation and application of IT-related external knowledge. Prior studies suggest that combining IT investments with other complementary assets strengthens firms' digital capabilities and, in turn, their absorptive capacity (Gold et al. 2001; Saldanha et al. 2017). Technology infrastructure can enhance knowledge management practices through the use of IT systems for business intelligence, collaboration, distributed learning, knowledge discovery, knowledge mapping, opportunity generation, and security (Dedrick et al. 2013; Ravichandran et al. 2017). Indeed, Zahra and George (2002b) conceptualize knowledge management as an IT-driven capability. In addition, the path-dependency assumption implies that development of IT-related absorptive capacity hinges on prior investments in IT infrastructure, and greater absorptive capacity in one period allows for more efficient accumulation of knowledge in the next period, resulting in positive feedback (Roberts et al. 2012).

Research on interorganizational knowledge transfer also suggests that the lack of absorptive capacity may limit the degree to which knowledge is successfully transferred from the source to the recipient (Alavi and Leidner 2001; Szulanski 1996). Malhotra et al. (2005) argue that by building IT infrastructure that enables efficient processing of information in external partner networks, organizations develop abilities to acquire, assimilate, transform, and exploit market knowledge. Empirically, studies conducted in the context of enterprise software show that the transfer of enterprise resource planning-related knowledge from consultants to their clients is greatly influenced by the clients' absorptive capacity (Ko et al. 2005; Xu and Ma 2008), because prior related knowledge and knowledge diversity lower the knowledge barrier of implementing complex technologies.

Applying this line of logic to our context of study, we propose that when a community sponsor makes knowledge investments on behalf of its community members, the knowledge bases that user populations from different countries possess will expand at different rates because they have different rates of learning. In particular, the user population from a country with a higher level of IT infrastructure is likely to have a greater absorptive capacity and will therefore be better at recognizing the value of new knowledge, assimilating it, and putting it to productive use. Because of the recursive relationship between absorptive capacity and learning (Roberts et al. 2012), the knowledge bases of countries with higher levels of IT infrastructure grow at a faster rate, resulting in a higher knowledge contribution *capacity* of community user populations from these countries. Thus, all else being equal, sponsor knowledge investments should stimulate a higher level of user contribution from these countries. Therefore, we propose the following:

> H3: *In a firm-sponsored knowledge community, a country's IT infrastructure positively moderates the return on sponsor knowledge investment in that country (i.e., the positive effect of sponsor*

knowledge investment on stimulating average user contribution is greater when a country has higher levels of IT infrastructure).

Methods

Research Context

Our research setting is the online knowledge community created by SAP, the largest enterprise software vendor by revenue. As part of its platform strategy, SAP established its Internet-based SAP Community Network (SCN) in 2004, with SAP Developer Network (SDN) and Business Process Expert (BPX) as its two major modules (see https://www.sap.com/community.html). SCN serves as a resource repository and a platform for SAP users, developers, architects, consultants, and system integrators to collaborate and exchange knowledge about the adoption, implementation, and customization of SAP solutions. SCN hosts forums, expert blogs, a technical library, article downloads, a code-sharing gallery, e-learning catalogs, wikis, and other facilities through which its members contribute their knowledge. These technologies support open communication between the active members of the community, which numbered more than 1.2 million people around the world from over 9,000 companies by 2008 (Hagel and Brown 2008), making it one of the most successful firm-sponsored open knowledge communities.

We have chosen enterprise software as the background for measuring user contribution because the adoption of complex IT platforms such as enterprise software often requires complementary, specialized knowledge to unlock their productivity. Enterprise software products are highly business-process oriented and usually need to be customized to fit specific business practices, where idiosyncratic local needs tend to drive complementary user innovations in workplaces (Hitt et al. 2002; Von Hippel 2005). An accumulation of specialized knowledge and user innovation is likely to result during this process of adaption and customization, and such knowledge is particularly susceptible to sharing through electronic channels.

A unique feature of SCN is that user contributions in this network can be quantified through its design mechanisms. To motivate active participation, SAP adopted a contributor recognition program (CRP), which awards points to community members for each technical article, code sample, video, wiki contribution, forum post, and weblog authored. For example, in the case of forum discussion participation, 2, 6, or 10 points may be awarded for forum posts in reply to existing threads marked as questions, depending on the helpfulness of the answer. Similarly, awards with varying points are given for contributing other resources such as code samples, wikis, videos, podcasts, or e-learning materials. In addition, anyone who registers as a member also provides basic personal information and builds a user profile. One field of this profile information is the user's country, which is required during user registration. Other identifying information includes company affiliation, relationship to SAP (e.g., client, employee, partner), e-mail address, phone number, expertise, LinkedIn profile page, and so forth. Figure 1 presents a sample user profile.

SAP, as the sponsor of the community network, makes significant investments to cultivate its platform ecosystem and to encourage user participation. For example, in the early days when the CRP was adopted, to encourage user participation and contribution, the reward points that a user earned could be redeemed for merchandise, such as T-shirts or mugs on from SAP online store (Mollenhauer 2003). Furthermore, in 2008, to encourage continued participation in SCN, SAP promised to donate €100,000 to the United Nations World Food Program if the collective contribution made by all users, measured by total reward points, exceeded a certain amount. The program was welcomed and has exceeded the target numbers, resulting in SAP doubling its commitment to €200,000 (Yolton 2008). But the most significant investment SAP has made is in the form of the human resources it commits to the community. Not only does SAP have fully dedicated employees who act as community moderators and create content via tutorials, blogs, and wikis, it also encourages its employees to directly interact with users in the community to provide free technical support to the community users. For example, the data we collected from discussion forums reveal that more than 9,100 SAP employees have participated directly in forum discussions to provide answers to questions raised by knowledge seekers, and about 11% of all the resolved questions were solved by SAP employees.

Empirical Models

We specify user knowledge contribution on SCN as a function of factors that may influence the propensity or capacity of such activity:

$$Y_{it} = f(\boldsymbol{X}_{it}, \boldsymbol{Z}_{it}, S_{it})$$

In this model, Y_{it} is the amount of user knowledge contribution from country i to the online community in year t (normalized by the number of registered community users from country i in year t); $\boldsymbol{X}_{it}$ is a series of knowledge factors related to the SCN, such as the number of active SAP employees in the community from country i or the average member experience on SCN; $\boldsymbol{Z}_{it}$ is a set of socioeconomic factors,

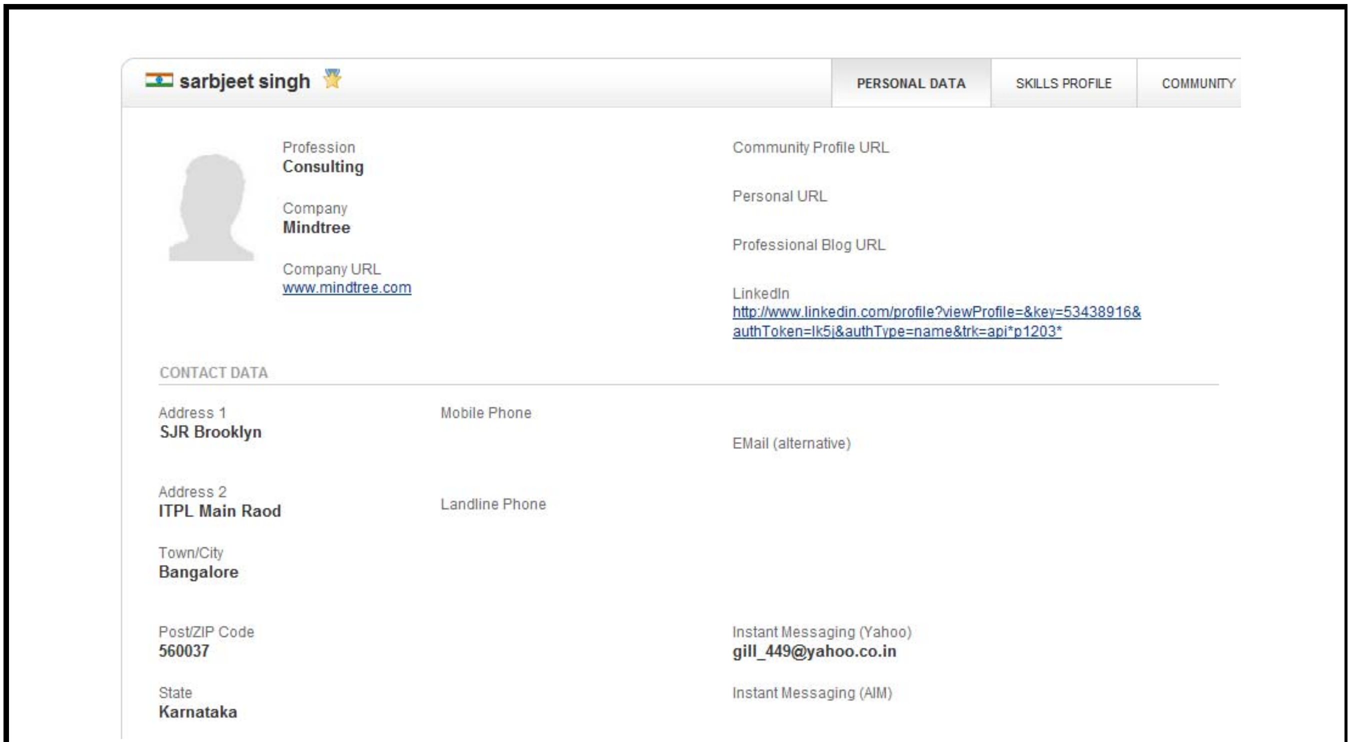

Figure 1. Sample User Profile

such as a country's labor force participation and the country's IT infrastructure; and S_{it} represents the sponsor's knowledge investment into the user group of the country through the online community (also normalized by the number of registered community users from country i in year t). Assuming a linear relationship between user knowledge contribution (in log form) and its factors, we specify a panel data fixed-effects model specified as follows:

$$lnY_{it} = \alpha + \boldsymbol{\beta}_1 \boldsymbol{X}_{it} + \boldsymbol{\beta}_2 \boldsymbol{Z}_{it} + \beta_3\, lnS_{it} + \delta_i + \mu_t + \varepsilon_{it}$$

where δ_i and μ_t are country and time period fixed effects, respectively. We can calculate the return on sponsor knowledge investment, or the output elasticity with regard to sponsor investment, as $\frac{\partial Y}{\partial S} \cdot \frac{S}{Y}$, which is equal to β_3.

To investigate variation in the returns on sponsor investment over time and the moderating effect of a country's IT infrastructure, we introduce the following model:

$$lnY_{it} = \alpha + \boldsymbol{\beta}_1 \boldsymbol{X}_{it} + \boldsymbol{\beta}_2 \boldsymbol{Z}_{it} + \beta_3\, lnS_{it} + \beta_4\, age_t + \beta_5\, IT_{it} \\ + \beta_6\, (lnS_{it}) * age_t + \beta_7\, (lnS_{it}) * IT_{it} + \delta_i + \mu_t + \varepsilon_{it}$$

where age_t is the age of the online community in year t and IT_{it} is the measure of IT infrastructure of country i in year t. For example, if the return on sponsor investment is indeed decreasing with the age of the community (as we predict in H2), we would expect a negative β_6. Similarly, if a country's IT infrastructure is associated with higher returns on sponsor investments, we would expect β_7 to be positive.

By using country-level fixed-effects models, our estimate is less likely to suffer from biases caused by slow-changing, unobserved heterogeneities, such as the industry composition, the official language, or other cultural factors of the country that may influence the rate of SAP technology platform adoption or user participation in the SCN. Because these factors are unlikely to change significantly over a short period of time, they are absorbed into country-level fixed effects (Angrist and Pischke 2008). We also control for year-level fixed effects, which would account for any common trends that influence the dependent variables over time.

Data and Variables

Dependent Variable

We use quality-weighted contributions made by a community user in forum discussions as a measure of user knowledge contribution to the community. Unlike some other communication channels on SCN, such as wikis or blogs, the reward points earned through forum discussions are peer-recognized and quality-adjusted, and therefore represent a more meaningful measure of user contribution. The primary purpose of the discussion forums is to provide an avenue for conversations between the community users so that they can help one another solve problems that they encounter during the implementation, deployment, and use of SAP software (Fahey et al. 2007). The forums are organized by domains of knowledge or expertise, each of which usually corresponds to a technical domain (e.g., the use of SAP software on Oracle databases), a particular SAP software module (e.g., the material management module), or the application of SAP in a particular industry (e.g., oil and gas).

Conversations in each forum are organized by discussion *threads*. Each thread is initiated by a knowledge *seeker*, who posts a specific question in a topic forum of his or her choice. Knowledge *contributors* post responses to the question and try to solve the problem. A discussion thread typically comprises a list of *messages*, and each message (either a question or an answer attempt) contains the information about the user who posts the message, the body of the message, and a time stamp. Once a correct answer (at the discretion of the knowledge seeker) is received, the discussion thread is closed. Community users may participate as both knowledge seekers and knowledge contributors on multiple discussion threads. For each question that is posted on SCN, the knowledge seeker may use his or her discretion to judge the quality of answers posted by knowledge contributors and distribute 10 reward points to a user who answers the question if the answer is deemed to be correct (at most, 1 answer per question can be rated as correct), 6 points if the answer is very helpful (at most, 2 answers per question), and 2 points if the answer is helpful (no limits per question).

Figure 2 presents excerpts from a sample discussion thread in the SAP Business Objects Design Studio forum; it includes a question, a correct answer, and a helpful answer. In this particular case, the knowledge contributor wrote a script using an API (application program interface) called "KPI Tile" to solve the problem raised by the knowledge seeker related to correctly displaying currency format under different regional settings.

We developed a web-scripting tool and obtained the complete history of forum discussions from 2004 to 2010. The dataset includes approximately 1.8 million discussion threads with more than 8 million messages posted in 240 forums. We aggregate the user contributions to create a country–year level panel dataset by using the country information in the user profiles. For country i and year t, we first retrieve the set of messages, M_{it}, that are answer attempts to existing questions by all the contributors from country i in year t. We then remove from M_{it} all the messages that are posted by SAP employees from country i because we are interested in user contributions rather than sponsor contributions, resulting in a reduced set, $\bar{M}_{it}$. Then, for each message m in $\bar{M}_{it}$, we examine if the message was rated as correct, very helpful, or helpful by the seeker who posted the question. If so, the corresponding reward points associated with the answer are added to a country–year sum, $User\ Contribution_{it}$.

Note that the country affiliation is based on the current contact address of a user rather than the country of origin, which implies that knowledge contribution by someone travelling internationally is attributed to that person's host country. Because every registered user must provide a country affiliation in his or her profile, there are no instances of missing data caused by this aggregation. We then normalize the user contribution by country i's number of registered community users in year t and use this as the dependent variable. In theory, the dependent variable—knowledge contribution—is subject to truncation issues because it is bounded by the knowledge demand of the knowledge seekers. However, we find that truncation does not actually happen in this empirical context, because only about a quarter of the questions raised by knowledge seekers are solved.

Figure 3 presents an illustration of the country-level user contribution (before normalization) from the top 10 most active countries on SCN during the sample period. We find that India, the United States, and Germany are the three most active countries. Among these three most active countries, users based in India contribute more knowledge to this repository than users in any other country, even though the United States has the largest installed user base of enterprise software and Germany is the home country of the sponsoring company that makes the product. This is consistent with the fact that India has become the global center of IT outsourcing and offshore IT services. In addition, we note that this online community has experienced rapid, exponential growth (note the y-axis is in logarithm scale) in the knowledge contribution activities, consistent with the rapid diffusion of enterprise software technology. However, the rate of growth tends to slow down after 2008 for the leading contributing countries, suggesting that the platform has reached a stage of maturity.

Independent Variables

We define sponsor knowledge investments into a specific country using forum discussions, similar to the way we define the dependent variable of user contributions. Intuitively, our

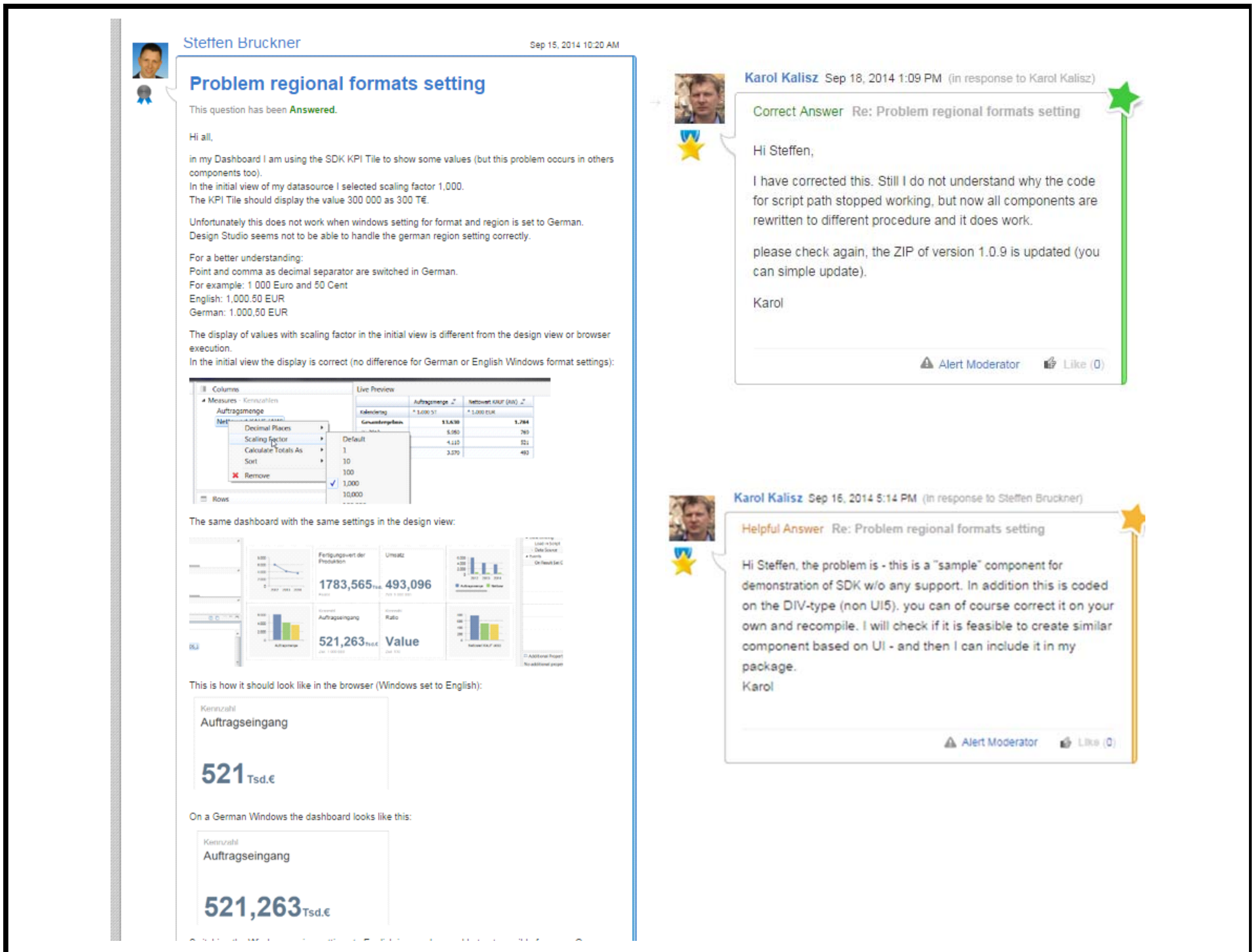

Figure 2. Sample Discussion Thread

variable captures the amount of effort SAP employees spent in answering the questions raised by knowledge seekers from a particular country. Specifically, for country *i* and year *t*, we first retrieve the set of questions, Q_{it}, that were raised by all the seekers from country *i* in year *t*. We then retrieve the set of messages that are answer attempts made by SAP employees in year *t* in response to all the questions in Q_{it}. We call this resulting set as S_{it}. Note that S_{it} includes answer attempts from SAP employees worldwide. Then, for each message *s* in S_{it}, we examine if the message was rated as correct, very helpful, or helpful by the seeker who posted the question. If so, the corresponding reward points are added to a country–year statistic, $Sponsor\ Investment_{it}$. Therefore, this variable measures the amount of quality-adjusted free technical support that SAP employees provide to the knowledge seekers in country *i* and year *t*. We normalize the sponsor investment by country *i*'s number of registered community users in year *t* and use this as the independent variable.

Figure 4 shows the levels of sponsor knowledge investments (before normalization) in the top 10 countries on SCN. Comparing Figure 4 and Figure 3, it is apparent that the returns on sponsor investment, as measured by user knowledge contribution, vary substantially from country to country. For example, Spain and Italy are among the top countries that received the greatest amount of investments from SAP, but neither country's users made significant contributions to the community. Conversely, although Singapore is a small country and did not receive a large amount of SAP investments, users from Singapore contributed a great deal of knowledge to SCN. These findings suggest that country-specific characteristics may have significant moderating effects on returns on sponsor knowledge investments in this online community.

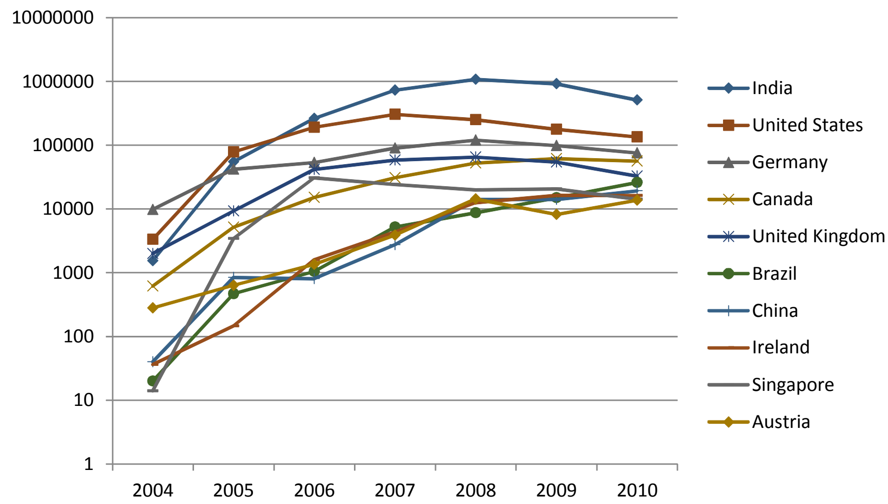

Figure 3. User Contributions of the Top 10 Countries

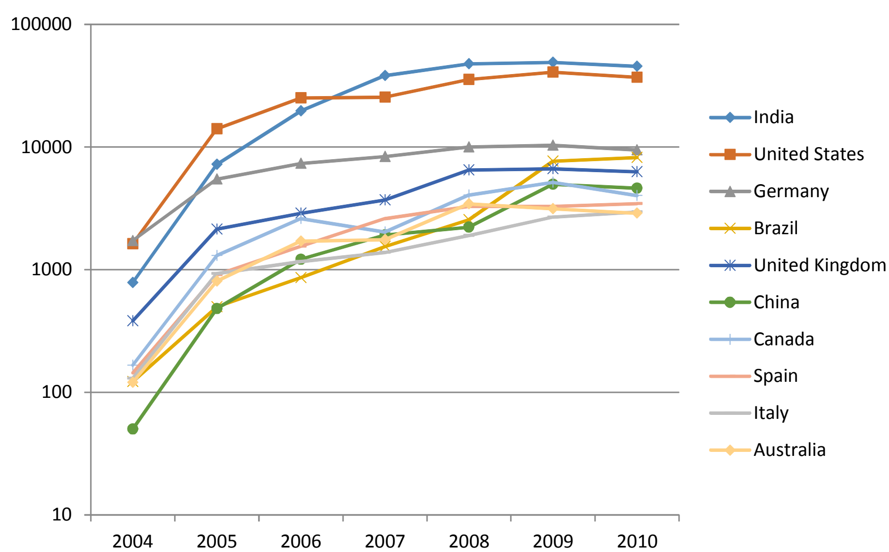

Figure 4. SAP Knowledge Investments in the Top 10 Countries

Moderator Variables

The key moderating variables of interest in this study are the country-level IT infrastructure and the age of the community. We use the number of secure Internet servers per million people as a measure of IT infrastructure (the data were retrieved from the World Bank database). Secure Internet servers use encryption technology in Internet transactions and are usually deployed to support enterprise-level web applications and e-commerce transactions. This is an appropriate measure because the context of our study is the online knowledge community of enterprise software.

To examine the pattern of the returns on sponsor investments over time, we use the age of the SCN. Because SCN was established at the beginning of 2004, the variable is constructed as (calendar year – 2004). Because our sample period is 2004–2010, the age variable ranges from 0 to 6.

Control Variables

A country's user knowledge contribution to SCN is likely to be driven by the accumulation of knowledge in the technology field, which is a function of the country's inputs into the focal technology ($\boldsymbol{X}_{it}$). To capture the effect of the accumulated knowledge base, we use several control variables. First, we control for the number of SAP employees in a country, particularly those who work in the technology field (instead of those who work in sales and marketing), because they help the accumulation and diffusion of knowledge related to SAP technology in the country. Precise data on the number of SAP employees in each country are not publicly available. However, many of SAP's technical personnel have registered for an account on SCN, and they actively participate in the forum discussions. Therefore, we retrieve the set of active SAP employees from each country i who posted at least one message in year t, and we use the aggregate counts of SAP employees who are active on SCN as a proxy to control for the number of SAP employees in each country i and year t.

Second, there may be some other forms of unobserved sponsor investments in the country that are correlated with knowledge seeding on SCN. For example, the sponsor's investments in providing training to its clients or its efforts in developing distribution channels and partner networks could lead to the accumulation and dissemination of knowledge related to its software products, which in turn results in more user contributions on SCN. To address this issue, we use the establishment of SAP offices in each country at different periods as a proxy for the sponsor's other general investments in the country. The underlying assumption is that setting up a local office is a decision that SAP makes based on its sales in the country and the size of the customer base; this variable represents significant investments that SAP makes outside of the online community. We visited the historical web pages (https://archive.org/), which contained the office contact information from the SAP websites in different countries at different time periods, and we construct a binary variable that indicates whether SAP had at least one office in the country in a particular year.

Third, the SCN user groups from different countries may have different levels of prior experience with SAP enterprise software, and such variations may be correlated with both sponsor knowledge investment and user knowledge contribution. Therefore, we explicitly control for the user group's average experience. We measure SCN members' prior experience by the number of years since they first registered on SCN and joined the community. We calculate the average member experience for each country–year observation and include this variable in the regressions.

Fourth, while SAP employees solve a fraction of the questions that are raised on the SCN, the majority of the questions are solved by the collective efforts of peer users other than SAP employees. If user contribution from country i is a function of the latter type of peer support (e.g., due to reciprocity) and the amount of peer support is correlated with sponsor investment, our estimate of the return on sponsor knowledge investment is biased. To address this concern, for each country i in year t, we derive the latter type of support from peer users (users other than SAP employees) and call this *peer support*. Consistent with our measure of sponsor investment, peer support is also normalized by a country's number of registered users. Our data show that users other than SAP employees contribute as much as 8.5 times the knowledge contribution of SAP employees (the mean sponsor investment in our sample is 637.6, while the mean peer support is 5459.7, before normalization).

We also collect information on country-level socioeconomic characteristics ($\boldsymbol{Z}_{it}$) that may influence the knowledge accumulation and contribution from a country's user group. For example, the availability of labor force could be correlated with sponsor investments in the country, which may produce biases in our estimate of the effects of sponsor investments on user contribution. We address this issue by incorporating the labor force participation rate into our regression. This variable represents the proportion of the population aged 15 years or older that is economically active, meaning that they supply labor for the production of goods and services during a specified period.[2]

Our final sample is organized in a panel data structure with 179 countries over a seven-year (2004–2010) period. The total number of observations is 1,155. Table 1 and Table 2 present the summary statistics and the correlation of the key variables, respectively. We find that community users contribute most of the knowledge on SCN. As Mark Finnern, the SAP community evangelist, predicted, ultimately 90% of knowledge contribution comes from users (7.09 reward points for an average country–year) compared with about 10% of knowledge seeding from SAP (0.87 reward points for a country–year).

[2]We also tried to include several other socioeconomic factors such as gross domestic product, population, foreign direct investment, education level, level of urbanization, and so forth. However, none were statistically significant, and including them introduced multicollinearity issues. Therefore, we do not use them.

Table 1. Summary Statistics						
	Unit	**Obs**	**Mean**	**SD**	**Min**	**Max**
User contribution/per user	Reward points	1155	2.63	7.20	0.00	167.00
Sponsor knowledge investment/per user	Reward points	1155	0.87	1.91	0.00	35.00
IT infrastructure	Secure Internet servers per million people	1155	136.69	322.41	0.01	3229.81
Community age	Year	1155	3.10	1.98	0.00	6.00
Active SAP employees	Person	1155	13.66	76.42	0.00	863.00
SAP office	Binary	1155	0.40	0.49	0.00	1.00
Average member experience	Years	1155	1.11	0.95	0.00	6.00
Peer support/ per user	Reward points	1155	7.09	19.49	0.00	372.00
Labor force participation	Percent	1155	63.31	10.18	40.20	89.60

Table 2. Correlations										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	User contribution/per user	1.000								
2	Sponsor knowledge investment/per user	-0.014 (0.649)	1.000							
3	IT infrastructure	0.076 (0.015)	-0.019 (0.549)	1.000						
4	Community age	0.024 (0.449)	0.026 (0.410)	0.151 (0.000)	1.000					
5	Active SAP employees	0.130 (0.000)	-0.012 (0.693)	0.165 (0.000)	0.070 (0.017)	1.000				
6	SAP office	0.166 (0.000)	-0.034 (0.282)	0.261 (0.000)	0.017 (0.572)	0.216 (0.000)	1.000			
7	Average member experience	0.037 (0.233)	-0.062 (0.048)	0.255 (0.000)	0.755 (0.000)	0.122 (0.000)	0.201 (0.000)	1.000		
8	Peer support/per user	0.043 (0.170)	0.215 (0.000)	-0.031 (0.326)	0.033 (0.288)	-0.015 (0.626)	-0.091 (0.004)	-0.107 (0.001)	1.000	
9	Labor force participation	-0.095 (0.002)	0.056 (0.072)	0.022 (0.449)	0.024 (0.415)	-0.044 (0.133)	-0.201 (0.000)	-0.070 (0.017)	0.057 (0.067)	1.000

Note: Significance levels are in parentheses.

Results

Main Results

We use fixed-effects panel data models to investigate the role of sponsor investment in stimulating contributions from users to the online community, as well as the moderating effects of community age and country-level IT infrastructure. We enter the dependent variable—user knowledge contribution, normalized by the number of users—in its logarithm form into the regressions. In all the models, we also include indicator variables for each of the time periods (except for a reference period). We use the logarithm form for the continuous explanatory variables IT infrastructure, sponsor knowledge seeding, and peer support due to overdispersion of these variables and to allow for a more intuitive interpretation of the regression coefficients in terms of elasticities.

The results of fixed-effects panel data analyses appear in columns 5–8 of Table 3. We include both country and time-period fixed effects and use heteroskedasticity-robust standard errors that are clustered by countries in all the models. Across all the models, the variance inflation factors of all the explanatory variables are below 10, suggesting that multicollinearity

Table 3. How Sponsor Investments Influence User's Knowledge Contributions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS				Fixed Effects			
	Main Effect	Community Age Interactions	IT Infrastruc-ture Interaction	Community Age and IT Infrastruc-ture Interaction	Main Effect	Community Age Inter-actions	IT Infrastruc-ture Interaction	Community Age and IT Infrastruc-ture Interaction
Log(Spon. Inv.)	0.282*** (0.057)	0.486*** (0.083)	0.180** (0.076)	0.385*** (0.098)	0.191*** (0.055)	0.401*** (0.084)	0.081 (0.076)	0.292*** (0.104)
Log(Spon. Inv.) × community age		-0.068** (0.026)		-0.066*** (0.024)		-0.069*** (0.025)		-0.066*** (0.025)
Log(Spon. Inv.) × IT infrastructure			0.043* (0.023)	0.041* (0.023)			0.046* (0.026)	0.043* (0.025)
IT infrastructure	0.063* (0.032)	0.064** (0.032)	0.087*** (0.024)	0.087*** (0.024)	0.142 (0.137)	0.110 (0.140)	0.173 (0.139)	0.140 (0.142)
Log(SAP employees)	0.475*** (0.068)	0.474*** (0.069)	0.472*** (0.036)	0.471*** (0.036)	0.799*** (0.129)	0.798*** (0.128)	0.785*** (0.130)	0.785*** (0.129)
SAP office	0.182 (0.195)	0.211 (0.198)	0.173 (0.120)	0.201* (0.121)	0.094 (0.316)	0.043 (0.322)	0.083 (0.318)	0.034 (0.324)
Member experience	0.046 (0.076)	0.036 (0.075)	0.036 (0.054)	0.027 (0.054)	0.404*** (0.095)	0.356*** (0.094)	0.399*** (0.096)	0.352*** (0.095)
Log(Peer Support)	0.093** (0.041)	0.094** (0.041)	0.094*** (0.034)	0.095*** (0.034)	0.139*** (0.038)	0.130*** (0.038)	0.141*** (0.038)	0.133*** (0.038)
Labor force participation	0.005 (0.007)	0.005 (0.007)	0.006 (0.004)	0.005 (0.004)	0.116** (0.045)	0.110** (0.044)	0.113** (0.045)	0.107** (0.044)
Constant	-1.201** (0.466)	-1.600*** (0.517)	-1.537*** (0.337)	-1.649*** (0.340)	-8.484*** (2.835)	-7.836*** (2.777)	-8.336*** (2.856)	-7.719*** (2.791)
Country fixed effects	—	—	—	—	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155
R-squared	0.333	0.340	0.336	0.342	0.604	0.609	0.606	0.611
Number of countries	179	179	179	179	179	179	179	179

***p < 0.01; **p < 0.05; *p < 0.10.

Notes: Dependent variable is the logarithm of user contribution. Robust standard errors are in parentheses.

is not likely to produce biases in the estimate. For comparison purposes, we also present results from ordinary least squares (OLS) models with robust standard errors clustered by countries in columns 1–4 of Table 3. In columns 1 and 5, we present a baseline knowledge contribution model in which we include sponsor knowledge investments, age of the community, and IT infrastructure, together with country-level inputs into the community and socioeconomic factors. We find that country-level inputs into the community, such as the number of active SAP employees from the country, or average member experience, significantly predict user contribution.

We find support for H1 because sponsor knowledge investment is consistently positive and highly significant in columns 1 and 5. Specifically, the coefficient estimate of the fixed-effects model suggests that the output elasticity of sponsor knowledge investment is 0.191 ($p < 0.01$) (see column 5 in Table 3), which means that a 1% increase in sponsor investment leads to a 0.19% increase in user contribution. Interestingly, we find that an average user responds to sponsor investments more strongly than to peer support (with elasticity 0.191 versus 0.139); however, the difference is not statistically significant ($F(1, 178) = 0.49$, $p = 0.49$). The output elasticity of the OLS estimate (column 1) is slightly higher (0.282), but this is not surprising because the fixed-effect model uses only within-country variations.

To test H2, which states that the returns on sponsor knowledge investment vary over time, we add the interaction term between sponsor investment and community age, and we present the results in columns 2 and 6 of Table 3. We find support for H2, in that there is a decreasing return on sponsor investment over time; its interaction with age is significantly negative ($p < 0.01$), suggesting that the average output elasticity of sponsor investment is lower in mature stages of the community. The estimates from the fixed-effects model and the OLS model are highly similar.

To test H3, we run a regression model that incorporate the interaction between sponsor investment and IT infrastructure, and we present the results in columns 3 and 6. We find support for H3 ($p < 0.1$) in both the fixed-effects estimation and the OLS estimation, suggesting that the sponsor receives higher levels of user contribution from the same amount of investment when the investment is made in a country with higher levels of IT infrastructure.

We combine both the age interaction and the IT infrastructure interaction into a single model, and we present the results from the full model in columns 4 and 8 of Table 3. Again, we find strong support for both H2 and H3 in both the fixed-effects model and the OLS model. Based on the results of the fixed-effects model (column 8), the marginal effect calculations suggest that when other variables are held at the mean level, the output elasticity of sponsor investment is 0.409 ($p < 0.01$) when the community was first established (age = 0), and it drops to level of 0.210 ($p < 0.01$) when the community is four years old.[3] The output elasticity drops to 0.077 (and not significant) in year five and even further to 0.011 (and not significant) in year six.

In Figure 5, we plot the output elasticity with regard to sponsor knowledge seeding over the lifetime of the community with a 95% confidence interval. This illustrates the change in return on sponsor investment over time, which clearly indicates a decreasing trend.

Similar marginal effect calculations based on the results from column 8 reveal that IT infrastructure significantly moderates the return on sponsor investments. For example, when we hold other variables at the mean level, the output elasticity of sponsor investment is 0.184 ($p < 0.01$) when IT infrastructure is at the sample median level (where log[Internet servers per million people] = 2.28). The elasticity increases to 0.278 ($p < 0.01$) when IT infrastructure is at the third quartile of the sample (where log[Internet servers per million people] = 4.47) and drops to 0.113 ($p < 0.1$) when IT infrastructure is at the first quartile of the sample (where log[Internet servers per million people] = 0.64). Figure 6 intuitively illustrates the positive moderating effect of IT infrastructure on the rate of return on sponsor investment, plotting the output elasticity with a 95% confidence interval.

[3]We used the "margins" command in Stata to calculate these marginal effects.

Robustness Tests

We conduct a series of additional analyses using alternative variable measures and model specifications to demonstrate the robustness of our findings. First, there can be measurement error in our focal independent variable (sponsor knowledge investment) because we constructed it based on evaluations and feedback from knowledge seekers (i.e., users who post the questions). To the extent that some knowledge seekers are less able to judge the quality of answers or are less responsive in recognizing other people's help and providing feedback, our independent variable may underestimate the true level of effort provided by the sponsoring firm to support the user group in a country. We conduct a robustness test using an alternative definition of sponsor knowledge investment. For each question that is raised by a country's user, instead of aggregating the reward points associated with the answers provided by SAP employees, we simply count the number of answer attempts provided by SAP employees, regardless of whether they were voted as helpful by the knowledge seeker. We then aggregate the numbers over the set of questions raised by country *i* in year *t* to create a country–year level measure (normalized by the number of registered users), which we use as a proxy for the sponsor's investment in the country. We present the regression results using this alternative measure in column 1 (the main effect of sponsor investment) and column 2 (the interaction effects) of Table 4. These estimates suggest that our findings are robust to the use of this alternative measure, although the coefficient estimates differ due to the different unit of measurement (i.e., the number of answers versus reward points).

Second, while our measurement of IT infrastructure (i.e., the number of secure Internet servers per million people) captures important aspects of the use of IT in a country, it may not be a good indicator for individual-level or household-level Internet use. As an alternative, we use the number of Internet users per 100 people of a country to measure country-level IT infrastructure development. We obtained these data from the International Telecommunication Union database. Prior research has shown that Internet usage is an important incubator for facilitating information exchange and knowledge acquisition and a primary indicator of IT infrastructure (Forman 2005). We rerun our models using this alternative measure of IT infrastructure and present the results in column 3 (the main-effect model) and column 4 (the full model) of Table 4. The results are highly consistent with those from the baseline models.

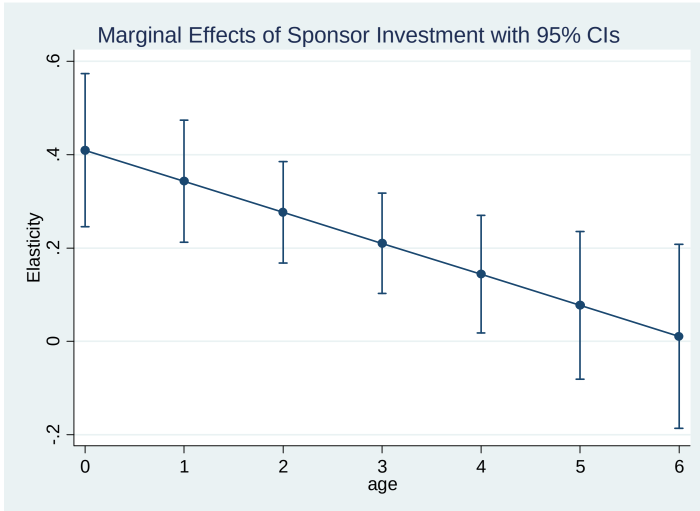

Figure 5. Marginal Return on Sponsor Knowledge Investments by Age of the Community

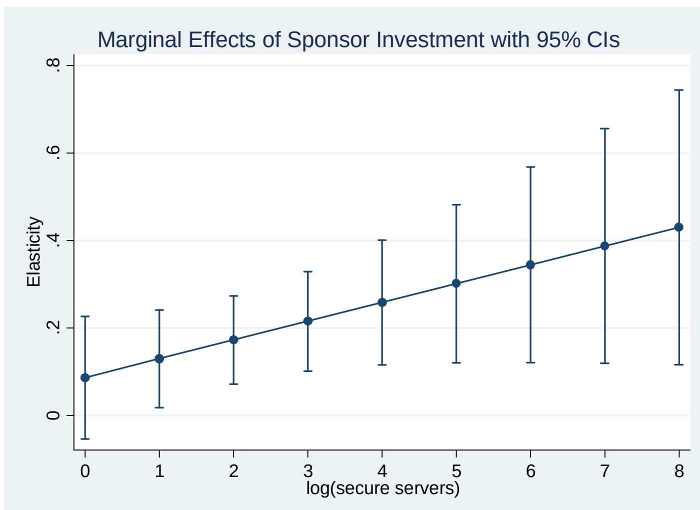

Figure 6. Marginal Return on Sponsor Knowledge Investments by IT Infrastructure

Third, as we discussed earlier in the paper, users from three countries—India, the United States, and Germany—are the most active and make significantly higher contributions to SCN than the other countries in our sample. It is possible that our estimates are disproportionally influenced by these three countries, whose user behaviors may be systematically different from users in the rest of the world. In column 5 (the main-effect model) and column 6 (the full model), we present models that exclude these top three countries from the sample and find that their exclusion results in little change to the coefficient estimates.

Fourth, because the set of year fixed effects do not fully control for the trend of the influence of sponsor knowledge investment on user knowledge contribution over time, we add a set of interactions (sponsor knowledge investment × year dummies) into the panel fixed-effects regressions. The results in column 7 (the main-effect model) and column 8 (the full model) suggest that the effect of knowledge seeding is even stronger after we control for the time trend.

Table 4. Additional Analyses and Robustness Tests										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Alternative Measure of Sponsor Investment		Alternative Measure of IT Infrastructure		Exclude Outliers		Add Log(Spon. Inv.) × Year Dummies		Dropping Controls	
	Main Effect	Inter-actions	Main Effect	Inter-actions	Main Effect	Inter-actions	Main Effect	Inter-actions	Main Effect	Inter-actions
Log(Spon. Inv.)	0.324*** (0.078)	0.336*** (0.100)	0.184*** (0.051)	0.300*** (0.095)	0.190*** (0.055)	0.289*** (0.105)	0.517*** (0.104)	0.401*** (0.124)	0.298*** (0.052)	0.399*** (0.104)
Log(Spon. Inv.) × community age		-0.048** (0.020)		-0.068*** (0.024)		-0.066*** (0.025)		-0.074*** (0.027)		-0.082*** (0.026)
Log(Spon. Inv.) × IT infrastructure		0.059*** (0.021)		0.004** (0.002)		0.043* (0.025)		0.041* (0.025)		0.054** (0.026)
IT infrastructure	0.141 (0.136)	0.158 (0.136)	0.014 (0.009)	0.015 (0.010)	0.147 (0.138)	0.144 (0.143)	0.096 (0.138)	0.126 (0.141)		0.406** (0.171)
Log(SAP employees)	0.753*** (0.126)	0.733*** (0.126)	0.805*** (0.128)	0.784*** (0.128)	0.791*** (0.135)	0.778*** (0.135)	0.774*** (0.132)	0.765*** (0.133)		
SAP office	0.073 (0.309)	0.022 (0.313)	0.037 (0.313)	-0.010 (0.318)	0.094 (0.315)	0.035 (0.324)	0.040 (0.320)	0.032 (0.322)		
Member experience	0.396*** (0.096)	0.355*** (0.099)	0.353*** (0.082)	0.295*** (0.083)	0.409*** (0.095)	0.356*** (0.096)	0.349*** (0.093)	0.347*** (0.094)		
Log(Peer Support)	0.131*** (0.038)	0.128*** (0.039)	0.129*** (0.036)	0.120*** (0.036)	0.137*** (0.038)	0.132*** (0.038)	0.125*** (0.038)	0.128*** (0.038)		
Labor force participation	0.121*** (0.045)	0.113** (0.044)	0.092** (0.043)	0.088** (0.042)	0.116** (0.046)	0.107** (0.046)	0.104** (0.044)	0.102** (0.044)		
Constant	-9.935*** (2.909)	-9.416*** (2.883)	-6.851** (2.689)	-6.404** (2.621)	-8.421*** (2.935)	-7.664*** (2.890)	-7.328*** (2.792)	-7.263** (2.806)	-0.253*** (0.083)	-1.756*** (0.547)
Log(Spon. Inv.) × Year dummies	—	—	—	—	—	—	Yes	Yes	—	—
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,155	1,155	1,155	1,155	1,134	1,134	1,155	1,155	1,155	1,155
R-squared	0.606	0.613	0.602	0.609	0.591	0.598	0.611	0.613	0.553	0.569
Number of countries	179	179	179	179	176	176	179	179	179	179

***p < 0.01; **p < 0.05; *p < 0.10.

Note: Dependent variable is the logarithm of user contribution. Fixed-effects panel data models are used in all columns. Robust standard errors are in parentheses.

Finally, beyond confirming that variance inflation factors are under 10 to mitigate concerns about multicollinearity, we take additional steps to address multicollinearity concerns due to the correlation between sponsor knowledge seeding and other control variables. We present the fixed-effects panel data estimates where we exclude all the control variables from the regressions in column 9 (the main-effect model) and column 10 (the full model). We find that the estimated effects of knowledge seeding are generally stronger, suggesting that multicollinearity issues, if any, tend to produce bias in the estimate toward zero.

Addressing Endogeneity Issues

Although using fixed-effect models effectively controls for the impact of many time-invariant sources of unobserved heterogeneity, there may be time-varying country-level characteristics that are correlated with both user knowledge contribution and our key independent variable, raising potential concerns about endogeneity. In addition, as the sponsor of the community, SAP may choose to provide more support to countries with more active users, leading to reverse-causality concerns. We discuss additional tests we conducted to alleviate endogeneity concerns.

First, because it is virtually impossible to control for all unobservables that may influence user contribution on SCN, we address potential concerns with regard to the endogeneity of sponsor investment using an Arellano–Bover/Blundell–Bond dynamic panel data estimation (Arellano and Bover 1995; Blundell and Bond 1998), which builds on the work of Arellano and Bond (1991). Dynamic panel estimates incorporate dynamic effects by adding a lagged dependent variable to the list of explanatory variables and use further lagged levels of the dependent variable and the first differences of exogenous variables as instruments to produce unbiased and efficient estimators for endogenous variables. The Arellano–Bover/Blundell–Bond estimator further improves the efficiency of the Arellano–Bond estimator by including lagged differences of the instruments. In column 1 (the main effect) of Table 5, we present the results of an Arellano–Bover/Blundell–Bond dynamic panel model in which we treat both vendor knowledge investment and peer support as endogenous variables, together with the set of instruments used in the model and the diagnostic tests. In column 2 (the full model) of Table 5 we estimate the Arellano–Bover/Blundell–Bond model in which we treat peer support, sponsor knowledge investment, and their interactions with age and IT as endogenous variables. In both models, we find that the estimates are consistent with our main results, thus mitigating concerns about endogeneity effects. In addition, the Arellano–Bond test for zero autocorrelation in first-differenced errors in both models rejects the null at the first order and cannot reject the null at the second order, indicating that our instruments are valid.[4] The validity of the instrumental variables is also confirmed by the Hansen J overidentification tests in both models.

Second, to reduce concerns related to the possibility of reverse causality, we tested a model in which we use the lagged value of vendor knowledge investment and peer support as explanatory variables. While user knowledge contribution may drive contemporaneous vendor knowledge seeding, it should not drive vendor knowledge seeding in the prior year. We present the results of this model, using both OLS and fixed-effects specifications, in Table 6. We find that the results are qualitatively similar to those from the baseline models presented in columns 1 and 5 of Table 3.

Third, to further investigate the extent to which our findings are robust to the presence of unobserved country-level heterogeneities, we construct a set of instrumental variables and use a panel two-stage least squares (2SLS) method to correct for possible bias caused by endogeneity of sponsor knowledge seeding. Specifically, we use the following three instruments, which are likely correlated with SAP's country-specific knowledge investment but are unlikely to influence user knowledge contribution on SCN:

1. *Regulatory quality of a country*: We retrieve this variable from the World Governance Indicators, published by the World Bank. It reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. A pro-business government is likely to attract an increasing amount of SAP knowledge investment to the country.

2. *Imports of goods and services by a country (% of GDP)*: A larger amount of imports represents a more attractive market for SAP; therefore, this variable is likely associated with greater SAP knowledge seeding.

3. *The dollar amount of R&D conducted by a country*: R&D is likely to increase complementary innovations that enhance the value of SAP products. However, because the R&D conducted by a country is unlikely to be specific to a firm, it should not drive up user knowledge contribution specific to SAP products.

Table 7 shows the results of the fixed-effects panel 2SLS estimation. In column 1, we report the results from the first-stage equation in which the three instrumental variables are used in combination with other exogenous variables to predict sponsor knowledge seeding. We find that all the instruments have a strong correlation with vendor investment in the first stage, and the Hansen J overidentification test does not suggest that the instruments are invalid. However, we acknowledge that the set of instruments is not ideal and may still be weak instruments, as suggested by the Cragg–Donald Wald F-statistic (5.70), which is below the Stock–Yogo critical value of 10% maximal instrumental variable relative bias. The second-stage results, presented in column 2, suggest that sponsor knowledge seeding has a positive effect on user knowledge contribution, even after we account for its endogeneity. The coefficient estimate of sponsor investment is larger than that from the fixed-effects models in Table 3, possibly due to the removal of the substitution effect between sponsor knowledge seeding and user contribution in the instrumental variables regression. The result suggests that the endogeneity caused by unobserved heterogeneities is likely to produce a downward bias, and the main fixed-effects models in Table 3 may be more conservative estimates.

Fourth, we conducted a falsification test using an exogenous event: the introduction of a gamification feature by SAP in the online knowledge community. SAP introduced a new feature in 2009 to the existing reputation system that awards

[4]For detailed discussion, see *Stata Longitudinal-Data/Panel-Data Reference Manual: Release 11* (Stata Press, 2009).

Table 5. Arellano–Bover/Blundell–Bond Dynamic Panel Data Estimation

	(1) Main Effect	(2) Interaction Effects
Lagged log(user knowledge contribution)	0.431*** (0.033)	0.390*** (0.024)
Log(Spon. Inv.)	0.099** (0.041)	0.161*** (0.060)
Log(Spon. Inv.) × community age		-0.041*** (0.014)
Log(Spon. Inv.) × IT infrastructure		0.002*** (0.001)
IT infrastructure	-0.006 (0.061)	-0.011 (0.035)
Log(SAP employees)	0.110 (0.075)	0.233*** (0.073)
SAP office	0.903*** (0.240)	0.925*** (0.149)
Member experience	0.484*** (0.090)	0.301*** (0.068)
Log(Peer support)	0.054** (0.025)	0.061*** (0.019)
Labor force participation	-2.008 (1.364)	0.022** (0.009)
Constant	-0.247 (0.240)	-3.112*** (0.676)
Year fixed effects	Yes	Yes
Model fit	Wald $\chi^2(13) = 322.86$ Prob > $\chi^2 = 0.0000$	Wald $\chi^2(15) = 1630.58$ Prob > $\chi^2 = 0.0000$
Arellano–Bond test for zero auto-correlation in first-differenced errors	First order z = -4.75, p = 0.000 Second order z = .90, p = 0.368	First order z = -4.89, p = 0.000 Second order z = .68, p = 0.494
Hansen test of overidentifying restrictions	χ^2 (54) = 60.71 Prob > χ^2 = 0.247	χ^2 (77) = 84.46 Prob > χ^2 = 0.262
Observations	1,007	1,007
Number of countries	179	179

***p < 0.01; **p < 0.05; *p < 0.10.

Notes:

Dependent variable is the logarithm of user contribution. Robust standard errors are in parentheses.

Instruments used in the main effect regression: Differenced equation: GMM type: L(2/.).user contribution, L(2/.).sponsor investment, L(2/.).peer support; standard type: first difference of all exogenous explanatory variables. Level equation: GMM type: LD.user contribution, LD.sponsor investment, LD.peer support; standard type: constant.

Instruments used in the interaction effects regression: Differenced equation: GMM type: L(2/.).user contribution, L(2/.).sponsor investment, L(2/.).sponsor investment × community age, L(2/.).sponsor investment × IT infrastructure, L(2/.).peer support; standard type: first difference of all exogenous explanatory variables. Level equation: GMM type: LD.user contribution, LD.sponsor investment, LD.sponsor investment × community age, LD.sponsor investment × IT infrastructure, LD.peer support; standard type: constant.

Table 6. Using Lagged Sponsor Investment and Peer Support as Independent Variables

	(1)	(5)
	OLS	**Fixed Effects**
Lagged Log(Spon. Inv.)	0.190*** (0.054)	0.118** (0.047)
IT infrastructure	0.068* (0.036)	-0.024 (0.157)
Log(SAP employees)	0.440*** (0.070)	0.367** (0.145)
SAP office	0.550** (0.226)	0.837 (0.529)
Member experience	-0.008 (0.075)	0.360*** (0.099)
Lagged Log(Peer support)	0.064 (0.045)	0.059 (0.044)
Labor force participation	0.006 (0.007)	0.101** (0.049)
Constant	-1.164** (0.495)	-8.330** (3.201)
Country fixed effects	—	Yes
Year fixed effects	Yes	Yes
Observations	1,007	1,007
R-squared	0.349	0.646
Number of countries	179	179

***p < 0.01; **p < 0.05; *p < 0.10.
Note: Dependent variable is the logarithm of user contribution. Robust standard errors are in parentheses.

platinum, gold, silver, and bronze medals as well as various badges to active contributors according to their contribution levels. SAP made the medals and badges highly visible, displaying the medals/badges in the user profiles of the contributors, in the discussion forums and blogs whenever the individuals make a post, and next to the individuals' names in the list of top contributors. The introduction of the medal/badge system by SAP represents a "natural experiment" that exogenously increases the visibility of the active contributors among their peers. Because the medal/badge system promotes the status of active contributors and their recognition among peer community users, we expect that after the event, the incentives of user contribution would depend less on vendor engagement and more on peer engagement. Therefore, we expect the elasticity of user contribution in response to vendor investment to drop and the elasticity of user contribution in response to peer support to increase after the event.

Because this event provides a shift in the incentives of user contribution but not a shock to vendor knowledge investment, we use this event to conduct a falsification test rather than as an instrument. We created a treatment variable, which is set to 1 after the event (in 2009 and 2010). We then interacted this variable with both sponsor investment and peer support and include the interactions in the regressions using both OLS and fixed-effects specifications. The results of this falsification test appear in Table 8. As we expected, in both models, the interaction with sponsor investment is negative, and the interaction with peer support is positive, suggesting that the effect of vendor knowledge seeding indeed becomes weaker after the event. Although this test does not fully rule out the possibility of unobserved heterogeneity, it circumscribes the nature of the unobserved heterogeneities; that is, if our results are driven by confounding factors, they must be factors that would give rise to similar patterns of interaction with the exogenous event of the introduction of gamification features. It is unlikely that a plausible explanation exists for how such potential confounding factors would also drive these interactions with gamification.

Finally, we assess the possible impact of an unobserved confounding variable by calculating the threshold value at which

Table 7. Instrumental Variables Regression		
	(1)	(2)
	2SLS Regression with Fixed Effects	
	First Stage Sponsor Investments	Second Stage User Contributions
Log(Spon. Inv.)		0.972*** (0.354)
IT infrastructure	0.206* (0.121)	-0.100 (0.164)
Log(SAP employees)	0.169*** (0.052)	0.652*** (0.114)
SAP office	0.036 (0.166)	0.054 (0.270)
Member experience	0.141* (0.075)	0.324*** (0.115)
Log(Peer support)	0.330*** (0.033)	-0.115 (0.125)
Labor force participation	0.022 (0.031)	0.103** (0.041)
Regulatory quality	0.418* (0.236)	
% of imports	0.011** (0.005)	
Log(R&D)	0.029** (0.012)	
Hansen J	2.55 (p = 0.28)	
F-test of excluded instruments	4.83 (p = 0.00)	
Cragg–Donald Wald F-statistic	5.70	
Stock–Yogo weak ID test critical values: 10% maximal IV relative bias	9.08	
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	1,039	1,039
Number of countries	164	164

***p < 0.01; **p < 0.05; *p < 0.10.
Note: Dependent variable (in second stage) is the logarithm of user contribution. Robust standard errors are in parentheses.

such a variable would render the effect of our focal variable (i.e., sponsor knowledge seeding) insignificant, using an approach similar to that used in other studies (Kim et al. 2014). Frank (2000) derives an index—the impact threshold for a confounding variable (ITCV)—that quantifies the impact of a confounding variable on the inference of a regression coefficient. The ITCV determines the minimum level of correlation that is required between the confounding variable and the focal variables to alter the estimated effect from statistically significant to insignificant. The higher the value of the ITCV, the more robust the estimated coefficient is to omitted variable concerns. For our model in column 1 of Table 3, the value of ITCV is 0.135, which implies that to invalidate the inference with regard to sponsor knowledge seeding, an omitted variable would have to be correlated at 0.32 with the independent variable (sponsor knowledge seeding) and at 0.34 with the outcome variable (user knowledge contribution) after controlling for the current set of covariates. We note that such threshold values for partial correlations are quite large: for example, among all the covariates we include in our regres-

Table 8. Falsification Test: Gamification Event

	(1) OLS	(5) Fixed Effects
Log(Spon. Inv.)	0.345*** (0.058)	0.248*** (0.061)
Log(Spon. Inv.) × treatment	-0.238* (0.131)	-0.218* (0.121)
IT infrastructure	0.063* (0.032)	0.120 (0.123)
Log(SAP employees)	0.476*** (0.069)	0.799*** (0.097)
SAP office	0.186 (0.198)	0.074 (0.251)
Member experience	0.051 (0.076)	0.394*** (0.077)
Log(Peer support)	0.064 (0.046)	0.108** (0.043)
Log(Peer support) × treatment	0.109* (0.060)	0.123** (0.059)
Labor force participation	0.005 (0.007)	0.121*** (0.035)
Constant	-1.666*** (0.514)	-10.351*** (2.265)
Country fixed effects	No	Yes
Year fixed effects	Yes	Yes
Observations	1,155	1,155
R-squared	0.337	0.607
Number of countries	179	179

***p < 0.01; **p < 0.05; *p < 0.10.
Note: Dependent variable is the logarithm of user contribution. Robust standard errors are in parentheses.

sion, the largest correlation with sponsor knowledge seeding is 0.22 (peer support, as shown in Table 2), and the largest correlation with user knowledge contribution is 0.17 (SAP office, as shown in Table 2). Therefore, a confounding variable that simultaneously satisfies both conditions is very unlikely, which helps rule out the possibility of an omitted variable that would significantly falsify the effect of sponsor knowledge seeding on user knowledge contribution.

Together, these additional analyses provide confidence in the robustness of our results and suggest that endogeneity due to omitted variables or reverse causality is unlikely to provide a complete and alternative explanation of our findings. Note also that endogeneity does not always bias the coefficients of interest significantly (see Tambe and Hitt 2012), and the bias may even be negligible for studies that use more complex models with interactions (see Tambe et al. 2012), as is the case in our setting.

Discussion and Conclusions

Main Findings and Contributions

This study presents evidence on how sponsors of a knowledge community can stimulate user contributions through knowledge seeding (in our context, the sponsor's employees provide free technical support by answering questions posted in the discussion forums). Our theorizing and analyses yield three main findings that are robust to a variety of alternative explanations. First, we find that sponsor knowledge seeding is significantly associated with user knowledge contribution. By our conservative estimate, a 1% increase in the amount of knowledge investment by the sponsor into a country's user group is associated with an increase of 0.19% in user knowledge contribution from that country. This finding provides empirical evidence for arguments in prior work that suggest that corporate sponsors' investments in knowledge can contribute to building trust among community members (Jarvenpaa et al. 1998; Porter and Donthu 2008) and enhance the community users' overall body of knowledge (Benbya and Van Alstyne 2011).

Second, we find that the effect of sponsor knowledge seeding on user knowledge contribution shows temporal patterns, as we hypothesized. Specifically, sponsor knowledge seeding has diminishing returns over time. This finding concurs with the observation that lead users, the population that represents the most active contributors of knowledge in an online community, tend to be early adopters of the underlying technology and join the knowledge community in its nascent stages (Jeppesen and Laursen 2009; Morrison et al. 2004; Morrison et al. 2000; Urban and Von Hippel 1988; Von Hippel 1986).

Finally, our analyses reveal that sponsor knowledge seeding yields varying returns across different countries. Greater returns are realized when investments are made in countries with higher levels of IT infrastructure. We attribute the effect to the greater absorptive capacity of countries enabled by advanced IT capabilities (Ko et al. 2005; Malhotra et al. 2005; Szulanski 1996), which leads to a greater capacity to make user knowledge contributions. This finding points to the importance of considering a country's IT intensity when trying to understand geographical patterns in IT-enabled innovation or IT-enabled entrepreneurship across countries.

Overall, our results suggest that sponsoring firms can encourage user contributions by making investments in the form of knowledge seeding, and we provide insight into the conditions under which the outcomes are most favorable. This is a significant contribution because firm-sponsored knowledge communities are gaining popularity as companies aim to harness the collective wisdom of the members in their platform ecosystem (Chen et al. 2012; Mithas and Arora 2015; Nambisan and Baron 2010; Porter and Donthu 2008; Wiertz and de Ruyter 2007). Although these virtual communities are created for a variety of purposes, including gathering ideas for new product development (Di Gangi and Wasko 2009; Di Gangi et al. 2010), reducing costs related to product support (Nambisan and Baron 2007; Wiertz and de Ruyter 2007), and creating/sharing knowledge related to a firm's products and services (Huang and Zhang 2016), virtual community sponsors face significant challenges in fostering sustained user engagement (Porter et al. 2011) and are constantly seeking solutions to address these challenges.

Our findings provide a better understanding of the role of sponsor investments in their open knowledge communities and quantify returns on sponsor investments over time and across countries. We contribute to the small but emerging body of work that focuses on the actions that online community sponsors take to foster sustained user engagement and to encourage users' contributions to firm-sponsored virtual communities (Liu et al. 2014; Porter and Donthu 2008; Porter et al. 2011). An open question in the study of firm-sponsored communities is whether the sponsoring firm should take a proactive role in managing the virtual communities they create to influence community member behaviors. Prior research suggests that a community sponsor needs to walk a fine line between encouraging unrestricted outside participation and exerting control over the community to advance the goal of the sponsoring organization (O'Mahony and Ferraro 2007). For example, to attract talented contributors, the sponsor should provide skilled participants with more leadership opportunities, which could ultimately result in relinquishing some control over decision making to the community (West and O'Mahony 2008).

Implications for Research

From a theoretical perspective, our findings have several important implications. First, our findings reveal that firms can nurture knowledge contributions from other parties in their value ecosystems (i.e., customers, partners, and other complementors) by seeding the knowledge with their own employees' contributions, a strategy that is less likely to cause goal conflicts and can be implemented at a relatively low cost compared with other strategies, such as making significant investments in expensive customer relationship management or exerting rigid and hierarchical control over the conventional knowledge management systems (Majchrzak and Malhotra 2013).

Our study suggests several theoretical mechanisms behind the effectiveness of this strategy. Knowledge seeding by the community sponsor increases both users' propensity to make knowledge contribution through building trust toward the sponsor and their capacity to contribute through enhancing the community users' collective body of knowledge. It would be useful to extend our work by studying how sponsor investments help improve the human capital of users and other partners or provide opportunities for new product development to the sponsor organization. Another attractive area of inquiry would be to understand how other forms of sponsor firm investments facilitate innovation ecosystems that combine internal resources and external partners (Foerderer et al. 2018; Nambisan 2013; Yoo et al. 2012). For example, prior research suggests that the crowdsourcing of innovation requires overcoming challenges such as simultaneously encouraging competition and collaboration; developing creative abrasion, which requires some level of familiarity and is therefore unlikely to happen among a crowd of strangers; and facilitating time-consuming idea evolution among crowd members, who are generally time-constrained (Majchrzak and Malhotra 2013). It would be useful to understand how sponsors can manage such tensions creatively to mitigate diminishing returns on R&D (Ravichandran et al. 2017) and other investments through appropriate managerial interventions (Mithas et al. 2017) and by developing ambidextrous IT-enabled capabilities (Jarvenpaa 2014; Majchrzak and Malhotra 2013; Nambisan and Sawhney 2011; Saldanha et al. 2017).

Second, our findings showing temporal variations in returns on sponsor investments are informative because most prior studies have overlooked the fact that knowledge communities evolve over time and that their members belong to heterogeneous groups with different inclinations and capabilities to contribute. As a result, it was unclear whether the same management practice or investment strategy from the sponsoring firm may trigger different levels of response from different user groups. We show that firms can optimize their community management efforts by making smart investments at the right time and to the right target user groups, and we highlight the conditions under which their investments receive the greatest payoffs. Our analyses suggest that future research on firm-sponsored knowledge communities needs to consider the nature of heterogeneity among the targeted user groups—in particular, the role of a community's lead users and how the composition of the community's members changes over time. Future research should also consider the implications of a knowledge life-cycle approach in terms of human resources (HR) practices, IT practices, and types of IT systems that firms should deploy (Birkinshaw and Sheehan 2002). For example, some types of HR and IT practices may be more useful in early stages of the knowledge life cycle (e.g., creation, mobilization) than in later stages (e.g., diffusion, commoditization). Studies along these lines will help extend related work on how empowering HR practices for IT professionals interact with firm-wide information systems practices to enhance productivity (Tafti et al. 2015).

Third, our findings demonstrate that it is important to consider the role of country-level investments in IT infrastructure, which can facilitate the assimilation of knowledge investments made by the sponsors and generate higher levels of user knowledge contribution, thereby creating a virtuous cycle. The findings also suggest that it is important to consider the interdependence between firm-level decisions and economic context of a country to better theorize with respect to externalities and spillover effects associated with technology investments at the firm or country level. Our study also highlights the important role of country-level characteristics in determining IT investments (Shih et al. 2007) and how the returns on IT investments may be influenced by these country-level characteristics (Bloom et al. 2012).

Managerial and Policy Implications

Our findings have important managerial implications as well, especially for firms that are trying to develop communities for knowledge sharing and user innovation. For these firms, it is important to realize that knowledge investments made by a firm as the community sponsor can be particularly effective when the firm introduces new products or technology platforms that have significant learning curves. Providing free support through open knowledge communities helps users overcome learning hurdles and accelerates the adoption of the new products by building a knowledge repository to which users may have recourse.

While we focus on a particular form of knowledge seeding—providing free technical support—it should be noted that there are other means that are equally important, particularly when the underlying technology requires high levels of customization and adaptation. For example, in the case of software platforms, providing detailed documentation about the application programming interfaces (APIs) in the form of tutorials through wikis and blogs or sharing source code of sample programs through code repositories can help ignite creativity among users. As the community knowledge sponsors make knowledge-seeding investments to encourage contributions from the community, they can engage the users of their products to share their own experience and knowledge in the process, due to greater propensity and capacity among community users to contribute knowledge.

For firms that have limited resources to allocate in support of their online communities, our research also points to ways they can prioritize their knowledge investments to achieve the greatest return on their investments. For example, our findings show that firms need to pay particular attention to lead users, who tend to hold up-to-date knowledge about the products and are the most active contributors (Franke et al. 2006; Jeppesen and Laursen 2009; Morrison et al. 2004; Morrison et al. 2000; Von Hippel 1986). Implementing a contribution recognition reward system, such as the one adopted by SCN, can quantify users' knowledge contributions and help identify lead users. Firms could direct their limited resources to target lead users by addressing their most pressing questions and issues and rely on peer support to help the rest of the user population, such that most of the questions from the larger community of users can be answered by the lead users.

In addition, when firms aim to expand internationally and promote their products and services to less developed countries, they need to be aware of IT infrastructure limitations that might hinder the ability of user groups in a particular country to absorb the related knowledge, and they must take steps to compensate for those limitations. Firms should also realize that providing free technical support to users from these countries is more costly, because such investments are likely to yield a lower return from users in that country in terms of the user knowledge contributions they generate. At the same time, our findings suggest that policymakers should invest in country-level IT infrastructure to better capitalize on knowledge investments by firms that can have positive spillover benefits.

To conclude, this study uses fine-grained longitudinal data from the community network of SAP, a leading enterprise software vendor, to provide useful insights regarding how sponsors of digital platforms should engage with and invest in online communities to encourage knowledge contributions by members of their platform ecosystems. We document that sponsor knowledge seeding helps encourage more user knowledge contribution in online communities. In addition, the effect of sponsor knowledge seeding on user contribution decreases over time. We also find complementarity between sponsor knowledge seeding and country-level IT infrastructure. These important findings can help guide future research on online communities and firms' actions as they embrace more open models of knowledge and innovation management.

Acknowledgments

We thank senior editor Paul Pavlou, an anonymous associate editor, and three anonymous reviewers at *MIS Quarterly*, as well as seminar participants at the International Conference on Information Systems for helpful comments.

References

Alavi, M., and Leidner, D. E. 2001. "*Review*: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," *MIS Quarterly* (25:1), pp. 107-136.

Angrist, J. D., and Pischke, J.-S. 2008. *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton, NJ: Princeton University Press.

Arellano, M., and Bond, S. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *The Review of Economic Studies* (58:2), pp. 277-297.

Arellano, M., and Bover, O. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models," *Journal of Econometrics* (68:1), pp. 29-51.

Bayus, B. L. 2013. "Crowdsourcing New Product Ideas Over Time: An Analysis of the Dell IdeaStorm Community," *Management Science* (59:1), pp. 226-244.

Benbya, H., and Van Alstyne, M. W. 2011. "How to Find Answers Within Your Company," *MIT Sloan Management Review* (52:2), pp. 65-76.

Birkinshaw, J., and Sheehan, T. 2002. "Managing the Knowledge Life Cycle," *MIT Sloan Management Review* (44:1), pp. 75-83.

Bloom, N., Sadun, R., and Van Reenen, J. 2012. "Americans Do IT Better: US Multinationals and the Productivity Miracle," *The American Economic Review* (102:1), pp. 167-201.

Blundell, R., and Bond, S. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics* (87:1), pp. 115-143.

Boudreau, K. J., and Lakhani, K. R. 2009. "How to Manage Outside Innovation," *MIT Sloan Management Review* (50:4), pp. 68-76.

Brodie, R. J., Ilic, A., Juric, B., and Hollebeek, L. 2013. "Consumer Engagement in a Virtual Brand Community: An Exploratory Analysis," *Journal of Business Research* (66:1), pp. 105-114.

Brown, J. S., and Duguid, P. 1991. "Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning, and Innovation," *Organization Science* (2:1), pp. 40-57.

Cavusoglu, H., Li, Z., and Huang, K.-W. 2015. "Can Gamification Motivate Voluntary Contributions? The Case of StackOverflow Q&A Community," in *Proceedings of the 18th ACM Conference Companion on Computer Supported Cooperative Work and Social Computing*, New York: ACM, pp. 171-174.

Chen, L., Marsden, J. R., and Zhang, Z. 2012. "Theory and Analysis of Company-Sponsored Value Co-Creation," *Journal of Management Information Systems* (29:2), pp. 141-172.

Cohen, W. M., and Levinthal, D. A. 1989. "Innovation and Learning: The Two Faces of R & D," *The Economic Journal* (99:397), pp. 569-596.

Cohen, W. M., and Levinthal, D. A. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly* (35:1), pp. 128-152.

Constant, D., Sproull, L., and Kiesler, S. 1996. "The Kindness of Strangers: The Usefulness of Electronic Weak Ties for Technical Advice," *Organization Science* (7:2), pp. 119-135.

Dedrick, J., Kraemer, K. L., and Shih, E. 2013. "IT and Productivity in Developed and Developing Countries," *Journal of Management Information Systems* (30:1), pp. 97-122.

Dennis, A. R., and Vessey, I. 2005. "Three Knowledge Management Strategies: Knowledge Hierarchies, Knowledge Markets, and Knowledge Communities," *MIS Quarterly Executive* (4:4), pp. 399-412.

Di Gangi, P. M., and Wasko, M. 2009. "Steal My Idea! Organizational Adoption of User Innovations from a User Innovation Community: A Case Study of Dell IdeaStorm," *Decision Support Systems* (48:1), pp. 303-312.

Di Gangi, P. M., Wasko, M., and Hooker, R. 2010. "Getting Customers' Ideas to Work for You: Learning from Dell How to Succeed with Online User Innovation Communities," *MIS Quarterly Executive* (9:4), pp. 213-228.

Ebner, W., Leimeister, J. M., and Krcmar, H. 2009. "Community Engineering for Innovations: The Ideas Competition as a Method to Nurture a Virtual Community for Innovations," *R&D Management* (39:4), pp. 342-356.

El Sawy, O. A., Kraemmergaard, P., Amsinck, H., and Vinther, A. L. 2016. "How Lego Built the Foundations and Enterprise

Capabilities for Digital Leadership," *MIS Quarterly Executive* (15:2), pp. 141-166.

Fahey, R., Vasconcelos, A. C., and Ellis, D. 2007. "The Impact of Rewards Within Communities of Practice: A Study of the SAP Online Global Community," *Knowledge Management Research & Practice* (5:3), pp. 186-198.

Foerderer, J., Kude, T., Mithas, S., and Heinzl, A. 2018. "Does Platform Owner's Entry Crowd Out Innovation? Evidence from Google Photos," *Information Systems Research* (forthcoming).

Forman, C. 2005. "The Corporate Digital Divide: Determinants of Internet Adoption," *Management Science* (51:4), pp. 641-654.

Frank, K. A. 2000. "Impact of a Confounding Variable on a Regression Coefficient," *Sociological Methods & Research* (29:2), pp. 147-194.

Franke, N., Von Hippel, E., and Schreier, M. 2006. "Finding Commercially Attractive User Innovations: A Test of Lead-User Theory," *Journal of Product Innovation Management* (23:4), pp. 301-315.

Füller, J., Jawecki, G., and Mühlbacher, H. 2007. "Innovation Creation by Online Basketball Communities," *Journal of Business Research* (60:1), pp. 60-71.

Gawer, A., and Cusumano, M. A. 2002. *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation*, Boston: Harvard Business School Press.

Ghazawneh, A., and Henfridsson, O. 2013. "Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model," *Information Systems Journal* (23:2), pp. 173-192.

Gold, A. H., Malhotra, A., and Segars, A. H. 2001. "Knowledge Manaegment: An Organizational Capabilities Perspective," *Journal of Management Information Systems* (18:1), pp. 185-214.

Gruner, R. L., Homburg, C., and Lukas, B. A. 2014. "Firm-Hosted Online Brand Communities and New Product Success," *Journal of the Academy of Marketing Science* (42:1), pp. 29-48.

Hagel, J., and Brown, J. S. 2008. "How SAP Seeds Innovation," *BusinessWeek*, July 23 (http://www.businessweek.com/stories/2008-07-23/how-sap-seeds-innovationbusinessweek-business-news-stock-market-and-financial-advice).

Hinchcliffe, D., and Kim, P. 2012. *Social Business By Design: Transformative Social Media Strategies for the Connected Company*, San Francisco: Jossey-Bass.

Hitt, L. M., Wu, D. J., and Zhou, X. 2002. "Investment in Enterprise Resource Planning: Business Impact and Productivity Measures," *Journal of Management Information Systems* (19:1), pp. 71-98.

Hosmer, L. T. 1995. "Trust: The Connecting Link Between Organizational Theory and Philosophical Ethics," *Academy of Management Review* (20:2), pp. 379-403.

Huang, P., Ceccagnoli, M., Forman, C., and Wu, D. J. 2012. "Network of Practice, IT Knowledge Spillovers, and Productivity: Evidence from Enterprise Software," in *Proceedings of the Workshop on Information Systems and Economics*, Orlando, FL.

Huang, P., and Zhang, J. 2016. "Participation in Open Knowledge Communities and Job-Hopping: Evidence from Enterprise Software," *MIS Quarterly* (40:3), pp. 785-806.

Jarvenpaa, S. L. 2014. "Open Innovation: A New Paradigm in Innovation Management," in *Computing Handbook, Third Edition: Information Systems and Information Technology (Volume 2),* H. Topi and A. Tucker (eds.), Boca Raton, FL: Chapman and Hall/CRC Press.

Jarvenpaa, S. L., Knoll, K., and Leidner, D. E. 1998. "Is Anybody Out There? Antecedents of Trust in Global Virtual Teams," *Journal of Management Information Systems* (14:4), pp. 29-64.

Jeppesen, L. B., and Frederiksen, L. 2006. "Why Do Users Contribute to Firm-Hosted User Communities? The Case of Computer-Controlled Music Instruments," *Organization Science* (17:1), pp. 45-63.

Jeppesen, L. B., and Laursen, K. 2009. "The Role of Lead Users in Knowledge Sharing," *Research Policy* (38:10), pp. 1582-1589.

Jeppesen, L. B., and Molin, M. J. 2003. "Consumers as Co-Developers: Learning and Innovation Outside the Firm," *Technology Analysis & Strategic Management* (15:3), pp. 363-383.

Kankanhalli, A., Taher, M., Cavusoglu, H., and Kim, S. H. 2012. "Gamification: A New Paradigm for Online User Engagement," in *Proceedings of the 33rd International Conference on Information Systems*, Orlando, FL.

Kim, A. J. 2000. *Community Building on the Web: Secret Strategies for Successful Online Communities*, Boston: Addison-Wesley Longman Publishing Co., Inc.

Kim, K., Mithas, S., Whitaker, J., and Roy, P. K. 2014. "Industry-Specific Human Capital and Wages: Evidence from the Business Process Outsourcing Industry," *Information Systems Research* (25:3), pp. 618-638.

Kleis, L., Chwelos, P., Ramirez, R. V., and Cockburn, I. 2012. "Information Technology and Intangible Output: The Impact of IT Investment on Innovation Productivity," *Information Systems Research* (23:1), pp. 42-59.

Ko, D.-G., Kirsch, L. J., and King, W. R. 2005. "Antecedents of Knowledge Transfer from Consultants to Clients in Enterprise System Implementations," *MIS Quarterly* (29:1), pp. 59-85.

Kuk, G. 2006. "Strategic Interaction and Knowledge Sharing in the KDE Developer Mailing List," *Management Science* (52:7), pp. 1031-1042.

Lakhani, K. R., and Panetta, J. A. 2007. "The Principles of Distributed Innovation," *Innovations* (2:3), pp. 97-112.

Lakhani, K. R., and von Hippel, E. 2003. "How Open Source Software Works: 'Free' User-to-User Assistance," *Research Policy* (32:6), pp. 923-943.

Lane, P. J., and Lubatkin, M. 1998. "Relative Absorptive Capacity and Interorganizational Learning," *Strategic Management Journal* (19:5), pp. 461-477.

Lee, G. K., and Cole, R. E. 2003. "From a Firm-Based to a Community-Based Model of Knowledge Creation: The Case of the Linux Kernel Development," *Organization Science* (14:6), pp. 633-649.

Lerner, J., and Tirole, J. 2002. "Some Simple Economics of Open Source," *The Journal of Industrial Economics* (50:2), pp. 197-234.

Li, Z., Huang, K.-W., and Cavusoglu, H. 2012. "Quantifying the Impact of Badges on User Engagement in Online Q&A Communities," in *Proceedings of the 33rd International Conference on Information Systems*, Orlando, FL.

Liu, H., Zhang, J., Liu, R., and Li, G. 2014. "A Model for Consumer Knowledge Contribution Behavior: The Roles of Host

Firm Management Practices, Technology Effectiveness, and Social Capital," *Information Technology and Management* (15:4), pp. 255-270.

Majchrzak, A., and Malhotra, A. 2013. "Towards an Information Systems Perspective and Research Agenda on Crowdsourcing for Innovation," *Journal of Strategic Information Systems* (22:4), pp. 257-268.

Malhotra, A., Gosain, S., and El Sawy, O. 2005. "Absorptive Capacity Configurations in Supply Chains: Gearing for Partner-enabled Market Knowledge Creation," *MIS Quarterly* (29:1), pp. 145-187.

Mayer, R. C., Davis, J. H., and Schoorman, F. D. 1995. "An Integrative Model of Organizational Trust," *Academy of Management Review* (20:3), pp. 709-734.

Mithas, S., and Arora, R. 2015. "Lessons from Tata's Corporate Innovation Strategy," *IEEE IT Professional* (17:2), pp. 2-6.

Mithas, S., Whitaker, J., Lee, D., Srivastava, S. C., and Arora, R. 2017. "Managing Trade-Offs in Innovation Outcomes: Evidence from a Leading Conglomerate," Working Paper, University of Maryland.

Mollenhauer, R. 2003. "Key Functionalities of SAP Community," in *Human–Computer Interaction—INTERACT'03,* M. Rauterberg, M. Menozzi, and J. Wesson (eds.), Amsterdam, IOS Press, pp. 1109-1110.

Moon, J. Y., and Sproull, L. S. 2008. "The Role of Feedback in Managing the Internet-Based Volunteer Work Force," *Information Systems Research* (19:4), pp. 494-515.

Morrison, P. D., Roberts, J. H., and Midgley, D. F. 2004. "The Nature of Lead Users and Measurement of Leading Edge Status," *Research Policy* (33:2), pp. 351-362.

Morrison, P. D., Roberts, J. H., and Von Hippel, E. 2000. "Determinants of User Innovation and Innovation Sharing in a Local Market," *Management Science* (46:12), pp. 1513-1527.

Nambisan, S. 2013. "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research," *Journal of the Association for Information Systems* (14:4), pp. 215-226.

Nambisan, S., and Baron, R. A. 2007. "Interactions in Virtual Customer Environments: Implications for Product Support and Customer Relationship Management," *Journal of Interactive Marketing* (21:2), pp. 42-62.

Nambisan, S., and Baron, R. A. 2010. "Different Roles, Different Strokes: Organizing Virtual Customer Environments to Promote Two Types of Customer Contributions," *Organization Science* (21:2), pp. 554-572.

Nambisan, S., Lyytinen, K., Majchrzak, A., and Song, M. 2017. "Digital Innovation Management: Reinventing Innovation Management Research in a Digital World," *MIS Quarterly* (41:1), pp. 223-238.

Nambisan, S., and Sawhney, M. 2011. "Orchestration Processes in Network-Centric Innovation: Evidence from the Field," *The Academy of Management Perspectives* (25:3), pp. 40-57.

O'Mahony, S., and Ferraro, F. 2007. "The Emergence of Governance in an Open Source Community," *Academy of Management Journal* (50:5), pp. 1079-1106.

Parker, G. G., Van Alstyne, M. W., and Choudary, S. P. 2016. *Platform Revolution: How Networked Markets Are Transforming the Economy and How to Make Them Work for You*, New York: W. W. Norton & Company, Inc.

Porter, C. E., and Donthu, N. 2008. "Cultivating Trust and Harvesting Value in Virtual Communities," *Management Science* (54:1), pp. 113-128.

Porter, C. E., Donthu, N., MacElroy, W. H., and Wydra, D. 2011. "How to Foster and Sustain Engagement in Virtual Communities," *California Management Review* (53:4), pp. 80-110.

Prasarnphanich, P., and Wagner, C. 2009. "The Role of Wiki Technology and Altruism in Collaborative Knowledge Creation," *Journal of Computer Information Systems* (49:4), pp. 33-41.

Ravichandran, T., Han, S., and Mithas, S. 2017. "Mitigating Diminishing Returns to R&D: The Role of Information Technology in Innovation," *Information Systems Research* (forthcoming).

Ridings, C. M., Gefen, D., and Arinze, B. 2002. "Some Antecedents and Effects of Trust in Virtual Communities," *The Journal of Strategic Information Systems* (11:3), pp. 271-295.

Roberts, N., Galluch, P. S., Dinger, M., and Grover, V. 2012. "Absorptive Capacity and Information Systems Research: Review, Synthesis, and Directions for Future Research," *MIS Quarterly* (36:2), pp. 625-648.

Saldanha, T., Mithas, S., and Krishnan, M. S. 2017. "Leveraging Customer Involvement for Fueling Innovation: The Role of Relational and Analytical Information Processing Capabilities," *MIS Quarterly* (41:1), pp. 267-286.

Shih, E., Kraemer, K. L., and Dedrick, J. 2007. "Research Note-Determinants of Country-Level Investment in Information Technology," *Management Science* (53:3), pp. 521-528.

Singh, P. V., Tan, Y., and Mookerjee, V. 2011. "Network Effects: The Influence of Structural Capital on Open Source Project Success," *MIS Quarterly* (35:4), pp. 813-829.

Spaeth, S., von Krogh, G., and He, F. 2015. "Research Note—Perceived Firm Attributes and Intrinsic Motivation in Sponsored Open Source Software Projects," *Information Systems Research* (26:1), pp. 224-237.

Szulanski, G. 1996. "Exploring Internal Stickiness: Impediments to the Transfer of Best Practice Within the Firm," *Strategic Management Journal* (17:S2), pp. 27-43.

Tafti, A., Mithas, S., and Krishnan, M. S. 2015. "Empowering IT Professionals Through HR Practices: Implications for IT Productivity," Working Paper, University of Illinois at Chicago.

Tafti, A., Sachdev, V., Mithas, S., and Mallik, L. 2015. "Alliances, R&D and Profitability of Software Firms," in *Proceedings of the 35th International Conference on Information Systems*, T. Carte, A. Heinzl, and C. Urquhart (eds.), Forth Worth, TX.

Tambe, P. B., and Hitt, L. M. 2012. "The Productivity of Information Technology Investments: New Evidence from IT Labor Data," *Information Systems Research* (23:3 Part 1), pp. 599-617.

Tambe, P. B., Hitt, L. M., and Brynjolfsson, E. 2012. "The Extroverted Firm: How External Information Practices Affect Innovation and Productivity," *Management Science* (58:5), pp. 843-859.

Urban, G. L., and Von Hippel, E. 1988. "Lead User Analyses for the Development of New Industrial Products," *Management Science* (34:5), pp. 569-582.

Von Hippel, E. 1986. "Lead Users: A Source of Novel Product Concepts," *Management Science* (32:7), pp. 791-805.

Von Hippel, E. 2005. *Democratizing Innovation*, Cambridge, MA: The MIT Press.

Von Hippel, E., and Von Krogh, G. 2003. "Open Source Software and the 'Private-Collective' Innovation Model: Issues for Organization Science," *Organization Science* (14:2), pp. 209-223.

von Krogh, G., Haefliger, S., Spaeth, S., and Wallin, M. W. 2012. "Carrots and Rainbows: Motivation and Social Practice in Open Source Software Development," *MIS Quarterly* (36:2), pp. 649-676.

Wasko, M. M., and Faraj, S. 2005. "Why Should I Share? Examining Social Capital and Knowledge Contribution in Electronic Networks of Practice," *MIS Quarterly* (29:1), pp. 35-57.

Wenger, E. C., and Snyder, W. M. 2000. "Communities of Practice: The Organizational Frontier," *Harvard Business Review* (78:1), pp. 139-145.

West, J., and O'Mahony, S. 2008. "The Role of Participation Architecture in Growing Sponsored Open Source Communities," *Industry and Innovation* (15:2), pp. 145-168.

Wiertz, C., and de Ruyter, K. 2007. "Beyond the Call of Duty: Why Customers Contribute to Firm-Hosted Commercial Online Communities," *Organization Studies* (28:3), pp. 347-376.

Wulf, K. D., Odekerken-Schröder, G., and Iacobucci, D. 2001. "Investments in Consumer Relationships: A Cross-Country and Cross-industry Exploration," *Journal of Marketing* (65:4), pp. 33-50.

Xu, Q., and Ma, Q. 2008. "Determinants of ERP Implementation Knowledge Transfer," *Information & Management* (45:8), pp. 528-539.

Yolton, M. 2008. "You're Helping the U.N. Feed and Educate Children Simply By Contributing Your Knowledge and Experience with Others, Help Us Double the Donation from SAP!" (https://blogs.sap.com/2008/10/25/you-re-helping-the-un-feed-and-educate-children-simply-by-contributing-your-knowledge-and-experience-with-others-help-us-double-the-donation-from-sap/).

Yoo, Y., Boland Jr., R. J., Lyytinen, K., and Majchrzak, A. 2012. "Organizing for Innovation in the Digitized World," *Organization Science* (23:5), pp. 1398-1408.

Zahra, S. A., and George, G. 2002a. "Absorptive Capacity: A Review, Reconceptualization, and Extension," *Academy of Management Review* (27:2), pp. 185-203.

Zahra, S. A., and George, G. 2002b. "The Net-Enabled Business Innovation Cycle and the Evolution of Dynamic Capabilities," *Information Systems Research* (13:2), pp. 147-150.

About the Authors

Peng Huang is an assistant professor of Information Systems at the Robert H. Smith School of Business, University of Maryland, College Park. He has a Ph.D. from the College of Management, Georgia Institute of Technology. His research interests include platform technologies and innovation ecosystems, knowledge-sharing virtual communities, as well as consumer decision-making in e-commerce. His recent work has appeared in journals such as *Management Science*, *MIS Quarterly*, *Journal of Marketing*, and *Communications of the ACM*. His research has received the Kauffman Dissertation Fellowship from the Ewing Marion Kauffman Foundation and the best conference paper (runner-up) award at the 2009 International Conference on Information Systems.

Ali Tafti is an associate professor of Information and Decision Sciences in the College of Business Administration at the University of Illinois at Chicago. His research interests include the role of information technology (IT) in interfirm relationships, digital convergence in economic networks, and the business value of IT investments. His prior work has appeared in journals such as *Management Science*, *MIS Quarterly*, *Information Systems Research*, *MIT Sloan Management Review*, and *PLoS One*. He completed his Ph.D. at the Ross School of Business at the University of Michigan and has also served on the faculty at the University of Illinois at Urbana–Champaign.

Sunil Mithas is the Ralph J. Tyser Professor of Information Systems in the Robert H. Smith School of Business at the University of Maryland, where he is codirector of the Center for Excellence in Service and codirector of the Center for Digital Innovation, Technology and Strategy. He is the author of the books *Digital Intelligence: What Every Smart Manager Must Have for Success in an Information Age* and *Dancing Elephants and Leaping Jaguars: How to Excel, Innovate, and Transform Your Organization the Tata Way*. He earned his Ph.D. from the Ross School of Business at the University of Michigan and an engineering degree from IIT, Roorkee. Identified as an MSI Young Scholar by the Marketing Science Institute, Sunil is a frequent speaker at industry events for senior leaders. He has worked on research or consulting assignments with organizations such as A. T. Kearney, Ernst & Young, Johnson & Johnson, Lear, the Social Security Administration, the Tata Group, and the U.S. Census Bureau. His papers have won best-paper awards, have received best-paper nominations, and have been featured in practice-oriented publications such as *MIT Sloan Management Review*, *Bloomberg*, *CIO.com*, *Computerworld*, and *InformationWeek*.