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The Core and Cosmopolitans: A Relational View of Innovation in User Communities

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Users often interact and help each other solve problems in communities, but few scholars have explored how these relationships provide opportunities to innovate. We analyze the extent to which people positioned within the *core* of a community as well as people that are *cosmopolitans* positioned across multiple external communities affect innovation. Using a multimethod approach, including a survey, a complete database of interactions in an online community, content coding of interactions and contributions, and 36 interviews, we specify the types of positions that have the strongest effect on innovation. Our study shows that dispositional explanations for user innovation should be complemented by a relational view that emphasizes how these communities differ from other organizations, the types of behaviors this enables, and the effects on innovation.

Key words: innovation; communities; collaboration; network; users; online
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Introduction

An individual often lacks sufficient expertise to innovate alone when the knowledge frontier is complex and expanding. Instead, collaboration in communities becomes an attractive means to tap diverse expertise to be recombined into innovations. Detailed studies of people who at first glance appear to be lone geniuses reveal that they have been embedded in a wider circle of friends and colleagues that enabled their innovations (Uzzi and Spiro 2005). Prominent examples of this process include Adam Smith, Edison, and Beethoven. What is remarkable about their stories is that although talent is distributed, often only a fortunate few are recognized as innovators.

In user communities, talent is distributed, and the innovative process is highly collaborative. When solutions to their problems are not available in the marketplace, users often have strong incentives to innovate (von Hippel 1988), and they share ideas and build on each other's work. User communities constitute a social structure woven from continuous interactions among individuals focused around shared interests and common practices, as well as usage of the same tools and products (van Maanen and Barley 1984, Wellman et al. 1996). Users interact to solve problems collectively in these communities, yet only a few innovate, share their innovations, and earn recognition for their achievements.

Innovation by users has not only become common but has major implications for scholars of organizations. Organizational theorists have become intrigued by how these processes work and how they can be harnessed for the mutual benefit of companies and communities (O'Mahony and Bechky 2008). It is thus not surprising that we have ample evidence of how users innovate (von Hippel 1988), but the explanations have been oddly disconnected from the social structures in communities where the users are embedded. A social structure emerges when users interact and help each other solve problems, which provide different opportunities for people to innovate. We argue that communities differ from other organizational forms in important dimensions and that this difference enables behaviors that affect innovativeness. More specifically, we ask, why are some users considered more innovative than others as a result of their relationships inside and outside a community?

There are features of communities that enable behaviors that would be unlikely and potentially unaccepted in other organizations. Communities and other organizations differ with respect to mode of governance, membership, ownership, and control of production (Lee and Cole 2003, O'Mahony and Bechky 2008). First, communities are typically built on voluntary participation. In contrast to many other organizations, communities often lack central hierarchical authority (Magee and Galinsky 2009)—no one is in charge of telling peers what to do. People can spend as much or as little time on their preferred task as they like, and they can work with whom they want to, without sanctions (Dahlander and O'Mahony 2011). By extension, a small core of devoted people account for the vast majority of the interactions in the community. This practice produces a social structure with a densely connected core and a loosely attached periphery. Although a few accounts discuss the core/periphery structure in online communities (Garton et al. 1997), we have limited knowledge about how positions in these structures influence innovation. People at the core of the community have better opportunities for innovation than those on the periphery because of superior access to information flows (Borgatti and Everett 1999). Nevertheless, core members can become too entrenched in the prevailing conventions of a community and thus be averse to discard existing knowledge and practices. Therefore those core members tend to ignore the potential contributions of new ideas from the outside (Fleck 1935, Schilling 2005).

Second, communities have more permeable boundaries than most other organizations because little prevents individuals from being members of multiple communities. People can engage in multiple communities to discover and adapt new ideas and solutions to problems that have been solved elsewhere (Brown and Duguid 1991, Jeppesen and Lakhani 2010). We refer to people spanning community boundaries as *cosmopolitans*. Individuals who span multiple communities are thus more likely to be innovative. Too much boundary spanning may turn detrimental, however, as the person faces problems in allocating attention and connecting divergent information.

We examine these arguments in the context of an online community hosted by the Swedish firm Propellerhead, which develops and sells award-winning computer-controlled musical instruments. The community was established to encourage and support interaction among users of the Propellerhead products as well as between users and the firm (Jeppesen and Frederiksen 2006, Jeppesen and Laursen 2009). Our study combines multiple methods, including interviews, network and content analysis of data from a database of interactions on community members' interactions, and an online survey instrument. We use "appropriate observers" embedded in the domain to rank individuals' innovations (Amabile 1982). Overall, our study shows that dispositional explanations for user innovation should be complemented by a relational view that emphasizes *both* the social structure inside a community *and* multiple external communities.

Theory and Hypotheses

Innovation is the result of a process in which previously disconnected chunks of knowledge are integrated and recombined into novel products, concepts, and practices to create value (Schumpeter 1934). Van de Ven's (1986) view of how individuals innovate highlights that innovations emerge when people foster, develop, carry through, react to, and modify ideas, which are then adopted and adapted in an appropriate market. The original *invention* needs to be brought to the market to be considered an *innovation* (Schumpeter 1934). In user communities, the "market" is not necessarily someone buying a product or service but an idea or artifact that is being used by peers in the community (von Hippel 2005). Individuals are thus innovative if peers perceive them as contributing something novel. This aligns with Csikszentmihalyi's (1996, p. 23) view of creativity: "If by creativity we mean an idea or action that is new and valuable, then we cannot simply accept a person's own account as the criterion for its existence. There is no way to know whether a thought is new except with reference to some standards, and there is no way to tell whether it is valuable until it passes social evaluation." Finding agreed-upon objective criteria to judge innovativeness is a challenge that often requires intersubjective assessments. Kline and Rosenberg (1986, p. 283) make a similar claim: "It is a serious mistake to treat an innovation as if it were a well-defined, homogeneous thing that could be identified as entering the economy at a precise date—or becoming available at a precise point in time." This is often the case in user communities, where there are few established formal institutions that define what constitutes an innovation. Some people come up with inventions they think are novel in the privacy of their homes, but if the inventions are not shared with others, and hence subject to evaluation by others, they cannot be evaluated by the community and potentially be considered innovative.

More generally, scholars have wrestled with the relation between social structures and innovation. One stream of thought analyzes how position in social networks within organizations (typically, research and development (R&D) laboratories) influences innovation (Perry-Smith and Shalley 2003, Perry-Smith 2006). These studies argue that relationships within and beyond the boundaries of the traditional organizational settings are crucial (Allen 1977, Shalley et al. 2004). Significantly less attention has been paid to how an individual's position within a community influences innovative behavior (Wasko and Faraj 2005).

Core: Core/Periphery Position *Inside* a Community

A few people typically account for the vast majority of contributions in user communities (Garton et al. 1997, Lakhani and von Hippel 2003). Members can self-select tasks and collaboration partners, and there are few, if any, sanctions for those who contribute only occasionally (Dahlander and O'Mahony 2011). The result is that these communities resemble a core/periphery structure with a cohesive subgroup of core actors and a set of peripheral actors who are loosely connected to the core (Borgatti and Everett 1999). The idea that some organizations have core/periphery structures has enjoyed considerable attention in social network analysis. A person's position can range on a continuum from core to peripheral. Extending this reasoning, we contend that one's position in the core/periphery structure within a community affects innovation.

As Podolny (2001) argues, relationships serve as both *pipes* for information and *prisms* that induce differentiation between various actors. People at the core are more likely to capture information benefits that emerge (pipes) as well as to be recognized for their innovations (prisms). In other words, the core is favorably positioned to mobilize resources because much vital information is funneled through them (Borgatti and Everett 1999). Relationships also induce differentiation among community members. Core individuals are more likely than peripheral members to gain credit for their ideas (Merton 1949, Crane 1972). This is the central idea of the Matthew effect: recognition accrues disproportionately to actors who already have plenty. As Hargadon (2005) says, because individuals closer to the core typically are deeply immersed in their social system of belief, rules, values, and norms, they can leverage their credibility among other community participants and hence secure the support needed to defend their achievements from scrutiny by skeptics.

However, a position too close to the core can have negative effects. Some researchers suggest that peripheral people may not "face the same level of social pressure to conform and are less likely to forgo opportunities from which new creative ideas originate" (Cattani and Ferriani 2008, p. 827). Simmel (1950) and Merton (1972) emphasize that strangers, fringe players, and outsiders transfer ideas that are less likely to be created by people who are more socially embedded in established ways of thinking. Peripherally positioned people can escape the "homogenizing effects typical of an established institutional framework" (Cattani and Ferriani 2008, p. 827) and thus focus on developing their innovation even if they do not conform to accepted standards and practices of the community.

Whereas a position on the periphery of a community's social structure allows people to explore ideas and information that the core members have ignored, the core is more effective in mobilizing support for those ideas. Uzzi (1997) stresses the information benefits that arise from strong ties that simultaneously constrain behaviors. McLaughlin's (2001) study about optimal marginality and innovation in the development of modern psychoanalysis implicitly claims that innovative performance is higher among people who occupy an intermediate position on a core/periphery continuum. In his view, people who have the legitimacy of the core but reach out to the periphery are likely to be innovative. To sum up, we posit that people on an intermediate position on a core/periphery continuum are more likely to be innovative.

Hypothesis 1. *There is an inverted U-shaped relationship between the position in the core/periphery structure inside a community and the extent to which an individual is innovative.*

Cosmopolitans: Boundary Spanning Across *Multiple* Communities

There are rich insights into how practices evolve and how individuals make sense of events by calling on their prior experiences and expertise in communities (van Maanen and Barley 1984). However, this stream of literature has often overlooked how members forge relationships with people outside the community or organization (Perry-Smith 2006). To consider relationships with external constituents is important, because some people are cosmopolitans who choose to be part of multiple communities (Gouldner 1958). When individuals are part of multiple communities, they can transfer, translate, and transform experiences from one community to another (Dougherty 1992, Bechky 2003, Carlile 2004). We argue that the extent to which people span multiple communities affects whether they are innovative because easy access to many sources of diverse knowledge from external communities provides increased opportunities for recombination.

The boundary-spanning literature (Allen 1977, Tushman and Scanlan 1981, Ancona and Caldwell 1992) has illuminated how individuals within R&D departments go outside their organization to find new ideas and resources. In bureaucracies there exist hierarchies that distribute authority and delegate tasks to their employees. In contrast, the boundaries of communities are permeable; there are no sanctions on members who span them. Individuals can be part of multiple communities and decide for themselves when and where to allocate their attention. They can "drop in" to ask questions or browse existing suggestions and ideas available in the community (Jeppesen and Laursen 2009, Kollock 1999). This behavior is perceived as normal by community members and, therefore, does not disturb any behavioral assumptions. In contrast to most organizations where, for example, legal contracts may prevent employees from maintaining membership in competing organizations, this norm creates a world in which people often belong to multiple communities.

People have an opportunity to learn and reuse practices, ideas, and references from various knowledge domains. These communities represent different "thought worlds" (Dougherty 1992) that expose participants to alternative ways of framing problems and heterogeneous expertise. Solutions to problems, or parts of the solutions, often already exist, because the problems have been solved outside a focal domain of expertise. Jeppesen and Lakhani's (2010) work, for instance, shows how companies broadcast unsolved problems to a diverse pool of solvers: solvers of complex technical problems frequently come from a background different from those who distributed the problem. People who span multiple communities are therefore more likely to be aware of existing solutions and ways of framing problems; they tackle problems from a fresh angle (Hargadon and Sutton 1997, Burt 2005). External communities also serve as a means of validation and offer suggestions for improvement of ideas that challenge the proposer to advance the idea further. External knowledge is often scarcer, and it can be valued higher than knowledge that emerged inside the organization (Menon and Pfeffer 2003).

Csikszentmihalyi (1996, p. 9) submits that there are benefits of spanning diverse contexts, but at the same time, "[I]t is important to recognize that given how little attention we have to work with, and given the increasing amounts of information that are constantly being added to domains, specialization seems inevitable." This suggests that there may be downsides to spanning multiple communities and hence drawing too much on external sources of knowledge. Information processing is both expensive and time consuming. Information needs to be noted, encoded, and interpreted to be useful. A potential attention problem may surface (Ocasio 1997): people can allocate only a certain amount of attention to a limited number of activities. Simon (1971, pp. 40–41) remarks that

> in an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence, a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.

An overabundance of information makes it difficult for one to prioritize and, by extension, to absorb it. Koput (1997), for instance, says that too many ideas and too much information can be harmful to innovative performance. In sum, we posit that people that span an intermediate number of external communities are more likely to be innovative.

HYPOTHESIS 2. *There is an inverted U-shaped relationship between spanning multiple external communities and the extent to which an individual is innovative.*

The Contingent Effect of Core and Cosmopolitans

There is a boundary challenge in network studies: researchers are forced to assume where the network ends (Wasserman and Faust 1994, p. 31). When focusing on a single community, one could take for granted that peripheral members lack relationships. In reality, some of them could be cosmopolitans, embedded in a wide network outside their focal community (Gouldner 1958). It is thus important to consider the joint effects of spanning multiple communities *and* core/periphery position on innovation.

Scholars of boundary spanning in firms have documented in detail how certain people link internal and external groups in organizations. According to this literature, "communication stars" situated in core positions of organizations are better positioned to sustain and benefit from external relationships. Tushman and Scanlan (1981, p. 292, italics in original) state that "informational boundary spanning will be accomplished *only* by those individuals who are well connected to external information areas and who also are well connected internally and thus able to disseminate new information and new ideas to their more locally oriented colleagues." Whereas boundary-spanning scholars suggest a positive association between centrality within an organization and being a cosmopolitan who spans multiple communities, others have argued that it is difficult to do both simultaneously. Core members have legitimacy in the community but are often blind to alternative ways of solving problems. In a study of innovation in an R&D lab, Perry-Smith (2006) demonstrates that people with few connections inside the organization gain the most from having external relationships. Those at the periphery are less embedded in the organization and better positioned to benefit from divergent ideas developed through relationships to external actors. Perry-Smith (2006, p. 89) submits that "these ideas can emerge without the constraints of worrying what key others will say or experiencing personal stress from potentially going against some accepted tenets of the network." Individuals on the periphery are less constrained by what is feasible according to the established logic of the community (Kuhn 1970, Crane 1972). In contrast, core members face the risk of becoming too inward looking because they focus on established ways of working (Schilling 2005). They may start to overvalue the information and contributions from the internal community and fail to appreciate ideas from the outside (Katz and Allen 1982). Core members may therefore be less able to become innovative from their engagement in multiple communities.

Individuals have finite capacities to maintain relationships, and they thus face trade-offs to span multiple external communities as well as maintain their position in the core of the local community (Whittington et al. 2009). This suggests a substitution effect between spanning multiple external communities and a core/periphery position. Hence, individuals who are *not* spanning community boundaries receive more and potentially better ideas for innovation from becoming positioned more in the core of the community than those who are active boundary spanners. In other words, the position in the core can alleviate the challenge of *not* spanning multiple communities.

HYPOTHESIS 3. *Core/periphery position and spanning multiple external communities are substitutes; thus increasing the effect of one dampens the effect of the other on innovation.*

Research Setting: Propellerhead's Online Community

We studied people in a public, unrestricted online user community established by the Swedish firm Propellerhead. We chose this setting for multiple reasons. First, the community encompasses a large number of people who differ substantially in experience, product use, and degree of participation in the community. Second, the initial qualitative phase of our research revealed that a number of people in the community were involved in multiple external communities. Third, we could relate participation in inside and external communities to why some individuals were more innovative than others. Fourth, Propellerhead is a mature online community, in existence for more than 10 years. Its longevity gave us the opportunity to study a community whose social structure has evolved. Fifth, this online setting allowed us to collect both self-reported and actual behavioral data from a database of interactions. Last, we were motivated to think about innovation in a field where most traditional measures of innovation (such as, for example, patents) do not apply. As in other immature fields, there is no clear definition of what constitutes innovation in online communities. Therefore it proves difficult to codify what is labeled as innovation.

In 1994, Propellerhead's first product was released, and the firm quickly became a market leader within its segment. Software-based musical instruments are tools for sound production, processing, and recording. They provide musicians and music technicians with a number of features used in the creation of musical content, such as sound-producing modules, sound effects, and tools for sound organizing. The main difference between these software-based instruments and "normal" instruments is that a single piece of software combines making, processing, and recording music. Before Propellerhead established its own community, a group of devoted musicians had founded another community in which they electronically shared ideas for how to use and improve the product. In 1999, this community prompted Propellerhead to establish and host its own official online user community on the firm's website. During our interviews (described in the next section), a community member explained, "Over time, Propellerhead turned its community into the dominant nexus for communication about product use and sharing of product alterations on the Internet."

Individuals in the community help each other use the products in new or better ways, share ideas, offer assistance in solving each other's problems, and comment on designs and suggestions made by other community members without any financial rewards (Constant et al. 1996, Bagozzi and Dholakia 2006).[1] Individual members rarely *directly* change the source code of Propellerhead's products, but they can *indirectly* influence the firm's decisions about product features and functionalities. Propellerhead has also encouraged significant additional applications invented around the original product by users. These innovations are called *mods* and *extras*.[2] One such extra was an application that linked the Propellerhead software to moving pictures. This user-developed application opened the door for the firm into a new market: using the music software for developing and editing film scores and commercials. A quotation from one of the three founders of Propellerhead exemplifies the firm's support for innovative user contributions for the development of new products:

> There's a parallel to games in the way we approach modifications. The gaming world has spawned a whole subculture of modding [changing functions, features, or design of the original product], so when modified versions of ReBirth 1.0 surfaced back in 1997, we responded like id Software [a games company that encourages users to develop modifications]. This kind of reverse engineering by users was cool with us. In fact, we encouraged it! We published mods and eventually we built mod support into the software.

When the firm releases a new product version or an entirely new product, people in the community detect bugs and errors and comment on missing product features. Feedback, product modifications, and applications are developed and shared in the community. Propellerhead employees can then make decisions about what suggestions, applications, and modifications can be integrated into the product development process or live on as stand-alone applications. Innovations to communities take many different forms, such as idea generation, idea realization, prototyping, and transfer and diffusion. Each of these is recognized as valuable by both the Propellerhead employees and the user community members (Nambisan and Baron 2010). The CEO stated,

> Communities are built on the innovation by users. If we only had individuals asking and answering questions, we'd have a support forum, not a community.

Methods

Data Collection

We use multiple methods for our study (Miles and Huberman 1994). Both qualitative and quantitative methods complement each other to improve the validity of findings (Jick 1979) and produce deeper theoretical insights. We conducted 36 interviews with users in the community and Propellerhead employees to gain a deeper contextual understanding of the research setting and the people involved, as well as to identify and validate variables useful for our quantitative study. The interviews were carried out before and in parallel with the survey. We used insights from the interviews to build a survey instrument that captured the community's language and style. After the survey was distributed, we conducted additional interviews to get face validity and interpret our emerging findings. As a consequence, the qualitative data analysis took place iteratively, moving back and forth between data, relevant literature, and embryonic theory (Dougherty 2002).

The interviews were selected through a nonrandom purposive snowballing technique (Miles and Huberman 1994). We began with several interviews within the firm (the CEO, head of product development, head of user support, and marketing personnel). We then interviewed community members who the firm recommended that we talk to in order to acquire deeper insight into how users innovate. When we had gained some expertise about the community, we selected experienced and inexperienced users in the community for additional interviews. In total, 12 interviews were conducted with 6 people from the Propellerhead firm; the remaining 24 interviews were conducted with users in the online community.

We carried out both face-to-face and telephone interviews. We recorded and transcribed 30 interviews; the remaining interviews took place during lunch meetings and coffee breaks where recording would have been inappropriate. In these instances, we wrote a lengthy memo of the central issues during and after the interviews. Initially, we asked open-ended questions about how the firm used its user community, how the community had evolved, what features constituted innovation, and who the respondent perceived to be the most innovative users in the community. We also asked about the ways community members engaged in external communities. As our study progressed and findings began to emerge, we conducted additional interviews directed toward establishing the link between engagement inside and outside the community and its association with individual innovation. When questions emerged after the interviews, we followed up via e-mail correspondence. We analyzed the interview data with manual coding. We derived specific categories such as "forms and drivers of multiple community participation," "position in the social structure of the community," and "forms of innovation." From the categories, we collected illustrative quotations. Before initiating the quantitative study, we read through 1,000 posts from our downloaded data from a database of interactions to gain a rich understanding about the context of "work" activities. We discovered discussions around new topics, suggestions for new use of products, advice, and even sharing of beta versions of software applications that had migrated from other online communities.

We combined a database of the interactions in the community with the responses to a questionnaire distributed to the community. Our data set combines survey data on individual attributes and attitudes with behavioral archival data to increase validity and circumvent common method bias (Doty and Glick 1998). The database of interactions contained 151,092 messages posted by 8,640 individuals. In addition to the subject and full message, the database also included the date of the message's posting, information on the message poster, information about which discussion thread the message belonged to, and whether it was in response to a particular message. We used this data source to study the interactions of the community members and to content code the 5,000 most recent postings before the distribution of the survey.[3]

The survey was hosted on the Propellerhead website. It appeared when a person logged on to the online community. People could then choose to participate or return to the community pages. The survey was posted in May 2008 and was open for 31 days. We received 280 responses useful for analysis out of 966 individuals who posted in the community during this period, equivalent to a 29% effective response rate. The questionnaire inquired about users' personal attributes: levels of technical competence, motivations for participating in the community, product experience level, professional status, and engagement in other communities. For the survey data, we used both procedural and statistical remedies to cope with the potential threat of common method bias. Following the suggestion by Podsakoff et al. (2003), we protected anonymity, counterbalanced question order, and used several scale anchors and scale formats. We used Harman's single-factor test when analyzing the responses to the survey.[4]

In the next step, we matched the people who were active in the community when the survey was distributed with their responses to the online survey. We used the unique user name of each person in the community to do the matching. Our method overcomes the problems inherent in many studies of online communities related to reliance solely on self-reported data. We thus avoided any problems of a social desirability bias for some of our key constructs (Podsakoff and Organ 1986). In addition, the content coding exercise of user posts took us "inside" the discussions, the languages, and the codes of conduct in the community (Barley and Kunda 2001), and hence it took us closer to the innovation process.

Variables and Measures

Dependent Variable. Our theoretical concern is individual innovation in the context of a user community. Inspired by Amabile's studies on creativity in which "a product or response is deemed creative to the extent that appropriate observers independently agree it is creative" (1982, p. 1001), we measure individual innovation by asking expert judges. This allowed us to move beyond respondents' self-reported perceptions, which could be biased toward social desirability (Podsakoff and Organ 1986). Innovation indicators such as patents, R&D investments, and new product introductions are useful in mature industries, but they potentially disregard innovations in emerging domains. In our context, for a process or an original prototype application to be accepted as innovative depends on whether the traits of novelty, difference, or importance are recognized as significant by experts in the community (Burt 2004, Obstfeld 2005).[5]

To develop the dependent variable, we asked Propellerhead and four experienced people in the community to independently rank our 280 survey respondents on a scale of 0, 1, or 2 for whether each had been innovative in the community in their view. The expert judge from the firm was the manager in charge of product support and the moderator of the community. He had been with Propellerhead for more than three years and has extensive knowledge of innovation related to the technology and the product. The four judges selected from the community are all experts in the area.[6] To incentivize care in the ranking process by the expert judges, we offered to pay them a small amount of money for their time and effort. The instruction we gave the expert coders for the ranking exercise was as follows: "Please identify users in the community who have made innovative, new, and valuable contributions to the community. These could be mods/GUI, extras, and new applications. However, beta testers should not be nominated as delivering innovations." This single-item criterion was built to capture the wide range of user innovation activities in the community. Following the literature on user innovation, we include innovations ranging from solutions to specific technical problems to more concrete innovations such as product modifications and beta versions of software applications. One of the authors has spent considerable time with the firm and within the community over the last five years. On the basis of this knowledge, we reasoned that a broad and open-ended question was the best way to capture the various types of innovation created and shared by users in the community. The question focuses mainly on technological innovation; a few of the expert coders, however, revealed that some of the people singled out as particularly innovative in the community contributed both technological solutions and content-based innovation, such as patch files of new sounds.

After the judges e-mailed us their evaluation lists, we contacted them by telephone. Together, we went through their individual lists and asked them in detail why certain community participants had achieved their rank. Judges thus had to explain their evaluation to us to ensure a high degree of reliability in the coders' ranking.

The judges evaluated whether they thought the respondents in our sample had contributed anything innovative. After they had given a score to each, we asked them to evaluate how novel they thought the people they had ranked as innovative were. In the left columns of Table 1(a), we show the Spearman correlations between the rankings considering the degree to which the judges thought the innovations were significant (0 = not innovative, 1 = innovative, 2 = very innovative). In the right columns, we show the tetrachoric correlations (0 = not innovative, 1 = innovative) between the coders' evaluations. Table 1(a) illustrates that the expert judges were often in agreement, but not always. We developed two composite scores of how innovative individuals were by summing the scores from the judges. The first variable captures whether people are ranked as innovative or not. The second measures the degree to which they were considered innovative. Table 1(b) shows the distribution of the innovative scores of the people in our sample.

The quotation below gives an example of a user who was considered very innovative by our judges. He came up with a radically different way of producing sounds that Propellerhead had overlooked:

> I know one guy who's working on a Hammond B3 plus, a spinning Leslie cabinet patch for Reason. And up until now that stuff has been purely sample based. People have actually gone out to sample actual sound. Like Propellerhead went out and recorded an actual Hammond B3 in a Leslie cabinet at Abbey Road studio, but it's all sample based, so it's dependent on samples. Whereas this other guy is based upon what is the sound of Hammond? How is it made? And then he analyzes what the B3 does and it's all just sine waves, so he's recreated a Hammond B3 out of just sound waves. He studied the physical properties of a Leslie cabinet and figured out how fast the base rotor spins, how fast does a treble rotor spin, what's the acceleration time based upon the motors in that thing. This re-creation is just amazing.

In cases where the user innovation took a form different from a novel process or original way of performing or combining certain features or functions—but had materialized into a prototype—we were often able to find mods, extras, or patch fills online, emerging from someone included in our survey sample.

Independent Variables.

Core/periphery position. A network has a core/periphery structure if it has a core of individuals who are densely tied to each other and a periphery whose members have more relationships to core members than to each other (Borgatti and Everett 1999). We measured all individuals' positions on a core/periphery continuum using Borgatti and Everett's (1999) algorithm. Following Cattani and Ferriani (2008), we chose a continuous core/periphery model, because we were interested in the continuum rather than in assigning people to either the core or the periphery (Fleck 1935).[7] The Borgatti and Everett (1999, p. 378) algorithm attributes "large values for pairs of nodes that are both high in coreness, middling values for pairs of nodes in which one is high in coreness and the other is not, and low values for pairs of nodes that are both peripheral." Although all individuals in the core of the community are central as calculated by most social network measures, the reverse is

Table 1(a) Correlations Between Coder Evaluations

	Spearman (using 0, 1, and 2)					Tetrachoric (using 0 and 1)				
	1	2	3	4	5	1	2	3	4	5
1 Propellerhead judge	1					1				
2 Community judge 1	0.48	1				0.72	1			
3 Community judge 2	0.52	0.69	1			0.67	0.92	1		
4 Community judge 3	0.59	0.54	0.53	1		0.72	0.81	0.76	1	
5 Community judge 4	0.45	0.38	0.32	0.44	1	0.64	0.50	0.51	0.69	1

Notes. Spearman correlations using the degree of contribution from each coder (0, 1, and 2). Tetrachoric correlations between contributions ranked ≥1.

Table 1(b) Composite Innovative Scores

Using 0, 1, and 2				Using 0 and 1			
Innovative score	Frequency	%	Cumulative %	Innovative score	Frequency	%	Cumulative %
0	166	59.29	59.29	0	166	59.29	59.29
1	51	18.21	77.5	1	60	21.43	80.71
2	23	8.21	85.71	2	18	6.43	87.14
3	11	3.93	89.64	3	17	6.07	93.21
4	11	3.93	93.57	4	12	4.29	97.5
5	10	3.57	97.14	5	7	2.5	100
6	1	0.36	97.5				
7	3	1.07	98.57				
8	1	0.36	98.93				
9	3	1.07	100				
Total	280	100			280	100	

not always true. Each core member may have a high degree of centrality because of connections to various cohesive parts of the community but may not have any connections to other core members (Borgatti and Everett 1999, p. 393). We used UCINET to calculate positions on the core/periphery continuum (Borgatti et al. 2002).[8]

Spanning multiple external communities. In the online survey, we asked for a yes or no answer to the following question: "Have you actively participated in other online communities NOT hosted by Propellerhead during the last three years?" For respondents who ticked the Yes box, there was a follow-up question about the communities in which they participated: "Please list the names of other online communities not hosted by Propellerhead that you most actively spend time in. It is no requirement to list ten." Respondents were then offered 10 slots for free text to list each community they found important.[9] Afterward, we used Google and other search engines to identify the communities mentioned by respondents to content code them by type. We excluded general social network communities such as Facebook. We used the number of communities listed by each respondent as the measurement for boundary-spanning activities. Contrary to the method used, for example, by Perry-Smith (2006) for measuring external relationships, we do not focus on the person's direct ties to a specified other but rather on the focal individual's access to and use of additional knowledge bases. We reasoned that external relationships in the online setting are not contingent on specific individual relationships but rather depend on involvement with other communities as repositories of knowledge. To further this analysis, we subdivided the number of communities into technical and artistic (see Table 2).

Control variables. Based on previous research and our interviews with Propellerhead community members and employees, we included several variables to control for various individual-level factors that can affect a person's probability to innovate.

We hypothesized that innovation is affected by the core/periphery position within the community *and* spanning external communities. We thus need to rule out the effect of the sheer number of postings in the community. However, the quality of the contributions varies considerably: some postings are sophisticated—for example, asking for suggestions to solve difficult technical problems while creating a new mod—whereas others are just "thank you" messages and other less relevant information. Following earlier research on online communities (Constant et al. 1996), we decided to content code 5,000 postings.[10]

We developed the content coding following the advice of Weber (1990). In preparation for coding, we read through a large number of postings, which we divided into distinct categories. From this preliminary analysis, we developed a coding scheme with four different categories: (1) question, (2) answer/response, (3) comment, and (4) other. We discussed the coding scheme with two

Table 2 Coding of External Communities

Category	Description of community	Examples of communities
Technical	Focused on practices, function, and features of software that both compete with and complement Propellerhead's applications. These communities concern products technologically similar to Propellerhead's software.	—KVR —Appleton —DigiTech —Line 6 —Cubase —Logic (Apple) —MP3
Artistic	Focused on creation, production, and recording of music mainly by use of software. These communities are used for sharing suggestions, evaluations and recommendations for gear and sampling, as well as communities for DJ activities.	—Harmony Central —ReasonStation —Sound on Sound —Reasonfreaks —EM411 —Combinator HQ

Note. The examples listed are the most commonly mentioned communities by respondents in our sample.

of the coders who had originally studied the messages independently. After categorizing the first 200 posts, we achieved 86% agreement and a Cohen's (1960) kappa of 0.83. We discussed sources of disagreement and how they could be overcome. Once we had ensured this level of reliability between the two coders, we developed two samples of 2,700 posts for each coder. We included an overlap to ensure good intercoder reliability throughout the process. The checks were similar to the first test for intercoder reliability, and they suggested that the coders were consistent over time. A Cohen's kappa of 0.83 is usually considered a good score of intercoder reliability (Cohen 1960), especially for a new coding scheme. The coders proved very able at separating appropriate questions from relevant answers/responses, and agreement for these two categories was 95%. We counted the *number of questions* by the content-coded posts. These posts to other members of the community included requests for information, clarification, or elaboration to solve a problem. We also measured the *number of answers* by counting only when a respondent provided an answer to a question from someone else.

We controlled for *community tenure* by counting the number of years a person has been active in the community since her first posting. People with a longer presence in the community will be more familiar with it, which should increase their likelihood of being innovative.

We expect that *product experience* influences the ability to innovate, because people who have used the product for a long time may be more aware—or more in need—of possible improvements. This is measured by the number of years of product experience.

People who spend more time in the community will have more chances to be innovative by virtue of being accustomed to the dialogue and being able to recognize new opportunities. We controlled for *time spent outside the community* by asking how many hours a week on average were spent in external communities, divided by the number of hours spent in Propellerhead's community.

According to von Hippel (1988), lead users are characterized by their ability to (1) foresee general market trends because their needs are heterogeneous, and (2) expect innovation-related benefits from a solution, which increases the motivation to innovate. von Hippel argues that lead users are likely to be innovators because they will try to find novel solutions to their unique problems. To control for this alternative explanation, we drew on Morrison et al. (2000) to construct a measure of degree of lead user characteristics. After pretesting the survey and analyzing the results with factor analysis and Cronbach's alpha, we amended some items to increase the reliability of the measure. Following Morrison et al. (2000), we captured von Hippel's (1988) definition of a lead user with a series of items.[11] Each item was scored on a seven-point Likert scale, ranging from "strongly disagree" to "strongly agree." We constructed the *degree of lead user attributes* variable by summarizing the scores assigned to these statements. The Cronbach's alpha for this measure was 0.76.

We control for a *familiarity bias* that may exist between the expert coders used for establishing our dependent variable and respondents in our sample. It is possible that coders recognize individuals with whom they have had previous interactions and potentially assign them a higher ranking as innovative. To assess this possibility, we count the number of judges a respondent had at least one interaction with in the community.[12]

Estimation Technique

The dependent variable *innovation* is an ordinal variable that ranks the extent to which a person is judged as innovative by experts in the community. We therefore use an ordered probit regression to ascertain the effects of the independent and control variables on the likelihood of individual innovation (Greene 1997).[13] As an alternative specification strategy, we also use quasi-maximum-likelihood (QML) Poisson regressions to predict innovation. This strategy is suitable because the dependent variable is a count variable taking only positive values. Because the Poisson model is in the linear exponential family, the coefficient estimates remain consistent as long as the mean of the dependent variable is correctly specified. QML Poisson standard errors are consistent even if the underlying data-generating process is not Poisson (Gourieroux et al. 1984). QML Poisson is suitable because it imposes little structure on the underlying data distribution and in general is a more conservative estimate of the coefficients because of larger standard errors.

More active members of the community might be more inclined to complete the survey, resulting in a nonrandom sample. We compared information on respondents and nonrespondents over the period that we content coded and found that respondents are slightly more active in the community (see the appendix for details about respondents and nonrespondents). To restrict our analysis to respondents could potentially bias our results because it would not account for what affected the selection process for inclusion in the sample. To counteract this potential problem, we first estimate the *inverse Mills ratio* as a selection parameter using information from the nonrespondents taken from the database of interactions (Heckman 1979). To calculate the selection parameter, we used the information on nonrespondents—namely, the numbers of answers and questions as well as tenure in the community. The number of questions a person asks in the community was correlated with submitting the survey, but it did not affect individual innovation. The inverse Mills ratio is integrated into our regressions.[14]

Results

Table 3 presents descriptive statistics and correlations between the variables. The highest correlation is 0.75 between the number of answers and the position in the core/periphery structure. We therefore assessed multicollinearity by deriving the variance inflation factors (VIFs). The highest VIF score was 5.8, well below the generally accepted threshold level of 10 (Greene 1997). We also included the independent variable stepwise to assess whether coefficients were consistent across the different models. Following Aiken and West (1991), we standardized our variables before developing the quadratic terms and the interaction effect that we hypothesized.

Table 4 presents the results from the regressions predicting individual innovation using three alternative strategies. Models 1–4 are results from ordered probit regressions predicting individual innovation using the dummy variables of the scores from the judges. Models 5–8 analyze the same dependent variable using QML Poisson regressions. Models 9–12 use QML Poisson regressions to predict individual innovation, also including the novelty scores. Across these regressions, the independent variables are remarkably consistent.

In Table 4, the first model for each estimation strategy is the baseline model, including only the control variables. The second model adds variables for boundary spanning to multiple external communities and position in the core/periphery structure as well as their squared terms to test for the inverted U-shaped effect that we hypothesized. The third model includes the interaction effect between external boundary spanning and position in the core/periphery structure. The fourth model parses out differences in spanning technical or artistic communities. Because the results are very similar, we use the results from Model 12 to interpret our results.

Hypothesis 1

We hypothesized that individuals at an intermediate position on a core/periphery continuum are most likely to be innovative. In support of this hypothesis, the coefficient for core/periphery position in the third model is significant at the 1% level, and the squared term is negative and significant at the 5% level. The magnitude of the squared effect, however, is not so great that we observe an inverted U-shaped relationship within the range of our data, but rather evidence of diminishing returns. In other words, to be innovative, a person benefits from being more core, but this effect tapers off: as the person moves closer to the core, the effect on innovation becomes weaker. Our interviews underscored the benefits of a position at the core to become innovative. The expectation of new contributions from people positioned in the core tends to be higher than for the average community member:

> It takes a bit of data mining to get to really good information and you have to learn about the way people post—who's posting, who's a reliable source, things like that.... But if you just show up and just sort of arbitrarily post once or twice about something you've learned, people probably won't pay attention to your contribution and no one is going to trust you.

> I think at this point now that I've been at the Propellerhead forum for five or six years, I think I've developed enough of a name for myself there.... People would say, oh, that's Ed, yeah, definitely listen to Ed—they know who I am.

When discussing why the periphery face obstacles to be innovate, a user said,

> If you're out on the periphery of the community, I think you'd have to invest a lot of time into making a name for yourself, for being known for quality.

Table 3 Descriptive Statistics ($n = 280$)

	1	2	3	4	5	6	7	8	9	10	11	12
1 *Innovative* (dummy)	1											
2 *Innovative* (ranking)	0.96	1										
3 *Spanning multiple external communities*	0.2	0.17	1									
4 *Spanning multiple external communities* (technical)	0.16	0.13	0.61	1								
5 *Spanning multiple external communities* (artistic)	0.14	0.12	0.81	0.03	1							
6 *Core/periphery position*	0.48	0.51	0.13	0.12	0.08	1						
7 *Degree of lead user attributes*	0.22	0.23	0.2	0.03	0.24	0.08	1					
8 *Time spent outside the community*	−0.1	−0.12	0.49	0.25	0.43	−0.16	0.03	1				
9 ln(1 + *Number of answers to questions*)	0.43	0.46	0.17	0.1	0.14	0.75	0.1	−0.15	1			
10 *Product experience*	0.2	0.18	0.22	0.17	0.16	−0.07	0.28	0.04	−0.04	1		
11 *Tenure in the community*	0.36	0.37	0.12	0.08	0.09	0.33	0.15	−0.15	0.33	0.2	1	
12 *Familiarity bias*	0.10	0.12	0.02	0.08	−0.03	0.44	0.12	−0.07	0.29	0.10	0.12	1
Mean	0.821	1.021	2.311	0.889	1.421	0.015	3.413	0.538	0.258	4.254	1.629	1.475
SD	1.288	1.762	2.187	1.275	1.737	0.037	0.775	0.258	0.604	0.853	1.883	0.306
Min	0	0	0	0	0	0	1.375	0	0	2	0	1
Max	5	9	10	7	9	0.274	5	1	3.296	5	5	3

Several users mentioned that there was an informal competition going on in the core of the community. This competition regarded solving particularly difficult problems that community members faced. These users tried to circumvent a particular critical problem in the most elegant and innovative way possible. They used functions of the current product in novel ways or introduced a new piece of software. Solving difficult problems earned them recognition as innovators.

Our results demonstrate that being too core in a community may cause individuals to become inward looking and blind to novelty from external communities. A user told this story:

> I remember mentioning to one user that his list and functions of orchestra samples could have been enhanced if he'd looked at some outside sampling packs, but he seemed, well.... I wouldn't say hostile. He wasn't hostile about it, but he was deliberately uninterested in it because he was very interested in promoting his work within Reason. And in fact, Propellerhead has used some of his stuff because his arrangements were so good.... I simply had suggested that perhaps he use more sophisticated orchestra samples inspired by what was going on outside the Prop community, and I made some specific comment about which samples he could look at; it would probably enhance the process a little bit. And he didn't seem very interested in that option. He wanted to stick with Reason.

This story implies that core members often become focused on established ways of solving problems. Core members also have greater expectations of delivering high-quality solutions. This sometimes results in performance anxiety. Consistent with Schilling's findings (2005), our interviewees noted that people embedded in the core experienced a homogenizing effect of beliefs and evaluation of activities, making them reluctant to contribute novelty to the field. At some point, being too core can limit members' ability to innovate.

Hypothesis 2

We proposed that external boundary spanning has an inverted U-shaped relationship to innovation. In partial support of our reasoning, the third model shows that the main effect of external boundary spanning is significant at the 5% level. However, in contrast to our reasoning, the squared term is insignificant, which suggests that the idea of an inverted U shape could not be supported. This implies that participating in a variety of communities is not detrimental to innovation.

People who spanned communities were confronted by other means of solving problems that spurred their ability to innovate and provoked the community members to think differently. Explaining the import and export of ideas between communities, an interviewee proposed,

> People take ideas from other communities focused on music software and introduce this in the Prop community. People mention features of other software and platforms that Reason doesn't do, and a lot of times those things show up and you give suggestions for them.... Someone will come along and say, you can do that in Reason. It's not in the same manner that you can do it in other software and here's how you do it...or use this small software application to enable this function.

Respondents use multiple external communities for a variety of activities that complement the activities in Propellerhead's community. An interviewee suggested that "external communities work as a kind of hunting ground for ideas for users' individual projects and clues to how to solve a particular problem in an alternative

Table 4 Predicting Innovation Using Three Different Strategies

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Dependent variable:	*Innovative* (dummy)				*Innovative* (dummy)				*Innovative* (ranking)			
Estimation strategy:	Ordered probit				QML Poisson				QML Poisson			
Control variables												
Degree of lead user attributes	0.147^{+}	0.133^{+}	0.133^{+}	0.143^{+}	0.159^{+}	0.144	0.164^{+}	0.168^{+}	0.224*	0.218*	0.246**	0.246**
	(0.077)	(0.078)	(0.078)	(0.080)	(0.092)	(0.094)	(0.091)	(0.094)	(0.091)	(0.096)	(0.092)	(0.093)
Time spent outside community	0.019	−0.077	−0.084	−0.05	0.009	−0.094	−0.12	−0.073	−0.011	−0.082	−0.119	−0.072
	(0.071)	(0.087)	(0.088)	(0.087)	(0.083)	(0.111)	(0.103)	(0.098)	(0.088)	(0.118)	(0.103)	(0.096)
ln(1 + *Number of answers to questions*)	0.340**	−0.008	−0.001	−0.024	0.299**	−0.027	−0.016	−0.041	0.324**	−0.017	−0.011	−0.038
	(0.075)	(0.110)	(0.109)	(0.114)	(0.062)	(0.098)	(0.091)	(0.103)	(0.059)	(0.109)	(0.098)	(0.111)
Product experience	0.278**	0.275**	0.284**	0.289**	0.271**	0.277**	0.295**	0.307**	0.207^{+}	0.226*	0.249*	0.263*
	(0.081)	(0.088)	(0.091)	(0.091)	(0.099)	(0.107)	(0.106)	(0.106)	(0.107)	(0.110)	(0.107)	(0.107)
Familiarity bias	0.204	−0.078	−0.029	−0.063	0.123	−0.152	−0.058	−0.105	0.125	−0.155	−0.06	−0.107
	(0.190)	(0.229)	(0.233)	(0.239)	(0.183)	(0.216)	(0.216)	(0.218)	(0.191)	(0.219)	(0.228)	(0.230)
Tenure in the community	0.160**	0.115**	0.115**	0.118**	0.174**	0.123*	0.118*	0.125*	0.199**	0.144**	0.139**	0.146**
	(0.041)	(0.043)	(0.044)	(0.043)	(0.048)	(0.051)	(0.051)	(0.051)	(0.050)	(0.053)	(0.053)	(0.053)
Independent variables												
Spanning multiple external communities		0.213*	0.219*			0.235*	0.296*			0.186*	0.275*	
		(0.104)	(0.105)			(0.107)	(0.125)			(0.086)	(0.131)	
Spanning multiple external communities^2		−0.062	−0.053			−0.091^{+}	−0.066			−0.096^{+}	−0.071	
		(0.052)	(0.052)			(0.054)	(0.058)			(0.054)	(0.064)	
Core/periphery position		0.683**	0.692**	0.797**		0.622**	0.627**	0.760**		0.684**	0.690**	0.840**
		(0.167)	(0.160)	(0.170)		(0.188)	(0.154)	(0.152)		(0.208)	(0.160)	0.161)
Core/periphery position^2		−0.067*	−0.066*	−0.071**		−0.068^{+}	−0.060*	−0.062**		−0.075^{+}	−0.065*	−0.069**
		(0.029)	(0.027)	(0.027)		(0.036)	(0.025)	(0.022)		(0.041)	0.027)	(0.023)
Core/periphery position ∗ *Spanning multiple external communities*			−0.077*				−0.120*				−0.141*	
			(0.028)				(0.051)				(0.056)	
Spanning multiple external communities (technical)				0.096*				0.117**				0.108*
				(0.044)				(0.044)				(0.047)
Spanning multiple external communities (artistic)				0.047				0.064				0.052
				(0.054)				(0.061)				(0.061)
Core/periphery position ∗ *Spanning multiple external communities* (technical)				−0.062**				−0.071**				−0.078**
				(0.021)				(0.019)				(0.020)
Core/periphery position ∗ *Spanning multiple external communities* (artistic)				0.002				−0.028				−0.036
				(0.038)				(0.036)				(0.035)
Inverse Mills ratio	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	3.246**	1.745*	1.844**	1.959**	−1.191*	0.394	0.193	0.083	−1.120^{+}	0.544	0.344	0.249
	(0.613)	(0.714)	(0.715)	(0.700)	(0.554)	(0.595)	(0.589)	(0.552)	(0.576)	(0.631)	(0.615)	(0.566)
Wald Chi square	82.1	115.9	125.5	149.5	159.4	170.9	190.7	195.0	177.0	194.7	241.8	250.9
Log likelihood	−308.9	−295.6	−290.0	−289.2	−326.3	−314.9	−308.6	−307.7	−375.4	−360.7	−354.9	−353.9
Number of observations	280	280	280	280	280	280	280	280	280	280	280	280
Degrees of freedom	7	11	12	13	7	11	12	13	7	11	12	13

Notes. Standardized coefficients. Robust standard errors are in parentheses. Cut points are suppressed in the ordered probit regressions.
$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$ (two-tailed tests).

way." In this context, external boundary spanning produces benefits from accessing mixing competencies:

> I interact with people in other communities who are professional composers and sound designers and/or music technicians. They hang out in these community spaces and you can pick their brains about things in ways that you'd have to have gone to college or you would have to spend all of your time hunting these people down and trying to talk to them in person. And now you can just do it online and everybody can do it all at once. It's pretty amazing.

This comment suggests that users need a degree of familiarity with the topics present in the external community to see the options for beneficial interfacing with the Propellerhead software. We therefore infer that users allocate some time to activities in external communities before they gain anything from such participation. One user in the Propellerhead community summarized the benefits of spanning external boundaries:

> When being involved in different communities you get a broader sense of opportunities and options. I mean for me as a professional musician, I'm looking for work. I'm often looking for new tools that will help me do my work faster and easier and the more things—the more persons you touch base with, the more you're going to have opportunities to have more work, to have more chances to learn about new software and different opportunities that are coming out.... So the upside is lots of information.... You kind of have to find a path for yourself in there to help you move forward with your career, whatever that may be.

Propellerhead did not discourage boundary spanning to multiple communities, as a product manager described:

> If there is a strong, positive spirit in one community, I think that that spreads across to other, adjacent communities, through this system that people are visiting more than one community. And that they pick up a notion, an idea, or get some feedback about a new feature, and the new software that they haven't tried out themselves. But they get that piece of information there, and it's like a little seed of information that grows. And then they can either confirm it themselves, or they get the confirmation from other users, and then they spread that to a second community, or a third community, and so on. So there is cross-contamination, if you like, between communities.

Our interviews, as well as coding of external communities, show that participants typically spanned two types of communities: technical and artistic (see Table 2). We decided to analyze these types separately to gain a better understanding of their effect on innovation. Some people interact in communities of professional composers and sound designers, whereas others sought communities of a more technical nature. The technical communities are engaged in *developing and improving* the software, whereas the artistic communities focus on developing the artistic content and thus are oriented toward *using* the music software. In the fourth model, we parse out these differences by separating the number of technical and artistic communities a person participates in. The coefficient for technical boundary spanning was significant, but the coefficient for boundary spanning to artistic communities was not. This finding underlines the importance of considering *types* of boundary spanning when we investigate individual-level innovation.

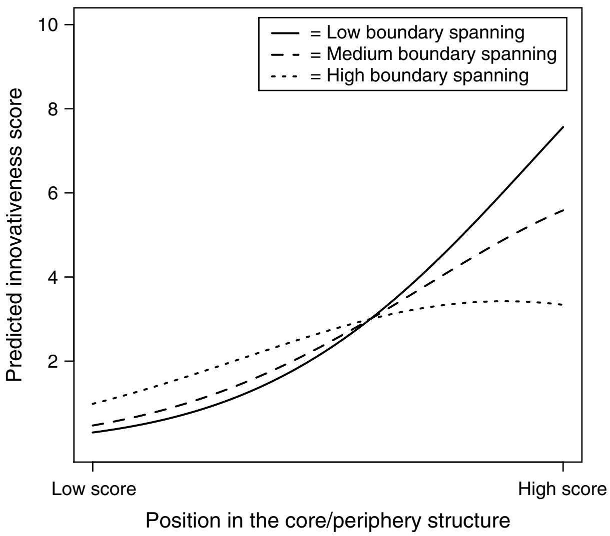
Technical communities are similar to the Propellerhead community and are focused around software; they include user interaction about improved technical use and features, sharing of code and prototypes, and pieces of alternative software, which are more directly useful to innovate. Information from technical communities serves as *inputs* into processes of innovation. When this type of information is integrated into the prototypes and mods of the Propellerhead community, it is easy for community peers to to identify and evaluate it as innovative. Artistic communities, in contrast, deal with *outputs* of the software; it is use-related knowledge that is more difficult to recognize when integrated into contributions from the Propellerhead's community. Artistic communities are thus more distant from the innovation process, and hence spanning these communities has no effect on innovation.

Hypothesis 3

We argued that there is a substitution effect between external boundary spanning and position within the core/periphery structure on innovation. In support of our argument, we found that the interaction effect between spanning multiple communities and position in the core/periphery structure was negative and significant at the 5% level. Using the coefficients from the final model, Figure 1 graphs the influence of the core/periphery position on the predicted innovativeness score with three levels of boundary spanning in the full sample: those at the 10th percentile, mean, and 90th percentile. The graph shows that increasing one's core position enhances innovation. Participants who span multiple external communities (i.e., 90th percentile) are more likely to be innovative than those who are not (10th percentile). However, the low boundary spanners garner the greatest reward from increasing their core position, and these people surpass the most active boundary spanners at the very highest levels of core/periphery. The three lines cross at the 94th percentile in core/periphery position, meaning that for about 17 individuals in the sample, boundary spanning is detrimental for innovation.

We see two main implications of this figure. First, spanning multiple external boundaries remains a positive delineator for most people, especially those that are not among the most core individuals (those with less than a 94th percentile position on the core/periphery continuum).[15] This finding is illustrated by the line for high boundary spanners at low levels of core/periphery

Figure 1 Predicted Innovativeness Score as Core/Periphery Position Changes, by Three Levels of Boundary Spanning to External Communities



Note. The figure is based on Model 12 in Table 4, with all other variables held at their mean.

position. Many peripheral people are cosmopolitans who have no ambition to become part of the core in the community but enjoy spanning multiple external communities. They have a sense of autonomy and feel that they could easily move between communities to find solutions to their problems. These users explained that they have lower expectations than people who were closer to the core. When they contributed, they could draw on experiences from other communities and develop artifacts that other community members recognized as innovative. One such story concerned a woman who developed graphical "skins" that changed the appearance and function of the software:

> There's this one girl named Wendy, and she makes skins. So whenever she comes on the community and says, I have a new skin, she's known for her quality and innovative work. So there's no question of who is this and what is the skin and, oh, that's garbage. It's always like, well, it's Wendy, it's got to be good. And she comes in and out of the community; she hasn't posted in a while but gets known for what she does.

The second implication is that for the most core members, boundary spanning can be detrimental for innovation. The line for low boundary spanning in Figure 1 illustrates that at very high levels, people who are close to the core and low on boundary spanning surpass those who are more active boundary spanners. These individuals play a different role in the community. Many of them reach out for inspiration *within* the community. They offer help and gain ideas from peripheral users without being involved in boundary spanning to external communities. One of the most core persons said,

> I'm on the community all the time. People think I just live there.... So I sit at my desk editing video on my computer and then when the computer's busy doing a one-minute render of some video file or graphics or something, I'll just hop over to the music software forum and see if there's anything new that I can answer or reply back to a message—solve a problem in a new way. In this way I gain a lot of new inspiration as well.

This comment suggests that core members partly depend on peripheral users in the focal community to span multiple communities.

We continued by analyzing the interaction effect between core/periphery and the two forms of communities: technical and artistic. This analysis shows that the contingent effect is driven by technical boundary spanning. This is consistent with the arguments presented above for Hypothesis 2. A person's position in the core/periphery continuum in the community is interacting with *the type* of external boundary spanning on its effect on innovation.

Robustness Checks

We conducted several robustness checks. First, our results control for a potential familiarity bias if the person being evaluated had interacted with one of the judges at least once before the survey was distributed. An alternative measure is the number of interactions between judges and users, but using this measure did not change our results. Second, the effect of artistic boundary spanning was insignificant in our regressions. It could be that this effect is important only in combination with technical boundary spanning. We assessed this potential interaction effect, but it was insignificant. Third, we experimented with various ways to define an individual's tenure in the community. It is plausible that some people have been part of the community for years but contribute only occasionally. We thus weighted the tenure by quantity of postings in the community and found no changes to the results. Fourth, we assessed different ways of defining a tie between individuals. In the reported results, we used the most intuitive measure: a tie exists if two people interacted at least once. The results did not change when we used at least two and three interactions as different cutoff points.

Discussion

Theoretical Contributions

This paper demonstrates how relationships inside and outside user communities affect why some individuals are considered innovative. Our findings have broad implications for scholars of user innovation. Research has shown that contributions from users to a community can create value for both contributors and firms (Urban and von Hippel 1988, Lilien et al. 2002). Central to this research is explaining innovation by examining various individual characteristics, such as user attributes (Urban and von Hippel 1988, Lerner and Tirole 2002). This literature has documented how users form communities to solve problems and find like-minded people with whom they share interests (Moon and Sproull 2008). Our work deepens this literature by considering how the community forms a social structure that provides opportunities for individuals to innovate. Our first important finding is how one's position in the core/periphery structure of a user community, controlled for alternative explanations, is consequential for innovating. Hence our findings indicate that even being an early member of a community with a high level of product experience is not enough to be innovative. The effects of being at the core and being a cosmopolitan who spans multiple communities trump the effects of individual characteristics such as lead user attributes, which implies that researchers need to consider a relational view that influences the conditions under which users innovate.

Our findings also speak to organizational scholars studying communities. Research has underlined the challenges of transferring knowledge from one community to another *within* organizations (Dougherty 1992, Bechky 2003, Carlile 2004). In the community literature, scholars have been primarily concerned with how communities organize *inside* (see, e.g., Lave and Wenger 1991) and overlooked membership in multiple *external* communities (Jeppesen and Laursen 2009, Wolfe 2006). When community boundaries are permeable and there are few sanctions for those who span them, individuals can draw on more divergent ideas and mind-sets than a single community could offer. We demonstrate that spanning multiple communities has a positive effect on the likelihood that a person will innovate. Our interviews illustrate how this boundary spanning enables Propellerhead's users to import ideas and find information that could be reused in a new community.

We deepened this analysis by coding all communities in which our survey respondents were engaged and divided them into two categories: technical and artistic. There are significant differences in the magnitude of the direct effects on individual innovation: boundary spanning had a positive effect *only* when spanning to other technical communities. Without separating the specific behaviors, it would have been easy to mistakenly attribute our findings to boundary spanning in general. This discovery emphasizes the need to consider different *types* of boundary spanning between organizations (Tortoriello and Krackhardt 2010), or in our case, communities. Information from technical communities serves as *inputs* to the innovation process, *whereas* artistic communities deal with *outputs* of the software. Information transferred from external technical communities is closer to the innovation process. In an interview, a user suggested that boundary spanning to technical communities is seen as providing real innovative ideas for developing the features and functions of the software, which was not the case when spanning boundaries to communities engaged with "doing music and just *using* the software."

In firms, managers have the authority to make decisions about who is supposed to work with whom, employees are accountable if they do not contribute, and there are formalized communication channels between organizational units. As a result, network structures are often fractionalized with only a few relationships across groups (Kleinbaum et al. 2009). Communities, by contrast, have a much more skewed distribution of contribution rates because of the possibility of multiple memberships and lack of vertical authority. By extension, there is a dedicated core of participants and a loosely attached periphery (Borgatti and Everett 1999). We elaborated on this argument by investigating what types of positions were associated with innovation. Prior work has resulted in conflicting arguments, contending that both periphery and core are more innovative (Crane 1972, Cattani and Ferriani 2008).

A common lament in this literature is the focus on a single network or community. Our study suggests that both the broader social context of external communities *and* social structures within communities need to be considered in tandem. Ignoring the internal social structure in arguments about external boundary spanning can result in an unintended omission of important social features that influence innovation. Communities do not evolve in isolation, and cosmopolitans who can span community boundaries are in a good position to assimilate divergent information.

The "boundary problem" is commonly observed in studies of networks within organizations when scholars are forced to make assumptions where the network ends (Wasserman and Faust 1994, p. 31). Our work points to the need to consider the social structure within communities and link these features to varying forms of external collaboration. Whereas Perry-Smith (2006) connects this to an individual's number of relationships within an organization, we link it to the core/periphery structure of the community. For most users, our results suggest that the combination of being core *and* a cosmopolitan who spans multiple communities has the greatest rewards on innovation. The effect of being core is stronger for low boundary spanners, however; for those who are located closest to the core, it could potentially be better for innovation to span few boundaries. In other words, there exists a substitution effect where the most core individuals do not become more innovative by spanning external communities. Instead, these individuals use other users located on the periphery of the focal community as sources of novel ideas for innovation, whereas peripheral users often span boundaries to other communities to become innovative. In sum, organization and community scholars are well advised to consider both internal and external relationships in tandem, because each explanation alone could miss how individuals engage in different forms of collaboration to be innovative.

Managerial Implications

In recent years, firms have invested significant resources in community-based innovation strategies, for example, creating online communities that tap into user-driven innovation processes. These companies hope to increase their competitiveness by gaining access to product-specific, difficult-to-imitate assets such as ideas for improvements, modifications, and applications (Williams and Cothrel 2000). This is a cumbersome task: von Krogh (2006) shows that a large number of user communities fade away because they cannot develop enough innovation to sustain interest. How can organizations prevent this? von Hippel (1988) has stressed identification of the "right" set of technically skilled users and the correct incentive structures to promote innovation. In contrast, our study underlines the significance of looking beyond individual users and investigating collaborations inside and outside communities. Cherry-picking a few people with certain attributes risks overlooking other more unexpected sources of innovation. The social web of relationships within and between communities exercises strong effects on innovation, over and beyond individual attributes.

Firms typically store the interactions within their community in a database. Investigating these data from a social network perspective yields insights into where—and potentially how—innovations emerge. Our study points to the need to integrate social network perspectives inside communities with the ways in which individuals span multiple external communities. Firms can easily collect data on where members surf next when leaving their Internet community, and in combination with the social network data, they may discover unparalleled conclusions about individual behavior and its association with innovation.

If companies invest resources in creating and moderating their communities, they may be tempted to prevent users from spanning community boundaries. They want users to spend the maximum time and attention within the firm's community. However, online communities can become too locked into a particular technological domain or solution space to be useful to the firm. The pitfalls of provincialism have been shown at the organizational level (Rosenkopf and Nerkar 2001), and our study supports this argument by providing evidence at the community level: spanning multiple communities sparks innovation. To keep their communities vibrant, firms should not deter individuals from membership in external communities. Propellerhead's product development director said,

> If you're going to dedicate all that time to a community, you as a user of Propellerhead products want to dedicate it in a community of people where you get lots of feedback, where you have possibilities to develop your own music and get help, and where new mods and software applications are created and shared. Surprises of ideas from outside the community are useful. I would much rather work in a less good, technologically, software environment, with a huge, energetic, friendly, good community, rather than a perfect software [environment], with no community. So the community, I think, it is a vital, and a very important, part of why Reason [Propellerhead's key product] has been so successful.

Users in external communities are just a click away, and they can contribute new ideas even if they contribute only occasionally. Firms can even explicitly promote external communities that are particularly helpful for users to visit to get complementary information. For instance, we found different effects for technical and artistic communities. Depending on a person's position inside the community (not only her personal attributes, which are commonly considered today), firms could tailor messages pointing her to other selected sites.

Generalizability and Future Directions

We focused on a single community, but we can elaborate on scope conditions of our theory. First, permeable boundaries allow for membership in multiple communities (Shah 2006). This is not always the case; firms often have mechanisms that prevent employees from revealing company-specific information. Although permeability is pertinent in the online world, where other communities are a click away, it is also present in off-line communities. Some organizations promote their technically skilled employees to be "cosmopolitans" who search for external information from various constituents to keep pace with an expanding knowledge frontier. Second, our theoretical argument is applicable when individuals collectively explore a knowledge frontier, as in user communities or science. In these cases, innovation occurs through collaboration, yet some innovators get more recognition than others (Douglas 1986). Future studies could replicate our research in various forms of communities and could validate the arguments or refine scope conditions.

Our suggestions for future research stem from the limitations of our study. First, a reverse-causality explanation is a possibility: innovative individuals from the periphery could be dragged to the core, driven by their aspiration to be seen as important and loyal community members (Jetten et al. 2003). Although it is difficult to rule out that possibility, several points speak to our proposed direction. We include several controls that have been pointed out in prior work to influence innovation: tenure in the community, level of education, and lead user attributes that control for individuals' ability to generate innovations.[16] Our proposed effects persist and retain their statistical significance when we include these factors. When our interviewees told stories about how individuals contributed to the community over time, they often explained that people start by lurking and then ask questions. They gradually come closer to the core of the community and begin to answer messages from fellow members, and then they post their innovations. Other people strategically choose to span multiple communities to advance their knowledge. We collected a number of stories about people who were peripheral yet *not* dragged to the core, supporting our line of reasoning. This led us to conclude that our results are difficult to reconcile with a theory built on reverse causality. Second, our survey and our judges' assessments of innovation come from a single point in time. Longitudinal data to capture how individuals move in the core/periphery structure could enrich our work. Finally, there are multiple ways to define individual innovation. We used judges to rank individuals' innovations because patents or new product introduction is not an appropriate measure in this context. In the Propellerhead case, we believe expert judges are appropriate because this method captures various forms of contributions. In extending the same research design to other contexts, however, other measures of innovation may be more suitable.

We believe our findings are important for organizational scholars in light of how common user communities have become as a means to spur innovation. Users form relationships within and outside communities that provide opportunities to innovate.

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Appendix
Because we had coded all 5,000 posts in the community before distributing the survey, we could compare respondents and nonrespondents. Respondents were more likely to answer questions and less likely to pose questions in the community. Individuals who posed questions were likely to respond to the survey, but this variable was not correlated with individual innovation. The idea that individuals who pose questions were not associated with innovation was also confirmed in interviews with community members. Table A1 shows the mean numbers of the variables and a *t*-test of the differences.

Table A1 *t*-Test Comparing Respondents and Nonrespondents

Variable	Respondents ($n = 280$)	Nonrespondents ($n = 686$)	*t*-test
Number of answers	0.77	0.41	**
Number of questions	0.48	0.81	**
Tenure in the community	1.62	1.51	

$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$.

Table A2 Correlations Matrix

Variable	1	2	3
1 ln(1 + *Number of answers*)	1		
2 ln(1 + *Number of questions*)	0.32	1	
3 *Tenure in the community*	0.22	−0.07	1

Note. $n = 966$.

Table A3 Probit Regression Predicting Response to Survey

Variable	Model A
Tenure in the community	−0.011
	(0.024)
ln(1 + *Number of answers*)	0.441
	(0.094)**
ln(1 + *Number of questions*)	−0.811
	(0.101)**
Constant	−0.353
	(0.066)**
Log likelihood	−545.49
Number of observations	966
Number of selected observations	280

Notes. $n = 966$. Robust standard errors are in parentheses.
$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$ (two-tailed tests).

Next we used a probit regression to predict the probability to respond to the survey. Table A2 shows the correlations between the variables, and Table A3 shows the results from the regression. Table A3 illustrates that the number of questions has a negative effect on the probability of responding to the survey (newbies are slightly less likely to be part of the survey). From this result we developed the inverse Mills ratio that we include in our analysis in Table 4. Including the inverse Mills ratio in our regressions did not alter the direction of coefficients or significance of our results.

Endnotes
[1]Although some Propellerhead employees post messages in the community, we were fortunate to receive their user IDs. We could thus include and exclude them from our analysis to see whether there were any differences. No Propellerhead employees responded to our survey.
[2]Users have developed about 250–300 mods and extras in the Propellerhead community since the inception of the community.
[3]Here, we included postings from individuals in our sample as well as other people. We elaborate more on this procedure in the variable description.

[4]We included all survey items used in the paper in the factor analysis. No single factor emerged that accounted for a large proportion of the total variance, which provides support for our claim that the survey does not suffer from common method bias (Podsakoff et al. 2003).

[5]Our study is comparable to the research of Fauchart and von Hippel (2008) that explores disputes among French chefs over allocating intellectual property rights to certain dishes, ingredients, cooking processes, or presentations. These disputes emerge because a lack of consensus of what is considered innovative has not been clearly defined by the community.

[6]Two of the coders were considered core in the community, and two were peripheral. We found no difference between the experts in how they ranked individuals depending on their position in the core/periphery structure.

[7]Fleck (1935, p. 39) believed that "thought collectives" can be defined as "a community of persons mutually exchanging ideas or maintaining intellectual interaction." Online communities resemble thought collectives because they have a particular character that determines their evolution. Fleck argued that such collectives consist of a relatively small esoteric circle of experts and much bigger exoteric circles of people who apply rather than advance new knowledge.

[8]The core/periphery measure for each person was calculated from the prior 5,000 posts before the survey was conducted. These were also the posts we content coded. We also used all posts in the community, and the results were similar.

[9]Only one person in our sample from the Propellerhead community indicated participation in 10 additional communities.

[10]Any member in the community posted these (i.e., not only people who replied to the survey).

[11]The items were as follows: "I find out about new products and solutions earlier than others in the community," "I would benefit by early adoption and use of new products," "I have tested prototype versions of new products," "I use Propellerhead's products more regularly than other software-related products," "I have made suggestions for how to improve Propellerhead's products," "I often identify important ideas or trends related to Propellerhead's community before other members in the community," "I am interested in doing prototype evaluation on products before public release," and "I would be willing to spend plenty of time to get access to novel information before others."

[12]We thank an anonymous reviewer for suggesting this measure.

[13]Ordered probit regressions rest on the proportional odds assumption—that the effect from moving from 0 to 1 is the same as moving from 1 to 2. We ran the regressions using ordered logistic regressions and pursued the Brant test. Our regressions did not violate the proportional odds assumption.

[14]Including the inverse Mills ratio does not change our results.

[15]This figure does not report confidence intervals for the lines to increase readability. That said, there are very few observations after the point where the lines cross.

[16]Our models also included controls for the number of answers in the community that measure the sheer *volume* someone posts.

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CORRECTION

In this article, "The Core and Cosmopolitans: A Relational View of Innovation in User Communities" by Linus Dahlander and Lars Frederiksen (first published in Articles in Advance July 5, 2011, *Organization Science*, DOI: 10.1287/orsc.1110.0673), the following reference has been added to the reference list and cited in text:

Jeppesen, L. B., K. Laursen. 2009. The role of lead users in knowledge sharing. *Res. Policy* **38**(10) 1582–1589.