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Why Do Users Contribute to Firm-Hosted User Communities? The Case of Computer-Controlled Music Instruments

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Studies of the sources of innovations have recognized that many innovations are developed by users. However, the fact that firms employ communities of users to strengthen their innovation process has not yet received much attention. In online firm-hosted user communities, users freely reveal innovations to a firm's product platform, which can put the firm in a favorable position (a) because these new product features become available to all users through sharing on a user-to-user basis, or (b) because it allows the firm to pick up the innovations and integrate them in future products and then benefit by selling them to all users. We study the key personal attributes of the individuals responsible for innovations, namely the innovative users, to explain creation of value in this organizational context. The main question is why such users contribute to firm-hosted user communities. Analyzing data derived from multiple sources (interviews, a Web-log, and questionnaires), we find that innovative users are likely to be (i) hobbyists, an attribute that can be assumed to (positively) affect innovators' willingness to share innovations, and (ii) responsive to "firm recognition" as a motivating factor for undertaking innovation, which explains their decision to join the firm's domain. In agreement with earlier studies, we also find that innovative users are likely to be "lead users," an attribute that we assume to affect the quality of user innovation. Whether or not a firm-hosted user community can be turned into an asset for the firm is to a great extent conditional on the issues studied in this paper.

Key words: innovation; user community; user characteristics

Introduction

There has been considerable interest in innovation resulting from user activities (Rothwell et al. 1974; Rosenberg 1976; von Hippel 1976, 1988). The need to know more about the phenomenon of user innovation coincides with the rapid spread of the phenomenon itself—recently, and most importantly, as a consequence of the Internet and enhanced connectivity among agents involved in innovative activities. This paper is concerned with a new form of business organization for innovation that relies on users for innovation through an online firm-hosted user community. It employs Internet communication technologies as vehicles to increase information sharing. Because online communication drastically lowers the costs of firm-to-user and user-to-user interaction compared to that of an "off-line," physically based community, online communities have been adopted by firms to build brands (Muniz and O'Guinn 2001), support product use (Moon and Sproull 2001), collect feedback and ideas (Williams and Cothrel 2000), and to charge community-based customer access fees (Armstrong and Hagel 1996). An important outcome of the Internet diffusion complementary to that of low-cost access to users is the rise of more flexible production processes that enable some firms to respond to new information, such as user feedback, for longer proportions of a development cycle, resulting in a better-performing product-developing project cycle (Iansiti and MacCormack 1997, MacCormack et al. 2001).

We study the context in which a firm uses online access to an innovative user community to benefit from complementary user innovations that extend the scope of its original product. Thus, in this context firms can not only gain rapid feedback on their development, they can also monitor and integrate, and get ideas from ready-made user innovations that have proven valuable to users. Recent studies of community-based innovation models in which users join "peer-to-peer communities of common interest" both online (Lerner and Tirole 2002, Lakhani and von Hippel 2003, O'Mahony 2003, von Krogh and von Hippel 2003) and "off-line" (Shah 2000, Lüthje 2003, Franke and Shah 2003) suggest that innovative user communities may yield important value, for example, new product concepts or product features. While these findings are important, so far few studies have investigated the context in which a firm and a user community intersect and what firms can do to organize user innovation and capture the benefits of such innovations.

In this paper, our specific interest lies with the key personal attributes of the main contributor to this type of organization: the innovative user. Our main question is: Why do users contribute to firm-hosted user communities? By "contribute" we mean that in these communi-

ties users freely reveal innovations complementary to a firm's product platform, which in turn can put the firm in a favorable position (a) because these new product features become available to all users by sharing on a user-to-user basis, or (b) because it allows the firm to pick up the innovations and integrate them in future products and then benefit by selling them to all users (Jeppesen and Molin 2003, Henkel and von Hippel 2005). We seek to answer the question by looking at the key attributes of the individuals who create and reveal value in this context, namely the innovative users. Hence, the relevance of this phenomenon to business economics is that, under the right conditions, firms may gain a competitive advantage from the effects of having a community of innovative users connected with it. Framed, for example, in the language of the resource-based view of the firm (Wernerfelt 1984, Barney 1991), a user community may turn into a strategic asset: an imperfectly imitable resource that can hardly be purchased but must evolve. By studying the personal attributes of innovative users, this study thus points to some of the necessary conditions under which a user community turns into an asset for the firm in the first place. The attributes we focus on in this paper are innovative users' work-related status, reputation mechanisms that may motivate users to innovate and participate in the community, and users' "leading edgeness" in the field of use.

To answer these questions, we conducted a study that draws on data collected from a variety of sources, such as interviews with users and in-house product developers, Web-log information, data from a Web-based questionnaire yielding 442 responses, and a targeted follow-up questionnaire generating 13 responses. We are aware that the question posed cannot be answered in full on the basis of the personal attributes of innovative users. Having users with the right attributes in the community is a necessary condition, but only a contributing factor in explaining why users contribute to firm-hosted user communities. However, user attributes are a crucial factor in determining why firm-hosted user communities can yield innovations.

The remainder of this paper is structured as follows: As a backdrop for the current research, we briefly review the results of studies on user innovation. Then we outline the empirical context of our study, focusing on recent examples of innovation by users in computer-controlled music instruments. Subsequently, we establish hypotheses, which are followed by a methodology section and a description of the data collected. Finally, we present our results and a discussion.

User Innovation—A Brief Review

For three decades, scholars of user innovation have studied the patterns of innovation by users. While the majority of the contributions within the literature on user innovation have focused on innovation related to industrial products within firms, there has recently been a surge of interest in the phenomenon of user innovation related to consumer products. Here innovation happens outside a firm. Many of the innovative users in the field of consumer products have turned out to be hobbyists in their fields of innovation (Shah 2000, Lüthje 2003, Franke and Shah 2003), meaning that the field in which they innovate is not the field of their core occupation. We use the notion of hobbyist to denote the fact that for these individuals, the development or use of the product in question is not their main source of income. Tables 1 and 2 below suggest a mixed picture, in which innovation by users covers the range from professionals to hobbyists.

Tables 1 and 2 above establish the fact that user innovation is indeed taking place across a number of different product fields. Both industrial user firms and individual end-consumers/hobbyists innovate in their respective fields of interest. In Table 1, where professionals are the users, we can observe that between 11%

Table 1 The Product Area and the Sources of Innovation in Cases Where Users Are Professionals in Firms

	Source of innovation			
Product area	User (%)	Mfr. (%)	Other (%)	*N*
Petroleum processing Enos (1962)	43	14	43	7
Computer innovations 1944–1962 Knight (1963)	26	74		161
Chemical processes and process equipment Freeman (1968)	70	30		810
Scientific instruments von Hippel (1976)	76	24		111
Semiconductor and electronics subassembly manufacturing equipment von Hippel (1977)	67	21	12	49
Wirestripping and connector attachment equipment VanderWerf (1982)	11	33	56	20

Note. Abstracted from Shah (2003).

Table 2 The Product Area of Innovation in Consumer Goods and the Share of User Hobbyists Who Report Having Innovated Within Each Area

Consumer products	Share of innovators in the population (%)	*N*
Hiking equipment Lüthje (2003)	9.8	153
Mountain biking equipment Lüthje et al. (2002)	15.4	291
Snowboarding, sailplaning, canyoneering, and handicapped cycling equipment Franke and Shah (2003)	38*	197

Note. Respondents were preselected on having an idea for an innovation.

and 76% of the innovation in a field was the result of user efforts. The studies of user innovation in consumer goods (Table 2) fields show that a large share (10% to 38%) of a given population of users report having innovated. These studies have focused on user communities in which consumers communicate and exchange information with fellow consumers (von Hippel 2001, Franke and Shah 2003, Lüthje 2003, Jeppesen and Molin 2003).

Although the economic implications of user innovation have not received much attention, one might assume that user innovation will have an important effect when introduced into the economic system through either sharing or commercialization. This assumption is supported by the facts that (a) user-created goods, such as skateboards (Shah 2000) and mountain bikes (Lüthje 2003), have formed the basis of new industries; (b) open source software has gained market shares from state-of-the-art commercial software manufacturers (Lerner and Tirole 2002, Lakhani and von Hippel 2003); and (c) products developed by collaborating with lead users have been shown to perform several times better than in-house-generated products (Lilien et al. 2003). The performance level of these user developments can be explained by the fact that innovations are often made by lead users, that is, users who are ahead of the trend in terms of demand and who have significant incentives to solve a given problem.

Recent studies in this field show that some firms are now realizing that the sources of innovation related to a given product can be modified or shifted. Firms that wish to increase user innovation related to their products may offer an "open system," as in the case of Sun Microsystems (see Garud and Kumaraswamy 1993); and free innovation equipment, such as toolkits for user innovation, that open up a solution space to users (von Hippel 2001, Thomke and von Hippel 2002, von Hippel and Katz 2002). We are interested in cases in which firms seek to enhance product development by opening up their product via the user toolkit method and through the implementation of a user community in a product field where product users from both the industrial as well as hobbyist setting are present.

An Innovative User Community in the Field of Computer-Controlled Music Instruments

Our empirical context is a firm-hosted user community hosted by the firm Propellerhead Software—a manufacturer of so-called computer-controlled music instruments that employs about 25 people. Propellerhead released its first product in 1994, and has since become a leading force within its segment. Computer-controlled music instruments are tools for sound production, processing, and recording. They are software products providing the musician with a virtual rack that comprises a number of features such as sound-producing modules (e.g., drum machines), sound effects (e.g., distortions), and sound-organizing elements (e.g., samplers) used in the creation of music content for, for example, CDs, games, movies, and advertising. The main difference between them and usual instruments is that they combine the making, processing, and recording of music in one piece of software. They act as a substitute for a physical sound-recording studio. As Propellerhead's products are quite affordable (prices range from 100–500 USD), easily accessible (via the Internet), and compatible with a range of other digital audiovisual production technologies, they are attractive to users with diverse needs, resources, and abilities. As our interviews show, the products are used by music creators ranging from highly skilled professional musicians and sound studio technicians, to music creators with almost no prior knowledge of sound creation.

Propellerhead's products are born digital. Their intangible nature, combined with the Internet-based mode of communication, allows the dispersed crowd of Propellerhead users to collaborate, exchange information, and learn product use relatively unconstrained by time and space. When the product technology features are easily transferable and the mode of communication is low cost, the conditions may be potentially favorable for an active user community. From the firm's perspective, Internet technologies also allow for a low-cost interface to users through which the firm can monitor what users do with their products, how they are altered, and what appear to be most pressing issues among users. Such abilities may come to replace several existing market research techniques (Moon and Sproull 2001). As an example of product market testing, Propellerhead decided to put a prototype of their first product "ReCycle" on the Web to monitor the potential of the product. The first day it got 30 hits, the next day 3,000, and thereafter 30,000 hits per day. These numbers confirmed Propellerhead's founders in their belief that interest in their product was substantial.

In the case of Propellerhead, it was also these low-cost features of the Internet that enabled the start-up of

the firm in the first place. As the chief executive officer and cofounder of Propellerhead explains, in 1996–1997 when Propellerhead started, there was "only" a good idea. The lack of financial resources initially blocked the firm's access to traditional and costly distribution channels through, for example, music instrument stores. Therefore, Propellerhead decided to focus on distributing its products entirely via the Internet. An early user recalls that "I don't think that Propellerhead Software had a premeditated strategy of marketing their products to online users . . . their product, ReBirth RB-338 and their customers, Acid and Techno enthusiasts, seemed to converge on the Internet at the right time."

Following the 1999 release of Propellerhead's product ReBirth, a number of users joined in an Internet-based chat hub where they managed to "hack" the ReBirth software. It was a collaborative process that went on for six to eight months. Later, the hackers began to integrate their own sound samples and graphic designs into their hacked product version: "It was a form of friendly competition among us," a user recounted. Further interviews with pioneering innovative users suggest that these users thought that the firm should know about these new creations. From then on, a frequent two-way communication between users and firm employees (mostly via e-mail) was established. When information about the hacking activity first reached Propellerhead, the management found themselves "overly surprised" by the fact that someone would spend so much time altering their product. "We were really excited about this," the CEO and cofounder of Propellerhead explains.

This approach to hacking opened up Propellerhead's eyes to the benefits of having access to a community of innovative users. Keeping a welcoming attitude toward users' product modifications, the firm decided to support users' innovative efforts by opening up parts of the product code to users who wanted to make so-called "mods" (modifications of the original product) to their products. The development possibilities for users have over time been refined and now include enabling technologies for user innovation, referred to as "user toolkits for innovation" in the literature (von Hippel 2001). Toolkits allow users to undertake innovative work in a way that is structured by the firm.

Along with these events emerged a user-organized online community of people interested in bringing their innovative efforts further. As they became aware of this, Propellerhead decided to set up their own "official" online user community on the firm's website. Over time, Propellerhead turned their community into the main hub for their products. Propellerhead Software, a user recounts, "now recognizes that their primary user base is comprised by people on the Internet, so they have developed an important electronic doorway into their company through their website." Today the community comprises approximately 3,850 members, generating approximately 150–200 interactions (question and answers) per day, typically involving close to 100 users. In the community, questions and answers are posted between users. However, users often directly address the firm through this channel to report bugs, etc. Users also help to test each other's developments, as well as comment on designs created by users. When the firm releases a new product, users are the first to find bugs and errors and report these to the firm. In addition, Propellerhead has started to use their website as a hub for diffusion and sharing of users' innovations. The following quote from Propellerhead's website illustrates the firm's position on the issue:

> Mods. A celebration of creativity. Here at Propellerhead we're crazy enough to let users take our precious ReBirth [a Propellerhead product] and redesign it any way they like. If you're skilled in graphic design and you have a bunch of cool drum samples you've always wanted to share—make a mod, mail it to us and maybe, just maybe, we will make sure it reaches every corner of the world. (www.Propellerheads.se)

That the strategy employed is not as "crazy" as Propellerhead indicates by the quote above becomes clear when observing the number of benefits that Propellerhead derives from the community. When users freely reveal the innovations they have made to Propellerhead's products, other users benefit from having additional fresh content or novel features available (produced free of charge by users) to their original product. "Each release of a new ReBirth mod was like getting a version upgrade for the application" a user explains. The process of constant development and content creation by users increases the value of the product to all users and may eventually result in a longer product life and greater sales of the original product (Jeppesen and Molin 2003).

We learned from our interviews with firm managers and product developers that user innovations are highly valued by the firm. One of the many illustrations of this is, for example, that a user has developed a radically different software interface that keeps Propellerhead's product working in sync with living pictures (movies and TV). In this way, user innovation has dramatically expanded the scope of the product and possibly opened up new potentials for Propellerhead. Another example is the invention of the so-called mouse wheel control application, which substitutes the music keyboard as the main control unit for the product. The mouse wheel application has been incorporated as a standard feature in Propellerhead's product (Reason) and is also likely to be a central component in future. The most typical user innovations appearing are the mods made using user toolkits supplied by Propellerhead. A mod is a combination of sound samples, accompanied by a graphical layout, that together create a device for music creation.

A similar development in-house took an experienced Propellerhead product developer between 100 and 150 hours to create. Assuming an average salary of

software developers (Nordic countries) and the time consumed to create an equivalent mod, the production cost amounts to €3,000–€4,500. Average hourly salary for programmers in the Nordic countries is approximately €30 (source: Sam-Data (Danish labor union for IT employees), accessed November 19, 2003).

The firm frequently picks up innovations in the community and integrates them into new versions of their products, which they eventually then sell back to all the users who buy the new version. However, more commonly, the firm selects and hosts the innovations or refers to them on their website, thus making them available to all users free of charge.

Approximately 100 mods similar to the one described above have been created by users, a fact indicating that users are an important source of innovation for Propellerhead's product environment. Apart from direct sourcing of innovations from the community, feedback from users often plays a role in product development at Propellerhead: "many enhancements of our current products are a direct result of end-user feedback," Propellerhead's chief product developer asserts.

As stated by employees at Propellerhead, the firm did not have to invest many resources in community development and communication. Community development was to a large extent managed by users, and the communication, a firm manager states, "was easy because our users are strikingly similar to us." According to Propellerhead, certain leading-edge users originating from early hacking groups willingly helped Propellerhead by suggesting and delivering concrete solutions to their development problems, and they have thus had a marked influence on the direction of product development and have shown the firm new applications of their own products. These users have written documents and manuals and made showcases for the firm, and have thus added value to the firm's products on several dimensions.

Furthermore, the firm also suggests that the community is like an enormous test lab for products. Feedback comes rapidly and can be integrated throughout the development cycle (MacCormark et al. 2001). According to Propellerhead, they use ideas and comments from users as waypoints for their developments. "Most of our products have been born and tested though user-involvement . . . this way we can see whether our ideas appeal to users." For example, it was not the firm's idea that their product Reason should include a sequencer. In fact, Propellerhead was counting on having an interface to sequencers from other manufacturers who would fill that need. However, enough Propellerhead users strongly requested a sequencer and got it, meaning that Propellerhead has now become a competitor instead of a collaborator of the other firms offering sequencer products. The community is now used by the firm on a large scale to observe and test the responses from users to ideas (firm as well as user generated) for new product features and/or functionalities.

The community also works as a helpline that users utilize to interactively solve problems of product use in a manner similar to that described by Constant et al. (1996), in which users tend to help out other users baffled by a certain problem. Below is an example of how such help is provided:

> **Christofer**: RV700 (May 19, 2003, 19:14:35)
> How do you use this device as an EQ without having any reverb effect. Obviously this a much better EQ device than the other one. I'm trying to EQ vocals but I don't want any reverb on them.
>
> **Ceffe**: (May 19, 2003, 19:46:36)
> I think what you want is not possible. According to the manual (p. 237) the EQ affects the wet reverb sound only. I guess, then, this EQ is for shaping the sound of the reverb. Try out the Vocoder as EQ instead!
>
> **Gnorpf**: (May 19, 2003, 23:59:49)
> It's actually possible to use the RV7000 as an EQ with a little bit of tweaking, and here's how:
>
> MAIN UNIT: EQ Enable: On, Gate Enable: Off, Decay: Min, HF Damp: Min, Hi EQ: Middle, Dry-Wet: Max Wet.
>
> REMOTE PROGRAMMER: Algorithm: Echo, Echo Time: 10ms (Min), Diffusion: 0, Tempo Sync: Off, LF Damp: 20 Hz, Spread: 0, Predelay: 0 ms.
>
> CABLING: Obviously, you need to make the RV7000 an insert effect (place it between your sound source and the mixer). The trick is basically to create a reverb that sounds like the original, because you can only apply the EQ to a processed reverb signal. Note that this solution introduces a 10 ms lag, and I've found no way around it. But for slow stuff like voices etc., you should barely hear the lag. And if you hate it, just introduce a DDL1 into all the other tracks to compensate for it. Cheers!

The process of user-to-user help reduces the amount of support that the firm would otherwise have to provide to their product users in a firm-hosted user community. Such user-to-user assistance in a related field (of computer games) has been found to outweigh several times the effort spent by a firm on supporting users (see Jeppesen 2005). It should be considered an important feature of the firm-hosted user communities, which clearly depends upon knowledgeable users' willingness to diffuse their problem-solving knowledge.

In the particular case under investigation, the firm's welcoming attitude toward initial "hacking activity" (the firm did not take legal action toward hackers) and the provision of a place to meet must be considered important in the establishment of an ongoing user innovation process. The firm's observation of "friendly hackers" and the establishment of fruitful interaction were wisely complemented by the implementation of a user toolkit that encourages user innovation to occur in selected areas perceived relevant to the users, such as in the modfield described. This kind of experimentation may be

refined into a real strategy in which the firm decides exactly which product areas it wants to "open up" to user innovation activities and in which areas it will take hackers to court. Such a strategy may also include a number of considerations about how best to structure product technology in order to obtain the most advantageous degree of openness—which invites consumers to undertake certain tasks, and not others, for the firm. Firm managers assert that without the community of users the firm would not have existed today. The help from users received in the early phases of Propellerhead's existence is perceived to have been especially crucial.

Hypotheses

In this section we put forward our hypotheses. We want to create an account of why users contribute to firm-hosted user communities by focusing on the presence of particular user attributes in such a community.

Hobbyist vs. Professional User Innovators

The rationale for hypothesizing about users' hobbyist versus professional status relates to the likelihood of innovation appearing from these respective groups. The major share of innovation appearing in the firm-hosted user community context is the result of voluntary and uncompensated activities where some users innovate and thereafter (most often) freely reveal their innovations. In such a context characterized by the absence of monetary rewards for innovative activity, innovation relies in great measure on intrinsic motivations. As outlined below, this feature leads us to expect that innovation will be more likely to come from hobbyists than from professional users. The first indication that hobbyists might be more likely innovators came from the straightforward observation that our first user-respondents (pointed out to us by the Propellerhead managers as those who had created important complementary innovations to the firm's products) were not musicians working with musical sound processing and production as their main activities. An illustrative example of this is that one of the most prominent innovators in the community and also one of the initiators of the hacking and extension of Propellerhead's ReBirth RB-338 has music creation only as a spare-time activity. He interacted and helped the firm, but did not generally derive any income from the use of the instruments. Two of the users from our sample who are professional sound creators explained to us that they create music (not modifications of the software) because music is what their job is about.

Such observations fit in well with research into social psychology (Deci 1975, Deci and Ryan 1985) and behavioral economics (Frey 1997, Frey and Oberholzer-Gee 1997, Kreps 1997, Bénabou and Tirole 2003), which focuses on the internal motivational forces propelling human efforts. According to these orientations, extrinsic rewards of a controlling kind—for example, performance-based monetary rewards; tangible rewards made contingent on work performance (Ryan and Deci 2000), such as working to deadlines (Amabile et al. 1976), under directives (Koestner et al. 1984), and under pressure from competition (Reeve and Deci 1996)—yield low persistence, involvement, and interest in many circumstances as they tend to "crowd out" intrinsic motivations. However, less controlling extrinsic influences such as interpersonal events and structures in social context (e.g., encouragement) that lead to a "feeling of competence" and "sense of autonomy" may coexist with and even enhance intrinsic motivation (Amabile 1993, Ryan and Deci 2000).

Much empirical research supports the crowding-out argument and shows that there is often a "hidden cost of rewards" (Lepper and Greene 1978): In the words of Deci (1975), controlling extrinsic rewards will "corrupt" voluntary efforts. The hidden cost of rewards becomes a reality when extrinsic rewards of a controlling kind have limited or no impact on current performance and reduce the agent's motivation to undertake similar tasks in the future (Bénabou and Tirole 2003). Results derived from a study of a now-classic experiment (see Deci 1975), in which college students were either paid or not paid to work for a period on an interesting problem, showed that unpaid students continued problem solving significantly longer in a nonrewarded leisure period than did those that had been paid, and showed to be more engaged in the task at hand. We expect that only hobbyists will be able to preserve a sufficient level of intrinsic motivation to participate in these innovation activities. Professionals will be "corrupted" by performance-based monetary rewards made contingent on performance and may therefore (other things being equal) not feel as attracted to participating voluntarily in community-based activities as do hobbyists. We find it likely that people using Propellerhead's tools "on the job" in music sound processing and production tend to focus on creating music with the tools as they are, as this is what pays off in their positions. It is less likely that these professionals will alter the tools, as this would be a nonrequired activity. The above arguments lead us to our first hypothesis:

HYPOTHESIS 1. *Innovative users located in firm-hosted user communities are likely to be hobbyist users.*

The professional versus hobbyist status of user innovators is also central to our study because the different types of users will have different motivations for revealing their innovations. Firm-hosted user communities rest on the fact that users are willing to share their innovations with others.

Reputation Mechanisms Motivating Users to Innovate

The motivations leading to the private provision of goods over which providers obtain no right has been dis-

cussed intensively in the literature that studies innovation by users. See, for example, recent open source software research (Lerner and Tirole 2002, O'Mahony 2003, Lakhani and Wolf 2003). An alternative set of "rewards" that go "beyond the dollar" (Pfeffer 1990), such as, for example, reputation gains and signaling (Glazer and Konrad 1996), may become relevant in a number of cases where monetary rewards or benefits from secrecy are low. One of the most influential studies interested in reputation as a driver of voluntary efforts in community settings is Lerner and Tirole's (2002) explanation of motivations of open source software programmers. In their view, the explanation for open source software programmers' innovative efforts and free revealing may be found in "peer recognition." Their argument is, further, that the gained "reputation capital" ultimately is a means of enhancing a provider's position in the job market. According to the authors, signaling of competence is the main driver of efforts in the community setting of this type of software production. In this respect, the setting of the firm-hosted user communities we have observed seems similar to that of the open source software movement. Users can easily signal their abilities to a large number of peers and may easily gain reputation this way. On the grounds of these similarities and the fact that our Web observations from the Propellerhead community reveal a high intensity of communication, clear signs of "showing off" and recognizing other users for their help, etc., we find reason to believe that peer recognition will be a motivator for innovative users to participate in and contribute to the community. In sum

HYPOTHESIS 2A. *Innovative users located in firm-hosted user communities will be motivated by recognition from peers.*

Despite Lerner and Tirole's (2002) compelling argument about peer recognition (and related career advancements) being the main motivator for innovation, recent survey evidence has not been able to verify the peer recognition hypothesis. Empirical studies from open source software programming (Hertel et al. 2003, Lakhani and Wolf 2003, von Krogh et al. 2003) and simulator software (Henkel and Thies 2003) find a more mixed picture of motivations underlying innovative efforts, although they do not discard the explanatory importance of the peer recognition account. We do not find that the reputation-based rewards story has been properly investigated. Therefore, in our study we wanted to allow for an alternative, yet still reputation-based, explanation of users' innovative efforts, which seemed plausible in the context of firm-hosted user communities. In this context, where a firm is intensely involved in community activity, we found it reasonable to examine an alternative hypothesis, namely, that users may be responsive to so-called "firm recognition." We found an indicator of the relevance of firm recognition by observing discussions on the Web and reading the Web-log in which users discuss whether or not their innovations were noted and acknowledged by Propellerhead. This recognition could take the form of, for example, the firm posting the innovation itself, or related information, or making a Web link to the innovation on its website. However, the main indication that firm recognition might be important came from interviews done with early innovative users, showing that these innovators had often actively made contact with the firm during or right after crafting their innovations. In sum, we propose

HYPOTHESIS 2B. *Innovative users located in firm-hosted user communities will be motivated by recognition from the firm hosting the community.*

Should this hypothesis be supported, we will have identified a possible explanation for why innovative users are attracted to join and reveal their innovations in the firm's domain.

The Leading-Edge Status of Innovative Users

The reason for hypothesizing about the presence of lead user attributes stems from the observation that lead users have been found to produce important results in the process of new product development, and their presence may thus partly explain why users can contribute value to firm-hosted user communities. The literature suggests that innovators are likely to have lead user attributes that differentiate them from the remaining users in a population. Our initial interviews with users who had made significant innovations and taken part in the hacking of Propellerhead's products revealed that these individuals had been early Internet users and also had adopted the very first Propellerhead products. They had participated in hacking activities to enhance the functionalities of the product. These observations fit in well with the notion of lead users who are defined as users of a given product or service type who combine two characteristics: (a) they expect innovation-related benefits from a solution and are thereby motivated to innovate; and (b) they experience the need for a given innovation earlier than the majority of the target market (von Hippel 1986).

A range of empirical studies have confirmed this relationship between being an innovative user and lead user attributes. In their study of library software users, Morrison et al. (2000) found that innovating users had high scores on lead user characteristics relative to other users in the same community, with the impact of characteristics being moderated by the capability of users to harness their resources and those of the external

environment. Also, Franke and Shah (2003) found that innovators exhibit these characteristics more strongly than noninnovators. Similar results are derived by Franke and von Hippel (2003), finding that a high intensity of lead user characteristics displayed by a user has a positive impact on the likelihood that the respective user will innovate. We believe that these results apply to the context of firm-hosted user communities. In sum, we conjecture

HYPOTHESIS 3. *Innovative users located in firm-hosted user communities will tend to exhibit lead user attributes.*

The leading-edge status of innovative users is important to our study in at least two respects: (i) it determines the value of the innovations produced, and (ii) leading-edge users are generally early adopters and willing to diffuse their "use-related knowledge."

Study Sample and Research Methods

The choice of Propellerhead's community as the study object was made for two main reasons. First, the community resides in the firm's domain, thus allowing us to study the intersection between a user community and a firm. Second, the Propellerhead community attracts users that employ the music tools for professional work activities as well as users that utilize the tools for hobbyist activities. Only in such a setting, where both groups are present, could we test our hypotheses about innovative and work-related status (hobbyists versus professionals).

There are clearly limitations to a case study based on one firm and its single community, such as research biases and other shortcomings. A case study of the kind that we undertake highlights only the nature of certain kinds of users, a particular branch of tools, and a limited set of innovation types. We chose our case for a specific reason, namely because it represented a setting in which we could test users with differing specific personal attributes. Studying a community of, for example, only professional users would not have allowed us to distinguish between the propensity of user innovation by professionals and hobbyists. We were also willing to trade off the study of a larger number of cases for the opportunity to gain deeper insight into an as-yet unexplored phenomenon.

Use of Multiple Methods and Data Sources. We chose a case study research design (see Eisenhardt 1989, Yin 1993) to arrive at an encompassing view of the personal attributes of innovative users in a firm-hosted user community. We employ multiple data sources, as it is the preferred method when one seeks to understand or explain a phenomenon (Wimmer and Dominick 1994, Barley and Kunda 2001). The use of overlapping research approaches is known as triangulation and defined as "the combination of methodologies in the study of the same phenomenon" (Denzin 1978). It may be used by the organizational researcher to enhance the precision of his conclusions by collecting different data related to the same phenomenon (Jick 1979). We make use of interviews, Internet questionnaires, and Web-logs as sources of data.

(1) Congruent with the exploratory nature of the research, we initiated the study by using a "netnographic" approach (Kozinets 1998). Netnography is described as the textual output of Internet-related fieldwork and is in essence an interpretive methodology. By observing the community, we attempted to gain sufficient insight into the Propellerhead online community to avoid misunderstanding as we progressed. We observed the Propellerhead online communities for approximately one hour per day during a three-month period (starting February 2003). This provided us with insights about the "local language" in the community, norms of communication, user interests, and "hot" topics, and helped us gain access to the users and to communicate appropriately with them.

(2) A Web-log was obtained that contained data about different quantitative aspects of the online communities, such as: usernames, the activity of users, the interaction frequency between users, and which types of discussions users were involved in. As we had acquired the user names of respondents for the Web-based questionnaire that we initiated later, we were able to cross-check their past appearances and interaction frequency through analysis of the Web-log data. The Web-log data was captured for the period starting July 18, 2002, through March 10, 2003.

(3) We conducted interviews with the CEO, developers, managers, and administrators from Propellerhead and users involved in the community: In total, three interviews were carried out with the CEO, two with the chief of product development and cofounder, one with a product developer, two with the firm's online community management, and seven with six leading-edge users, of whom four were identified via Propellerhead employees' recommendations and the other two through data derived from our questionnaire (described below). The interviews were semistructured. Nine of them were carried out prior to the launch of our questionnaire in the spring of 2003, while the other six were undertaken after we had completed our questionnaire, and were used as an aid to interpreting the findings obtained. We have corresponded with the majority of our respondents a second, and in a few instances a third, time to get their reaction to the inferences we made from the study. These interactions were not counted as interviews. The fact that we had already obtained an essential understanding of the community from our "netnographic" study and the examination of the Web-log allowed us to carry out more targeted interviews and contrast respondents' information with observed behavior and Web-log information.

The data gathered up until this stage influenced the formation of our outlined hypotheses.

As stated in Hypothesis 1, we learned through our first interviews that (at least) some of the important user innovations made to Propellerhead's products had not emerged from professional users, and that some user innovators had been using their spare time for making important innovations. We thus came to expect that innovative users were likely to be hobbyists. Although we only interviewed four innovative users in this stage, we believe that their knowledge from deep involvement in innovative parts of the community makes them good "representatives" of the beliefs among innovative users in general. Further, through our study of the Web-log and observation of the online community activities, we found that users who were involved in problem solving and innovative activity were typically referring to each other in specific situations when help and successful support had been provided.

Through our observations and specific searches in the Web-log's subdivisions concerned with technical problem solving and development, we also found that "appearing competent" seemed to be important for a great number of users involved in development activities. We thus reasoned that "peer recognition" would be important for innovative user's motivations, as stated in Hypothesis 2a. We confronted two innovative users with the peer recognition hypothesis in our initial interviews. They did not find it particularly important personally, but would not refute it either. As they did not refute our expectations, we decided to establish the hypothesis. One of the main indications of relevance to our hypothesis formation came from interviews conducted with users who had made significant innovations. It indicated that usually such users would make contact with the firm after completing their innovation. This led us to hypothesize that users would be interested and motivated by recognition from Propellerhead.

We revisited the Web-log and found several discussions in which users chat about whether a given innovation had been noted by the firm and whether the firm had "approved" the innovation (for example, by posting it on its website). This supported our expectation, established on the basis of the interviews. Finally, our interviews with two innovative users provided us with the information that they had been using Propellerhead's products since they were released. Early adoption of product technologies, combined with the fact that these users had also modified the products to their own needs, matched the behavior ascribed to lead users and led us to our final Hypothesis 3.

(4) After gaining the necessary insights from the first round of interviews and our observation in the community, we designed and released a Web-based questionnaire (in the following referred to as "main questionnaire") to the Propellerhead user community. This questionnaire was launched on May 14, 2003, and continued through to June 18, 2003. The objective of the survey was to collect data on users' personal attributes, particularly regarding innovative users.

The object studied practically determined the choice of a Web-based survey method because our population could hardly have been reached in other ways. The community goers were asked questions about: their background, community participation information, whether they had undertaken innovative work, and about their motivation for community participation. The main questionnaire appeared in a pop-up window, when a community participant logged onto the online community. When completed, the respondent submitted the questionnaire directly to our database. Respondents could reply mainly with 1–7 (Likert scale) or yes/no answers.

We are aware that a Web-based survey design holds a number of possible biases (Roztocki 2001). We tested for the most important possible bias, namely response bias. This tests for the nonresponse problem that some users (e.g., due to their general interest in the field) may find it more interesting to participate in the survey than other users (Armstrong and Overton 1977). In our case, this implied testing that innovative users were not more likely to answer than noninnovative users. To test for this potential bias, we compared the earliest 10% of respondents with the last 10% of the sample and tested for higher frequency of innovative users answering in the early part. No bias was discovered.

The main questionnaire had a response rate of 62.7% (i.e., 62.7% of those offered the questionnaire responded). The total number of responses was 442, of which 345 were found valid for our statistical analysis and 97 had to be omitted due to missing values. Of our 34 respondents, 10% reported having innovated, while 3.8% (13) said that their creation was "new to the world" when it was revealed. The share of innovation is in line with earlier studies that surveyed a population representing the entire customer population. Earlier studies that found remarkably higher rates of innovation were focused on users who were preselected as leading edge.

In the main questionnaire, we also asked innovators to describe their innovations. By doing so, we obtained information on the characteristics of 26 out of 34 innovations, including all 13 of the innovations rated as "new to the world" by innovative users. We were therefore able to ask two experts in the field (the CEO of Propellerhead and an expert user) to rate the novelty of the innovations. They are in agreement with the reported data on this issue and point out the same 13 innovations as being new to the world, as reported by users.

We conducted a follow-up investigation (in the following referred to as the "follow-up questionnaire") of the group of user innovators identified through the main questionnaire. From this questionnaire we gained additional detailed information on the individual innovators and their innovations, allowing us to examine and

validate the findings from our main questionnaire. In October 2003, we distributed the follow-up questionnaire to the 28 user innovators for whom we were able to obtain contact information. This questionnaire yielded 13 responses.

Statistical Method and Variables for the Main Questionnaire. The focus here is on the relationship between various variables of our main questionnaire. Given that data are discrete and inherently ordered, we opted for an ordered probit regression model as an analytical tool in the estimation.

Our dependent variable is user innovation. The variable is discrete and is constructed as follows. To test whether users had innovated they were asked: "Have you developed modifications, add-ons, or extras to Propellerhead's products?" The following question was: "If yes, do you think that your modification, add-on, or extra was 'new to the world' at the time it was developed?" By asking in this manner we were able to establish innovation as a discrete variable: If no innovation was reported, the value of the innovation variable was set to equal 0. If users had innovated, but the innovation was not new to the world, the innovation variable was set to the value of 1. If a user reported having made an innovation that was "new to the world," the value of the innovation variable was set to equal 2.

Our first independent variable is professional status. The degree to which a user can be considered professional or hobbyist was measured by the user's income, derived from the use of computer-controlled music instruments. The question asked was: "How large a share of your income do you generate from activities of sound production and processing?" Answers were provided on a scale containing four possible answers: (1) none, (2) less than 25%, (3) less than 50%, or (4) I am a professional, this is my main job. To establish users' status as professionals or hobbyists, respectively, we employ *income* that is generated from user activities as a measure. This is in line with the definitions used by the Internal Revenue Service (IRS). The IRS distinguishes hobby expenses from expenses incurred in an activity engaged in for profit by, for example, whether "you depend on the income from the activity for your livelihood" (source: http://www.irs.gov/businesses/small/article/0,,id=135520,00.html).

The second and third independent variables measure recognition and were constructed from two simple questions: (1) "Is recognition from other community goers a great reward?" (2) "Is recognition from Propellerhead a great reward?" Answers could again be provided on a seven-point Likert scale.

Our fourth independent variable is Lead User: It is built from the Lead User Construct (Morrison et al. 2000) and involved three questions that identify leading-edge users: (1) "I usually find out about new products and solutions earlier than others," (2) "I have benefited significantly by early adoption and use of new products," and (3) "I have tested prototype versions of new products for manufacturers." Each of these questions could be answered using a seven-point Likert scale. The three items were then collapsed into one single variable by means of summation. As our independent variable—Lead User—was constructed from those three variables, we chose to perform a standardized Cronbach's Alpha test. Because the standardized Cronbach's Alpha is 0.67, the variable has an acceptable degree of internal validity.

Results

This section presents results derived by use of our various methods and data collection approaches and uses the different types of information collected to conjointly test the findings.

First, for our main questionnaire results three models were estimated. In Model 1 the variable "Firm recognition" has been dropped, and in Model 2 the variable "Peer recognition" is dropped. This is done to test whether these two arguably interrelated variables, independently of each other, maintain their sign and significance. In Model 3 the complete set of variables is analyzed. As the table (Table 3) shows, the sign and significance of the parameters for these variables are robust to the change in specification: The parameter for "Peer recognition" remains insignificant throughout the analysis, while "Firm recognition" is positive and significant across the models. Further, the goodness of fit (measured by pseudo R-squares) is the highest in Models 2 and 3—a result of "Firm recognition" (which is significant) not being included in Model 1. (The pseudo R-squares of the respective models are: Model $1 = 0.07$; Model $2 = 0.10$; Model $3 = 0.11$.)

Test of Hypothesis 1. In Model 3 of Table 3, the coefficient for professional users' showing of innovation activity is negative and significant (significant at the 5% level, $p = 0.019$), thus indicating that user innovators are not likely to be professional in the field of sound production and processing. Our results from the main questionnaire indicate that innovation is likely to appear from hobbyist users. The crude data show that out of 34 innovative users, 22 had no income from music software activities, 7 earned 25% or less, while 3 earned less than half of their income from these activities. Two innovative users indicated earning more than 50% of their income from music software activities. Interviews with innovative users indicated that innovative users are mostly skilled IT individuals who are not professionals in the field of music creation and sound processing. One gave the following reason for innovation being less likely to come from professional users: "People who are working in the music industry are too busy and live a different lifestyle . . . these people who earn their living

Table 3 Regression Results Explaining Innovation at the Level of the Individual User ($n = 345$)

	Model I		Model II		Model III	
Variables	Coefficient	Stand. err.	Coefficient	Stand. err.	Coefficient	Stand. err.
Constant	−3.120	0.774	−3.581	0.905	−3.660	0.917
Professional	−0.247*	0.129	−0.284**	0.131	−0.308**	0.131
Lead user	0.769***	0.028	0.809***	0.028	0.860***	0.032
Reciprocity expectations	0.090	0.087	0.061	0.091	0.069	0.092
Critical for my business	0.032	0.055	0.010	0.057	0.088	0.056
Enhance career opportunities	0.047	0.079	0.034	0.079	0.053	0.080
Peer recognition	0.082	0.064			0.067	0.077
Firm recognition			0.137**	0.066	0.174**	0.074
Log-likelihood	−113.414		−106.705		−106.159	
Restricted log-likelihood	−121.823		−118.805		−118.805	
P-value for log-likelihood test	0.010		0.0005		0.0007	

Notes. Presents the results of the ordered probit analysis of the relation between user innovation and characteristics of users in the Propellerhead user community.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

from music simply do not have the time or experience to spare to create mods or other extras." Our findings from interviews also suggest that professional users do in fact use the products in advanced ways to create innovative music and sounds, but they generally do not have an interest in developing the IT-related skills needed to redevelop the music instruments software.

From our follow-up questionnaire ($n = 13$) with only the innovative users, we derived detailed information on the personal attributes of innovative users. An important observation is that all innovating users are young (mean age is 29 years—min = 17; max = 40) and well-educated (almost half of them hold at least a bachelor's degree) males who are either teachers or students or who have information technology jobs. Teachers, students, or employees in IT-related positions account for 10 of the 13 individuals in the sample, and IT-related people account for 6 of these 10. Again, only two people derive more than 50% of their income from music and sound production, and according to the findings obtained from our follow-up questionnaire study, the innovative users typically do not innovate for the sake of monetary rewards. In fact, only 2 of the 13 users had acted in some way to obtain monetary rewards in return for innovative efforts. This seems to confirm findings from our multivariate regression analysis and the indication of innovators being nonprofessional in the field of music production or music tool development, and further suggests that these people may have attained their skills in innovating music tools from outside the music field. This fits in well with the observation that innovative users are hobbyists, but quite capable of creating valuable innovations. The ability to innovate (expert knowledge) is gained in closely related fields in which users are experts, and brought into the music software field. Hypothesis 1 states that innovative users located in a firm-hosted user community are likely to be hobbyist users, and it is thus supported by the findings.

Test of Hypothesis 2*a.* In our multivariate regression analysis representing our main questionnaire results, the coefficient of user innovation being related to peer recognition is positive but not significant, hence not supporting the idea that innovative users are likely to be responsive to peer recognition. Thus, this finding cannot support earlier claims made in the literature that peer recognition is a driver of innovative efforts—at least, not in this context. On the level of all users, our Web observations from the Propellerhead community reveal a high intensity of communication, clear signs of "showing-off" and recognizing other users for their help, etc. Although one might have expected such peer recognition dynamics to also influence innovative users, this seems not to be the case. Our interviews indicate that innovative users are advanced users interested in technical aspects of product development and who therefore identify less with "nontechnical" peers, but more with firm-based developers. Our findings could not, hence, support Hypothesis 2a, that innovative users located in firm-hosted user communities will be motivated by recognition from peers.

Test of Hypothesis 2*b.* However, the coefficient of user innovation related to firm recognition is positive and significant at the 5% level, $p = 0.019$, suggesting that innovative users are motivated by the desire to be recognized for innovative behavior by the firm.

As indicated by the results of the follow-up questionnaire, innovative users generally respond to recognition from the firm (6 out of 13 report it as being important), and they would be more than happy to see their innovations integrated in the firm's official commercial product. All innovative users have sought contact with the firm through the Internet (personal e-mail, or other means), and one has met firm employees face to face. Innovative users from our sample indicate their willingness to innovate "on demand" to serve manufacturers:

All but one innovative user identified in our follow-up questionnaire would develop innovations for the firm if the firm asked them to do so. Interviews also reveal this belief, which can be summed up best by the following expression of an innovative user: "...I can tell you that it was very gratifying to have the company acknowledge my own mod making efforts ... an official 'Propellerhead approved' mod must meet certain standards; having the firm recognizing it not only means that one's work meets the company standards to qualify, but there's a sense that your work is accepted by the music industry."

We observed that a means by which Propellerhead provides firm recognition to innovative users is exposing and promoting important user innovations and their creators on their website (see Appendix 2 for examples). Further, our observations of the community activity and the study of Web-log data reveal that users honor Propellerhead's products. This makes it similar to a brand community formed by admirers of a brand (Muniz and O'Guinn 2001). The following common examples extracted from our Web-log point this out: "...I love Reason and happily work with it daily. In fact it's the most aesthetically pleasing interface for any program I've used. Just thought it comical, how Swedes seem to be into small stuff..." and "I love Props and Reason. I am grateful that Reason is in my life." However, as the second example indicates, users not only honor the product, they identify with the firm (Props) and, more specifically, with the people who created the product. The identification may be strengthened by the fact that Propellerhead's employees participate in the community and are visible there as individuals.

Our analysis of Web-log data shows that during approximately nine months, 10 different firm developers and managers actively participated in Web discussions with users and generated a total of 830 messages. Propellerhead's employees thus appear to have a close, and sometimes almost personal, relationship to users in the community. Both product appreciation and the feeling of having a close relationship to developers in the firm are illustrated by the following sentence extracted from our Web-log data: "I'm not sure whether the Reason compressor is more of a 'Pelle' device (Pelle is the main DSP man) or a 'Marcus' device but I would imagine that at least to some extent the Reason comp was...." It seems plausible that users want to attract attention from the firm, or more importantly, the firm's employees, who in their eyes are the idols that develop the vital parts of the product. Referring to employees in the above manner is common in the community and shows that users have a very detailed perception of who is who in the firm and what specific employees do. Again, due to the nature of innovative users' activities, they tend to want to identify with firm developers rather than peers.

In sum, when innovative users honor the product, have a strong relation to the firm, and identify their work with the work of firm developers, it seems likely that obtaining acknowledgment from the firm for a given innovation can be an important additional benefit of making an innovation. We thus find support for our Hypothesis 2b, that innovative users located in firm-hosted user communities will be motivated by recognition from the firm hosting the community.

Test of Hypothesis 3. The coefficient for lead users related to innovation by users is positive and significant, suggesting that users who reported having created innovations are likely to comprise the lead user characteristics (significant at the 1% level, $p = 0.008$). As revealed in interviews, some of the initial innovators who had taken part in hacking Propellerhead's products had been (by being some of the first using these product versions) early adopters. Two other lead user characteristics—the need for novel solutions and putting the products through tests—are also closely connected to the act of hacking. These findings support Hypothesis 3, that innovative users located in a firm-hosted user community will tend to exhibit lead user attributes.

In the regression model, the impact of control variables on the performance is largely as expected. We find no significant relationship between being an innovative user and expecting reciprocity for participating or giving to the community. Neither do we find any significant relationship between innovative users and drawing on the community for business purposes, and we do not find any relation between the wish to enhance career opportunities and being an innovative user.

Beyond the results reported above, an additional analysis of the marginal effects of Model 3 (see Appendix 3) shows that being an innovative user increases the probability of generating incremental-type innovations the most. Being an innovative user also increases the probability of producing new-to-the world innovations of a radically different nature, but to a lesser extent.

Further, we have emphasized above the existence of a general pattern of sharing of innovations by innovative users. This pattern is backed up by findings from our follow-up questionnaire, showing that innovative users in our sample share their innovations with the community and other users to a great extent: All but one of the innovative users have shared their innovation with others.

Discussion

We have extended the study of innovative user communities to include a setting in which a firm is the host of an online user community. The research serves as a preliminary step toward understanding why users contribute to firm-hosted user communities. When users contribute to these communities, for example, by freely revealing their innovations to a firm's product platform, it can place the firm in a favorable position because the new product features become available to all product users, and

allow the firm to pick up promising innovations, integrate them in future versions of the products, and benefit by selling them back to all users. We saw both of these approaches reflected in the case of Propellerhead Software and found that the firm embraces innovative users' efforts. Drawing on multiple methods to triangulate the results, we analyzed a range of different data on a population of users and identified innovative users' personal attributes, which we believe provide a large part of the explanation of why users contribute to firm-hosted user communities.

The first key finding is that innovative users are likely to be hobbyists in the field in which they innovate. The finding that many professionals within music and sound production are under work pressure provides some support to our argument that extrinsic factors may crowd out free-choice activities such as unpaid innovation work. Hobbyist users can contribute with capabilities from related fields that are necessary to innovate. Many professional users do not acquire these capabilities because they focus on using tools and not on improving and extending the tools. In other words, in this case professionals are less motivated to undertake innovative work on the tools, and this means that they develop fewer of the skills needed to do so. Thus, in our account the pattern of professionals being less likely innovators than are hobbyists is reinforced because lack of motivation leads to weak skill development for innovation.

The idea that hobbyist users "import" work-related professional expert knowledge to their hobby fields has also to some extent been identified by Lüthje et al. (2002) in a study of sports innovations. The authors find that only a minor share of user innovators in the mountain bike field needed to acquire new knowledge to develop their solutions. The examples given show a pattern similar to the one developed in this paper, namely, that innovative users often bring expert knowledge from their profession already "in stock" to use in their hobby fields (i.e., leading-edge mountain bikers who are pushing the limits of downhill biking and who also are orthopaedic surgeons innovate their mountain bikes utilizing their specialized orthopaedic knowledge to deal with the equipment and technique problems that they run into). A large share of innovative users in our case are competent in generic technologies related to (but not within) the field in which they innovate (many are IT people). This may explain why they can be hobbyists and still produce high-quality innovations.

The important implication of the finding that user innovators are likely to be hobbyists is that it will positively affect sharing of innovations. Because hobbyists in this setting are not in competition with other users and do not have anything to lose by sharing innovations, sharing and free revealing of innovation are commonplace. Sharing of innovation is a key condition for firm-hosted user communities to succeed. If users were professional, they would not have the same propensity to reveal and share, because secrecy would often be a precondition for reaping the benefits of a given innovation. This is consistent with the Morrison et al. (2000) study of information sharing among lead users. This study found that 19 out of 26 innovative users shared their information about their innovation. In fact, 56% of the modifications made to the software were shared in some way. In our case, users share their innovation mainly with the Propellerhead community. This finding is not surprising in light of the fact that Propellerhead product users are the most obvious users of user innovations. Further, innovations made to Propellerhead's products are not necessarily compatible with other types of products. One important outcome of sharing is, of course, that other community members can enjoy the products of innovative users. However, sharing in the community also allows interested innovators to build on and extend existing innovations without having to start from scratch: Approximately one-third of the innovating users report that they have built their innovation on earlier work by other user innovators.

The second major finding is that innovative users' motivation for participation and innovation in the community are related to a wish to be recognized by the firm hosting the user community. Users generally honor the product, the firm, and its developers. Innovative users may therefore feel proud when the firm acknowledges their innovative work openly in the community and perceive this recognition as an additional benefit of creating an innovation. The main implication of this finding for our main question is that it explains why innovative users will tend to join precisely the community hosted by the firm. Here their innovations and their knowledge are visible to the firm. Firm recognition explains why innovative users are drawn to the community and why they openly show their innovation in precisely this domain. If innovative users did not respond to firm recognition, they would have no particular incentive to reveal in the firm domain. We expect this finding to be of importance to the function of firm-hosted user communities. We also think that it may be a sign of a more general pattern of user innovation diffusion, in which users reveal innovations and knowledge in the domains where the expected recognition benefits are highest. The finding that innovators respond to recognition from the firm is also interesting in that it opens up a scope for management regarding how the firm may chose to "allocate" recognition to motivate users. It implies that figuring out how the firm may more deliberately exploit this source of motivation will be useful to firms that deal with user communities. A simple way to allocate firm recognition in return for user innovation is to openly acknowledge their contributions in the most visible fashion. A useful way to do this may be to host examples of the best

user innovations in the firm domain and to credit innovators openly. These points are essentially related to the broader issue of firms' user community management.

There are two related explanations why innovative users are likely to find firm recognition important, while peer recognition seems to have less importance. First, innovative users are advanced and may want to identify more strongly with firm developers than with their peers. It is therefore not surprising that they want acknowledgment from firm developers. Secondly, firm recognition, to a great extent, comprises peer recognition, meaning that achieving firm recognition by being openly acknowledged by the firm in front of the entire community indirectly also leads to recognition by peers. The acknowledgment the firm sends (by, for example, putting a user innovation on the firm's website as a firm-approved user innovation) signals the competence of the innovative user to peers. The innovator thus gets recognition from peers based on the fact that the firm acknowledges the work. Although we refuted the hypothesis about peer recognition being of importance to innovative users, we think that peer recognition has this indirect effect.

The third of our main findings is that important contributions are made in firm-hosted user communities because the innovations are likely to come from leading-edge users. According to our argument, this affects the quality of the innovations positively, because lead users are found more capable of delivering important and high-quality innovations due to the fact that they are ahead of the market in terms of discovering new product concepts and connections to other products. Our evidence from interviews with firm employees indicates that the innovations produced are indeed highly valued and that several product features have been built from user innovations. It has also been shown that lead user innovations represent a better commercial potential (Urban and von Hippel 1988, Herstatt and von Hippel 1992) and perform better in the market (Lilien et al. 2003) than other types of innovations. Further, in a study of open source software programmers, it was found that a single component of the lead user definition—being at the leading edge of a marketplace trend—predicts *not only* user innovation likelihood *but also* innovation attractiveness (Franke and von Hippel 2003).

Another reason that the presence of lead users would seem to support the usefulness of firm-hosted user communities in which they are embedded is that these individuals act as opinion leaders (Morrison et al. 2004). They are most often early adopters and willing diffusers of new products, knowledge, and practices. Due to these characteristics, lead users are critical in the contagion process (assisting others in the adoption process) and can pilot their organizations faster to the adoption of new product and practices.

Lead users have also been found to be willing to diffuse their state-of-the-art innovative "use knowledge" to the remaining members in the community (Morrison et al. 2004). This will happen in the form of concrete innovations and/or in the form of creative solutions to problems. The diffusion of user knowledge plays an important role in that lead users provide help and solutions to their fellow community members. Hence, the way is paved for contagion processes in which users learn from leading-edge users, leading to a diffusion of best-practice problem solving and support.

According to theory in the field, lead users are motivated to innovate by their desire for new product features or functionality not yet available on the market. In other words, lead users have to take on innovation tasks to satisfy their own unserved needs. While this motivation for innovation seems very likely to be true in our case, we also believe that what we observe is a set of nonmutually exclusive motivations jointly at play. On the basis of our results we argue that in firm-hosted user communities, innovation by users may be propelled both by unserved user needs *and* by a wish for recognition from the firm hosting the community.

An additional finding is that being an innovative user (in this setting) increases the probability of generating incremental-type innovations the most. This result does not come as a surprise when the fact is kept in mind that users in the firm-hosted user community setting merely extend an already existing product. Users can be said to be locked into innovating to this product, and the outcome naturally seems often to be extensions to the product rather than breaking with the fundamental concepts of the product. This finding is consistent with Morrison et al. (2000), showing that although user innovations are generally rated by manufacturers as being important, they are usually low on novelty. The result indicates that the innovative users fill out small niches in the market, niches the firm has not paid attention to or has not found interesting enough to invest in. The innovations produced complement (do not substitute) the firm's product. This is of major importance to the firm's abilities to obtain fruitful outcomes from this type of organization.

In the same way that firms may derive competitive advantage from their access to intangible and difficult-to-imitate assets such as connection to knowledge networks, university R&D, and so on, the establishment of user communities may also come to represent an important source of innovations and possibly a means to achieve a competitive advantage. Whether or not a firm-hosted user community can be turned into an asset for the firm is conditioned in large part by the issue discussed in this paper.

In generalizing the findings from this study, one should keep in mind that the access to the Internet favors the kind of distributed work collaboration we see in the

case of Propellerhead. Users gain easy access to their software parts and low-effort communication with fellow developers. The low-cost communication compared to that of an "off-line" physically based community offers a number of advantages for both participants and the host firm. Therefore, the appearance of an innovative user community is favored in an IT setting.

As explained in the study, the firm is able to obtain a number of insights that can be potential substitutes for traditional marketing techniques and efforts. It can also get direct access to innovative prototypes. Such claims fit in well with the insight generated by earlier studies, which found that increased information sharing could improve organizational efficiency, learning, and innovation (e.g., Sproull and Kiesler 1991). Furthermore, collaborative work on software is favored by the ease with which the product (code) can be passed around among developers, as observed in other cases of distributed innovation processes such as open source software projects (Moon and Sproull 2000, Lakhani and von Hippel 2003). Although "physical user communities" are very frequently observed, the favorable conditions found in relation to IT-based products may not apply in such settings. Hence, the applicability of some of our findings (especially the finding on firm recognition) may be limited to contexts in which users and firms can easily share information, signal competence, and collect ideas. We do believe, however, that the growing number of "physical products," the functions of which are to some extent controlled by software components, can also benefit from the IT environment when user communities collaborate on new product features or functionalities within the software parts of the physical products. For example, computer chips for autoengine control are today being modified in collaborative user environments similar to those described in the case of Propellerhead.

Moreover, firms embarking on a strategy of firm-hosted user communities for innovation should keep in mind that in order to attract leading-edge users they may need a product that is somehow open to innovation by users. According to our findings, this organizational form may be most relevant in areas where a certain number of the users are hobbyists. This implies that the potential of this type of organization may be most effective in the area of consumer goods, or at least in areas in which hobbyists are likely to be present.

Limitations and Implications for Further Research. We are restricted in our ability to make broad generalizations by studying only one case of a user innovation community. Further research should address the differences between the Internet setting and physically based communities—hence adding to the research by Shah (2000), Franke and Shah (2003), and Lüthje (2003) on user communities, but going a step further by identifying the effects on the firms that are having their products innovated. We are also aware that this question requires more answers to be properly explained: Future research should examine more closely how firms structure technologies for innovation (toolkits) and govern their community, and the external factors such as broader change in technologies and social dynamics allowing for this new type of organizational form.

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Appendix 1

We can classify the innovations into three main groups: (1) "content innovations" such as song or sound and samples; (2) "technological-element innovations" such as patch files and mods combining sound samples and design aspects; and (3) "interface innovations" developed to solve problems related to hardware interfaces and interconnected instruments.

A rough classification of content and style of innovations shows that the bulk of the user innovations are of a technical nature. The table includes the comments made by users, indicating their perceptions of their own innovations (obtained from the follow-up questionnaire).

Community user name of innovators	Innovation category	Statement on the character of the innovation
Wwwobbler	2	Uh, jag började faktiskt att rita ett skin till en ny modul. Bara för att se om jag skulle kunna matcha den grafiska standarden som gäller idag. Raytracade animerade knobs, hittade på en logotyp å så.. ja, lekte mest iofs =)
Abraxis	3	Additional Useful "Rack Modules."
Niklas	2	Homemade modifications that were for my pure entertainment only.
AndersPier	3	It is not really a mod. I use MidiOX, and have found a method to get my 13 knobs-mapped to 1664 (by using program changes). So now "I can use knobs all over" Reason, wv though I only have 13 physical knobs on my keyboard:-)
DJDM	1	Custom patches for the Malstrom (Reason Synth).

Appendix 1 (cont'd.)

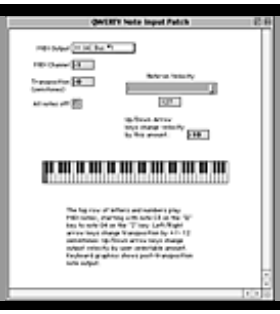
Divstah	2	ReBirth mod for ReBirth 2.1. Both graphic and sounds. Graphic: light and blurry. Sounds: many pads and stabs. Mainly for ambient.
nitro2k01	2	A MIDI arpeggiator that was never public.
Flashmofo	3	Creative use of hardware and MIDI implementation.
Robotovat/jonyo	2	MIDI input remapping application for use with Reason.
Johnpil	2	Small applet to temporarily set dual monitor setup to 800×600 or other preset res while in Reason, then restore on exit.
Vector	1	A lot of refills and sound banks.
Peff	2	I created the first official ReBirth Mod:-)
Ninjadog	2	Someone showed me a homehade Tape Ecco Effect. It was very complex, and I still can't repplicate it from scratch, but I made a few cool fx by trying.
RykThekreator	2	All three of my inventions are currently residing under the care of Propellerhead Software. Once I know whether either will be used or not, shall I then be able to release them. (Two of them had been built into modular synthesizers by me, between 1996 and 1998.)
Janvc	2	Reason 1.0 javascript LFO-sync calculator (does that count or didn't I understand the question?).
Beatmincer	2	LFO setting -->> BPM calculator for Reason 1.0.
Lawbreaka	1	Various Refills with Song Templates and Sampler Implementations.
Einzelganger	2	ReBirth Mods.
Supraphonic	1 + 3	Additional samples, rewiring Reason.
DJVampeal	1	Ripped samples from my cousins synthesizers, and put them into ReFill format.
Jonas	2	ReBirth mods.
Tunein	1	New samples/loops.
Suma	2	ReBirth mods.
Aenforever	1	I've just made a few drum mods for ReBirth, stansard loop chopping stuff.
Mschill	3	Pattern Master for ReBirth to edit ReBirth patterns in a piano roll view http://www.mschill.com/patternmaster.
Zx81	2	ReBirth mod with own sounds.

Appendix 2

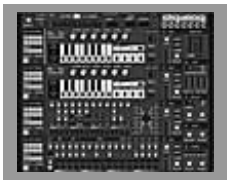
What are user-developed innovations in the case of Propellerhead's products?

The examples below illustrate the types of innovations that were made for Propellerhead's products.

QWERTY Note Input v1.1
by Robotovat
This little program lets you play MIDI notes from your Mac's computer keyboard. You can use OMS's IAC to transmit notes to Reason. QWERTY Note input is Freeware.

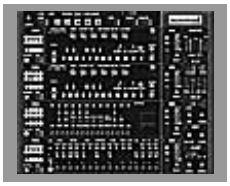


Digalog
By Einzelgänger.



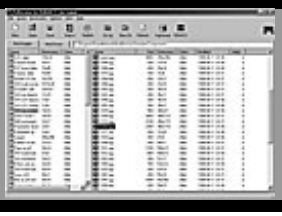
Long time board veteran Einzelgänger has made this very electronic sounding and synthetic looking mod. The interface is a very plastic blue, and the sample set offers lots of bleeps and synthetic percussion sounds.

minimod
By Peff.



The house producers toolbox! Peff's minimod has an excellent sample set that includes house organs, house basses, house pianos, stabs, bleeps, and much more. The beautifully crafted GUI makes you think of a certain old synth brand . . . .

Appendix 2 (cont'd.)

Extra interface utilities - **Pattern Master 1.01** by Matthias Schill Are you confused by the 303 programming interface? Wish you could edit 303 patterns visually? Now you can! Pattern Master is a tool to program 303 patterns using a piano roll view. The program can save and open .rbs files so that you can edit songs made in ReBirth.		FTP-Sweden (267 kb)
ReNovator 2.0 by Florian and Rob1 ReNovator is a tool that assists you in creating mods by keeping track of all the files needed in your mod. It also has an image viewer and a very handy tool that lets you preview your mod without actually building it. A must if you build mods on a PC!		ReNovator homepage
ReVision 1.1 by Granted Software Makes soundtrack composition a bit more convenient by allowing a QuickTime movie to be played in sync with Reason. The latest version ov ReVision holds new features such as tempo and time signature changes at the marker locations. It's also got AIFF and movie export and better timecode handling.		Get it from the Granted Software website

Appendix 3

The marginal effects (at the mean) for a particular explanatory variable express the incremental change in predicted probability of obtaining a particular value of the dependent variable caused by unit changes in that particular explanatory variable. For each of the outcomes a marginal effect is computed. In our case, we have three possible outcomes of the dependent variable, INNO (0, 1, 2). A particular problem with the *ordered* probit model that we are applying in this paper is that the sign of the marginal effects is not a priori known for the value "1" of the dependent variable. If the coefficient of a given independent variable is significant and positive, we know that the marginal effect for the value "2" is positive and that the value for "0" is negative (Greene 1997, pp. 928–929). However, a given explanatory variable may either affect the probability of getting the outcome "1" (=introduced an innovation not new to the world) positively or negatively. In our case, it could be that a particular explanatory variable has a significant and positive coefficient—this is the case for "lead user characteristics" in Appendix 3, Model I. However, from this finding we can only conclude that the explanatory variable affects the probability of not being an innovator (INNO = 0) negatively, and that the given explanatory variable ("lead user characteristics") affects the probability of having produced an innovation new to the world (INNO = 2) positively. However, without the sign of the marginal effect for "INNO = 1," we do not know whether the given explanatory variable affects the probability of having produced an innovation "not new to the world." The sign of the marginal effect gives this information. From Appendix 3, Model I, we can see that, in fact, lead user characteristics affect the probability of having introduced an innovation not new to the world (INNO = 1) positively, because the marginal effect is 0.0062.

Variable	INNO = 0	INNO = 1	INNO = 2
Marginal effects of Model I			
Constant	0.4133	−0.2512	−0.1621
Professional	0.0327	−0.0199	−0.0128
Lead user characteristics	−0.0102	0.0062	0.0040
Reciprocity expectation	−0.0119	0.0072	0.0047
Critical for my business	−0.0042	0.0025	0.0016
Enhance career opportunities	−0.0062	0.0038	0.0024
Peer recognition	−0.0011	0.0007	0.0004
Firm recognition			
Marginal effects of Model II			
Constant	0.4158	−0.2600	−0.1558
Professional	0.0329	−0.0206	−0.0123
Lead user characteristics	−0.0094	0.0059	0.0035
Reciprocity expectation	−0.0071	0.0044	0.0027
Critical for my business	−0.0012	0.0008	0.0005
Enhance career opportunities	−0.0045	0.0028	0.0017
Peer recognition			
Firm recognition	−0.0159	0.0099	0.0059

Appendix 3 (cont'd.)

Variable	INNO = 0	INNO = 1	INNO = 2
Marginal effects of Model III			
Constant	0.4152	−0.2616	−0.1537
Professional	0.0350	−0.0220	−0.0129
Lead user characteristics	−0.0098	0.0061	0.0036
Reciprocity expectation	−0.0078	0.0049	0.0029
Critical for my business	−0.0010	0.0006	0.0004
Enhance career opportunities	−0.0060	0.0038	0.0022
Peer recognition	0.0076	−0.0048	−0.0028
Firm recognition	−0.0265	0.0168	0.0097

References

Amabile, T. 1993. Motivatial synergy: Toward new conceptualizations of intrinsic and extrinsic motivation in the workplace. *Human Resource Management Rev.* **3**(3) 185–201.

Amabile, T. M., W. Dejong, M. R. Lepper. 1976. Effects of externally imposed deadlines on subsequent intrinsic motivation. *J. Personality Soc. Psych.* **34** 92–98.

Armstrong, A., J. Hagel. 1996. The real value of on-line communities. *Harvard Bus. Rev.* **74**(3) 134–141.

Armstrong, S. J., T. S. Overton. 1977. Estimating non-response bias in mail surveys. *J. Marketing Res.* **14** 396–402.

Barley, S. R., G. Kunda. 2001. Bringing work back in. *Organ. Sci.* **12**(1) 76–95.

Barney, J. 1991. Firm resources and sustained competitive advantage. *J. Management* **17**(1) 99–121.

Bénabou, R., J. Tirole. 2003. Intrinsic and extrinsic motivation. *Rev. Econom. Stud.* **70** 489–520.

Constant, D., L. Sproull, S. Kiesler. 1996. The kindness of strangers: The usefulness of electronic weak ties for technical advice. *Organ. Sci.* **7**(2) 119–135.

Deci, E. L. 1975. *Intrinsic Motivation*. Plenum Press, New York.

Deci, E. L., R. M. Ryan. 1985. *Intrinsic Motivation and Self-Determination in Human Behavior*. Plenum Press, New York.

Denzin, N. 1978. *The Research Act, A Theoretical Introduction to Sociological Methods,* 2nd ed. McGraw Hill, New York.

Eisenhardt, K. 1989. Building theories from case study research. *Acad. Management Rev.* **14**(4) 532–551.

Enos, J. L. 1962. *Petroleum Progress and Profits: A History of Process Innovation*. MIT Press, Cambridge, MA.

Franke, N., S. Shah. 2003. How communities support innovative activities: An exploration of assistance and sharing among end-users. *Res. Policy* **32**(1) 157–178.

Franke, N., E. von Hippel. 2003. Satisfying heterogeneous user needs via innovation toolkits: The case of Apache security software. *Res. Policy* **32**(7) 1199–1215.

Freeman, C. 1968. Chemical process plant: Innovation and the world market. *National Inst. Econom. Rev.* **45** 2957.

Frey, B. S. 1997. *Not Just for the Money: An Economic Theory of Personal Motivation*. Edward Elgar Publishing Limited, Cheltenham, UK.

Frey, B. S., F. Oberholzer-Gee. 1997. The cost of price incentives: An empirical analysis of motivation crowding-out. *Amer. Econom. Rev.* **87**(4) 746–755.

Garud, R., A. Kumaraswamy. 1993. Changing competitive dynamics in network industries: An exploration of Sun Microsystems' open system strategy. *Strategic Management J.* **14**(5) 351–369.

Glazer, A., K. A. Konrad. 1996. A signaling explanation for charity. *Amer. Econom. Rev.* **86**(4) 1019–1028.

Greene, W. H. 1997. *Econometric Analysis*, 3rd ed. Prentice-Hall, Upper Saddle River, NJ.

Henkel, J., S. Thies. 2003. Customization and innovation—User innovation toolkits for simulator software. *Proc. 2nd Interdisciplinary World Congress Mass Customization Personalization*. Munich, Germany.

Henkel, J., E. von Hippel. 2005. Welfare implications of user innovation. *J. Tech. Transfer* **30**(1–2) 73–87.

Herstatt, C., E. von Hippel. 1992. From experience: Developing new product concepts via the lead user method: A case study in a low "tech" field. *J. Product Innovation Management* **9** 213–221.

Hertel, G., S. Niedner, S. Herrmann. 2003. Motivation of software developers in open source projects: An Internet-based survey of contributors to the Linux kernel. *Res. Policy* **32** 1159–1177.

Iansiti, M., A. MacCormack. 1997. A developing products on Internet time. *Harvard Bus. Rev.* **75**(5) 108–118.

Jeppesen, L. B. 2005. User toolkits for innovation: Consumers support each other. *J. Product Innovation Management* **22**(4) 347–362.

Jeppesen, L. B., M. J. Molin. 2003. Consumers as co-developers: Learning and innovation outside the firm. *Tech. Anal. Strategic Management* **15**(3) 363–384.

Jick, T. D. 1979. Mixing qualitative and quantitative methods: Triangulation in action. *Admin. Sci. Quart.* **24**(4) 602–612.

Knight, K. E. 1963. A study of technological innovation: The evolution of digital computers. Unpublished Ph.D. dissertation, Carnegie Institute of Technology, Pittsburgh, PA.

Koestner, R., R. M. Ryan, F. Bernieri, K. Holt. 1984. Setting limits on childrens behavior: The differential effects of controlling versus information styles on intrinsiv motivation and creativity. *J. Personality* **52** 129–137.

Kozinets, R. V. 1998. On netnography: Initial reflections on consumer research investigations of cyberculture. *Adv. Consumer Res.* **25**(1) 366–372.

Kreps, D. M. 1997. Intrinsic motivation and extrinsic incentives: The interaction between norms and economic incentives. *Amer. Econom. Rev.* **87**(2). *Proc. 104th Annual Meeting Amer. Econom. Assoc.*, 359–364.

Lakhani, K. R., E. von Hippel. 2003. How open source software works: "Free" user-to-user assistance. *Res. Policy* **32**(6) 923–943.

Lakhani, K. R., R. G. Wolf. 2003. Why hackers do what they do: Understanding motivation effort in free/open source software projects. Working Paper 4425-03, Sloan School of Management, MIT, Cambridge, MA.

Lepper, M. R., D. Greene, eds. 1978. *The Hidden Costs of Rewards: New Perspectives on Psychology of Human Motivation*. Erlbaum, Hillsdale, NY.

Lerner, J., J. Tirole. 2002. Some simple economics of open source. *J. Indust. Econom.* **50**(2) 197–234.

Lilien, G., P. D. Morrison, K. Searls, M. Sonnack, E. von Hippel. 2003. Performance assessment of the lead user generation process for new product development. *Management Sci.* **48**(8) 1042–1060.

Lüthje, C. 2004. Characteristics of innovating users in a consumer goods field: An empirical study of sport-related product consumers. *Technovation* **24**(9) 683–695.

Lüthje, C., C. Herstatt, E. von Hippel. 2002. The dominant role of "local" information in user innovation: The case of mountain biking. Working paper, Sloan School of Management, MIT, Cambridge, MA.

MacCormack, A., R. Verganti, M. Iansiti. 2001. Developing products on "Internet time": The anatomy of a flexible development process. *Management Sci.* **47**(1) 133–150.

Moon, J. Y., L. Sproull. 2000. Essence of distributed work. The case of the Linux kernel. *First Monday* **5**.

Moon, J. Y., L. Sproull. 2001. Turning love into money: How some firms may profit from voluntary electronic customer communities. Working paper.

Morrison, P. D., J. H. Roberts, D. F. Midgley. 2004. The nature of lead users and measurement of leading edge status. *Res. Policy* **33**(2) 351–362.

Morrison, P. D., J. H. Roberts, E. von Hippel. 2000. Determinants of user innovation and innovation sharing in a local market. *Management Sci.* **46** 1513–1527.

Muniz, A. M., T. O'Guinn. 2001. Brand community. *J. Consumer Res.* **27**(4) 412–432.

O'Mahony, S. 2003. Guarding the commons: How community managed software projects protect their work. *Res. Policy* **32**(7) 1179–1198.

Pfeffer, J. 1990. Incentives in organizations. O. Williamson, ed. *Organization Theory*. Oxford University Press, New York.

Reeve, J., E. L. Deci. 1996. Elements of the competitive situation that affect intrinsic motivation. *Personality Soc. Psych. Bull.* **22** 24–33.

Rosenberg, N. 1976. *Perspectives on Technology*. Cambridge University Press, New York.

Rothwell, C., C. Freeman, A. Horlsey, V. T. P. Jervis, A. B. Robertson, J. Townsend. 1974. Sappho updated—Project Sappho Phase II. *Res. Policy* **3**(3) 258–291.

Roztocki, N. 2001. Using Internet-based surveys for academic research: Opportunities and problems. *Proc. 2001 Amer. Soc. Engrg. Management* (ASEM), National Conference, Huntsville, AL, 290–295.

Ryan, R. M., E. L. Deci. 2000. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psych.* **25**(1) 54–67.

Shah, S. K. 2000. Sources and patterns of innovation in a consumer product field: Innovation in sporting equipment. Working Paper 4105, Sloan School of Management, MIT, Cambridge, MA.

Shah, S. K. 2003. Community-based innovation and product development: Findings from open source software and consumer sporting goods. Unpublished doctoral dissertation, MIT, Cambridge, MA.

Sproull, L., S. Kiesler. 1991. Computers, network and work. *Sci. Amer.* **265** 116–123.

Thomke, S., E. von Hippel. 2002. Customers as innovators: A new way to create value. *Harvard Bus. Rev.* **80**(4) 5–11.

Urban, G., E. von Hippel. 1988. Lead user analyses for the development of new industrial products. *Management Sci.* **35**(5) 569–582.

VanderWerf, P. A. 1982. Part suppliers and innovators in wire termination equipment. Working paper, Sloan School of Management, MIT, Cambridge, MA.

von Hippel, E. 1976. The dominant role of users in the scientific instrument innovation process. *Res. Policy* **5**(3) 212–239.

von Hippel, E. 1986. Lead users: A source of novel product concepts. *Management Sci.* **32**(7) 791–805.

von Hippel, E. 1988. *The Sources of Innovation*. Oxford University Press, New York.

von Hippel, E. 2001. Innovation by user communities: Learning from open-source software. *MIT Sloan Management Rev.* **42**(4) 82–86.

von Hippel, E., R. Katz. 2002. Shifting innovation to users via toolkits. *Management Sci.* **48**(7) 821–833.

von Krogh, G., E. von Hippel. 2003. Open source software and the "private-collective" innovation model: Issues for organization science. *Organ. Sci.* **14**(2) 209–223.

von Krogh, G., S. Spaeth, K. R. Lakhani. 2003. Community, joining, and specialization in open source software innovation: A case study. *Res. Policy* **32**(7) 1217–1241.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management J.* **5** 171–181.

Williams, R. L., J. Cothrel. 2000. Four smart ways to run online communities. *Sloan Management Rev.* **41**(4) 81–91.

Wimmer, R. D., J. R. Dominick. 1994. *Mass Media Research: An Introduction*. Wadsworth, CA.

Yin, R. 1993. *Applications of Case Study Research*. Sage Publishing, Beverly Hills, CA.