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**Abstract:**

This paper introduces a model of knowledge sharing of lead users located in a public and unrestricted community of users. While existing literature on knowledge sharing focuses on allocation and collaboration processes inside or among companies we extend this to the community level. We then focus on how key agents — lead users — facilitate knowledge sharing in this setting and the features that moderate such sharing. Our results show that lead users are central to search and integration of knowledge from different external sources of relevance to their communities. Inside the community lead users are active in both "giving and taking" knowledge. Further, as users build up experience they tend to give more knowledge, thus suggesting a dynamic pattern of knowledge sharing in which increases in experience make way for important knowledge diffusion processes in the community.

**Key words:** Lead users; knowledge sharing; innovation; on-line community

**Jel codes:** D83; O31

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## 1. Introduction

Over the last decade new institutions and organizational forms have emerged in the form of knowledge intensive communities of practice in which knowledge is created and diffused among the community members and beyond. In this context, knowledge sharing is important as it sustains learning, but also because it supports processes of technological innovation (Borgatti and Cross 2003; Kogut and Zander 1992; Lave and Wenger 1991; Orr 1996; Tsai and Ghoshal 1998). The vehicles of knowledge sharing include face-to-face interaction in geographically bound communities and, increasingly, Internet based community interaction of distributed and loosely connected collaborating individuals (Armstrong and Hagel 1996; Benkler 2004; Muniz and O'Guinn 2001; Williams and Cothrel 2000). Previous literature that has dealt with the opportunities and challenges raised by the emergence of these communities has been valuable to our understanding of how they may add value to the processes and products of the communities themselves (Kollock 1999; Moon and Sproull 2000; Raymond 1999; von Hippel and von Krogh 2003) and to established firms (Jeppesen and Frederiksen 2006). At the same time, the literature has provided important insights concerning the motivations and opportunities that may induce agents to contribute to these communities (Lakhani and von Hippel 2003; Lerner and Tirole 2002; von Krogh 2002). However, researchers have only to a limited extent addressed how key agents facilitate knowledge sharing in this setting and the dynamic features that moderate such sharing.

In this paper, we study lead users' role as facilitators of knowledge sharing in an Internet based community of practice. By knowledge sharing we understand the provision or receipt of task information, know-how, and feedback on a product or a procedure (Hansen 1999). As in most settings, not all individuals should be considered equally important knowledge sources. In the context of teamwork, it has been shown that perceived experts in groups assume responsibility for managing the information of the group, aggregating both shared and unique knowledge (Thomas-Hunt et al. 2003). The motivation of this study is to investigate the process by which knowledge sharing takes place among users located in communities and the role that lead users play in this process. We thus study the factors that moderate the sharing of knowledge by lead users.

It is well-established that lead users are an important source of value creation in the innovation process. As early adopters with strong needs for a solution lead users become the sources of new product ideas when they go ahead and create novel solutions where no commercial solutions are available (Morrison et al. 2000; von Hippel 1986). Such ideas and prototypes have been found to form the basis of numerous successful commercial products (Lilien et al. 2002) as well as being key contributions to "commons-based production systems" (Benkler 2004), for instance, in the form of open source software projects. The need to know more about lead users' knowledge sharing behavior stems from the fact that advances in technology allowing for decreases in the costs of establishing experimental capabilities (Thomke 1998; Thomke 2003) and communication capabilities have quickly been exploited by lead users to collaboratively design and build what they want for themselves and for others (von Hippel 2005). Therefore they may increasingly exert an impact on existing industries as the outcomes either complement or substitute existing products or create entirely new product categories. For instance, lead users have been found to play a key role in the creation of open source software products that have gained significant market shares from state-of-the-art commercial software (Franke and Shah 2003; Lerner and Tirole 2002). Also in more low-tech areas of consumer goods innovations, such as skateboards (Shah 2000) and mountain bikes (Lüthje 2004) lead users have been responsible for the creation of entirely new industries. Secondly, as internet activity has increased user-to-user help lines via online communities has become a widespread phenomenon that may alter the way in which services and assistance is provided and in general how experts are accessed for advice. The effectiveness of the community as a problem solving and innovation setting relates to the extent to which individuals are able to find complementary "bits" of information and knowledge to make up for their deficiencies in certain areas of, for instance, heuristics or task-related abilities. The community becomes a setting for exchange of help services crucially dependent on knowledge sharing among members. Due to their motivations for solving problems and innovating, key individuals such as lead users, are possibly important individuals for both demand and supply side in these processes.

Studies of knowledge disclosure have shown that users often freely reveal their innovation related information and have examined why it makes economic sense for them to do so (see, Harhoff et al. 2003; Lakhani and von Hippel 2003; Morrison et al. 2000). Importantly, studies of knowledge sharing and transferring have found that the effectiveness with which knowledge is shared within, and across, organizations impacts an organization's technology development abilities (Appleyard 1996) and that teams get better at what they do when members engage in helping each other and seek advice from experts (Orr 1996). This jointly suggests that knowledge sharing behavior of experts (such as lead users) may be centrally important to the functioning of a given development context. The majority of studies of knowledge sharing have focused on intra-firm and inter-firm knowledge transfers. Although important, the knowledge transfer processes underpinning technological development outside the boundary of organizations have so far received relatively little attention. Here, we focus on knowledge sharing at the level of a public and unrestricted community of users that revolves around the interest in the development of technologies pertaining to an established software firm.

We propose a model of knowledge sharing in user communities in which lead users are portrayed as intensely involved in both the demand and supply of knowledge. The model predicts that lead users, due to their requirement to fill leading edge needs they must generate novel solutions. In that process they will reach roadblocks and have high demand for new knowledge which will then motivate them to search actively for knowledge of others (Majchrzak et al. 2004) both beyond and within their community's boundaries. As these activities allow lead users to accumulate knowledge and given the low rivalry conditions of the community and the low marginal cost of passing the accumulated knowledge on to others, the model also predicts that lead users are central in providing knowledge to others in the community. The model thus contains three components predicting that: 1) lead users perform a boundary spanning and gate keeping role exposing themselves to external (to the community) and novel sources of knowledge of value to their activities in the focal community, 2) they augment their body of knowledge by also actively seeking knowledge in their own focal community, and 3) they tend to actively provide other users with their knowledge.

A survey was undertaken and web-log information was collected to learn about the knowledge sharing processes of lead users. Consistent with our proposed theory, the results show that lead users are centrally involved as boundary spanners in the search and integration of knowledge from different sources of relevance for their communities. Inside the community lead users are active in both "giving and taking" knowledge. Moreover, as users build up experience they tend to take less — and give more — knowledge, thus making way for important knowledge diffusion processes in the community.

## 2. Theoretical and Empirical Background

### 2.1. Lead users and value creation in the innovation process

Empirical studies find that users often modify products and also create new products. In some cases, up to 40 percent of a population of active users engages in these activities. Research also shows that product modification and development among users is concentrated among users displaying "lead user" characteristics (von Hippel 2005). Lead users of a given product or service type have three defining characteristics that makes them key agents in the knowledge sharing process: 1) They are early adopters of the product or service; 2) They experience the need for a given innovation earlier than the majority of the target market; and 3) They are users who expect attractive innovation-related benefits from a solution to a problem related to the product or service and are therefore motivated to innovate.

Studies carried out since the late 1980s have shown the importance of lead users in the innovation process. Urban and von Hippel (1988), studied the characteristics of PC-CAD systems and found that almost one-fourth of those found to have lead users characteristics had innovated, thus indicating a close relation between leading edge demands and the inclination to undertake innovative activity. Studies also shows how lead users were successfully applied in the product development within firms (Herstatt and Von Hippel 1992) and how such involvement can be used to generate radical product innovations (von Hippel et al. 1999) and that sales performance (projected sales) of lead user generated product lines is several times higher than for product lines generated through the involvement of in-house staff only (Lilien et al. 2002). A likely explanation for this performance is found in recent studies, showing that the commercial attractiveness of the innovation increase in step with the intensity of lead user characteristics displayed by an innovator (Franke and Shah 2003; Franke et al. 2006; Franke and von Hippel 2003).

The importance of studying the social behavior of lead users is evident as such users — when connected — may provide and/or receive needed know-how and task information; thus sustaining the level of knowledge supply in a population of individuals with an increased propensity to invent important novel product concepts as a result. The present study applies to company-based innovation processes, in which a firm seeks novel product concepts from a community of users, as well as to the situation of autonomous peer-to-peer invention, in which no firm is involved, such as open source software development communities.

**2.2. Why does knowledge sharing matter?**

Scholars of knowledge sharing and exchange have argued and shown that it has an important impact on knowledge creation (Hansen 1999; Nonaka 1994; Tsai and Ghoshal 1998; von Krogh 1998). Most studies have focused on "within-organization sharing" and on the organization's ability to perform well. Within this literature, some studies have considered intra-firm knowledge sharing as an indicator of organizational capability and established how firms create new knowledge and maintain their competitiveness (Kogut and Zander 1992). In this view organizations learn by recombining current capabilities through a process of knowledge sharing. The way recombination takes place largely determines the development opportunities of the firm in the future, while growth of the firm occurs by building on the existing social relationships established within the firm.

Studies of the knowledge sharing processes at the individual, group and team levels are found in the learning literature. Individuals may learn from searching for information from colleagues (Borgatti and Cross 2003), and teams learn through action when members provide each other with advice and help or seek advice from experts (Orr 1996). In studies at the group level, Edmondson (1999) focused on the approaches used by group members to get better at their tasks. When group members needed supplementary knowledge they requested feedback, shared information with others, asked for help, talked about errors and so forth. The groups that engaged more intensely in such activities performed better.

Research by Dyer and Nobeoka (2000) looks at the importance of knowledge sharing beyond firm boundaries, and find that interaction in production networks creates dynamic learning capabilities resulting in competitive advantage. The authors speculate that if a network can create well-functioning coordinating rules, it may be superior to a firm as an organizational form in creating and recombining knowledge due to the diversity of knowledge that resides within a network. Related to the access to the outside sources of knowledge, the presence of effective gatekeeper functions (Allen 1977) will be of importance because firms and other organizations may learn from having gatekeepers interact with "outsiders" to integrate and bridge new combinations of knowledge (Hargadon and Sutton 1997).

In this paper, we analyze knowledge sharing in an open public on-line community of product users that collaboratively develop modifications and new product concepts of a commercial product owned by a firm.

According to the knowledge sharing literature briefly surveyed above, knowledge sharing has an important effect on the efficiency of the production systems in which knowledge is shared, such as in established organizations. However, it should also be considered of equal importance in "decentralized and distributed production systems", such as communities of practitioners (Brown and Duguid 2000) and communities of users (Jeppesen 2005). As mentioned above, research has shown that network formations of knowledge holders are conducive to knowledge sharing. The community setting that we study in this work is one such network in which users share knowledge. Not all users should, however, be considered equally important knowledge sources in this context. Accordingly, we have a specific interest in the factors that affect the sharing of knowledge behavior of the lead users in the community.

## 3. Hypotheses

As mentioned above, lead users have certain characteristics that relate to the innovation processes. However, those characteristics may also play a key role in shaping their knowledge sharing behavior in a community. The three defining characteristics of lead users are that they are early adopters, that they perceive the need for an innovation earlier than others, and that they expect great benefit from solving problems. These three characteristics are conjectured to shape the way in which these users share knowledge in the community context. Here, we adopt the view that an innovation is a new combination (Fleming and Sorenson 2001; Fleming and Sorenson 2004; Nelson and Winter 1982; Schumpeter 1912/1934, 1939/89; Tsai and Ghoshal 1998) and that search and information exchange is central activities in achieving such combinations (Fleming and Sorenson 2004).

Our first hypothesis pertains to lead users as agents that take advantage of searching the focal community for solving their needs that are ahead of the trend curve. There several advantages to searching locally. Sorenson and Fleming (2004) define "local" (search) as referring to activities that relate quite closely to prior activities, "…by definition implying some experience with the technologies being developed." In our setting, local search corresponds to searching for a solution within the domain of the focal on-line community. Although local search has a lower potential for knowledge recombination of a more radical nature, the search costs for local solutions are most often much lower within a familiar domain (Rosenkopf and Almeida 2003). This explains why searching knowledge and information inside the community might be an obvious first choice for lead users. In addition, since agents develop an understanding of the "local" elements that can potentially be combined, they are better able to invent with greater reliability by avoiding elements that did not work in the past (Fleming and Sorenson 2004). Accordingly, given the defining characteristics of lead users — in particular a high need and motivation for finding a solution — but not necessarily having all the components to the solutions, these users should be expected to look for solutions in their own community. Accordingly, we propose:

H1. Lead user characteristics increase with the propensity of the user to take knowledge from the community.

Searching inspiration for a solution locally may not always yield the appropriate outcomes due to the limited scope of the local knowledge base. Our second hypothesis relates to lead users as individuals with motivation to search inspiration from different communities. One proposition that has repeatedly been made is that innovative ideas are most readily adopted by those that also have "out-of-town" contacts (Chubin 1976; Coleman et al. 1957; Menzel and Katz 1955; Park 1950; Rogers 1962), i.e. connections to people or content areas at the margin of their own field of activity. Given lead users' characteristic as early adopters, we expect them to be more likely to be exposed to a variety of sources of solution input outside of their local environment. Their activities can be illustrated as gatekeeping (Allen 1977) processes by which they bring about some of the variety necessary to create "new combinations." The existence of the "gatekeeper," an individual who links his or her organization to the world at large, was pointed to by Allen (1969). While early studies pointed out that the average engineers made little or no use of information from outside their organizations (Allen 1966) subsequent investigations found the existence of key individuals who specialized in an informal bridging role between the external environment and the R&D laboratory (Allen and Cohen 1969). These individuals that were well connected to external individuals were called technological gatekeepers. In our community context, the crucial function that gatekeepers perform is to bridge external information to internal community knowledge and other resources.

In dealing with novel problems encountered in the process of solving needs ahead of the trend curve where no solutions are yet available (that is where lead users are active), the knowledge input required will likely not coincide with an agent's own knowledge base. This creates a large gap between the current state and the wished goal state that motive the use of distant knowledge of others (Majchrzak et al. 2004). In such situations the need to go beyond the boundaries of a present community for complementary knowledge may be quite prevalent (Postrel 2002). Hence, local sources of inputs may often offer too little inspiration and variety for to solve a lead user's problems. In other words, the local environment may not offer enough opportunities for knowledge combination and recombination (Fleming and Sorenson 2004; Rosenkopf and Nerkar 2001). Accordingly, given the benefits lead users obtain from a solution to leading edge needs, they also have the motivation to seek inspiration and inputs outside of their local domain, as local inputs are often insufficient on their own to solve leading edge problems. In sum:

H2. Lead user characteristics increase with the number of communities the user engages in.

As one of the three defining characteristics of lead users is that they are early adopters of new products or services, these users can be assumed to hold experience early on with a given technology or question. Therefore, they most often posses knowledge and information that is valuable to the community. Lead users also have incentives to disclose this knowledge and information to the community, given the characteristics of the context. These incentives has been put under scrutiny in the literature on the reasons for open source developers to freely reveal the source code they have produced (see for instance, Harhoff et al. 2003; Morrison et al. 2000; von Hippel and von Krogh 2003). These arguments may apply not only to open source software, but to a much wider set of activities, where collective invention is important. One incentive for contributors to freely reveal knowledge is the incentive related to reputation effects. The argument here in the context of open source software is that free revealing of quality code can increase a programmer's reputation with peers (Raymond 1999) as well as his/her value on the job market (Lerner and Tirole 2002). Moreover, those who have contributed code to open source projects often report that they both enjoyed and learned from the work of coding. With respect to the potential unavoidability of losses associated with free revealing, programmers may often feel that others have developed code similar to their own and are likely to freely reveal it if they do not do so themselves — which would render any decision that they might make to hide their code useless (Lakhani and von Hippel 2003). Furthermore, a number of authors have argued that opportunities, communal norms, and generalized reciprocity (Ekeh 1974; von Krogh 2002; Wasko and Faraj 2000) may play an important role in inducing free revealing and sharing of knowledge.

In addition to this set of motivations, Harhoff et al. (2003) propose an additional set of incentives for free revealing that are consequences of increased diffusion. Translated into our on-line setting, the basic argument is that when a lead user freely reveals his or her knowledge, the direct result is to increase the diffusion of that knowledge relative to what it would be if the knowledge was held secret. The lead user may then benefit from the increase in diffusion in a number of different ways. Among these are network effects, reputational gains, and related innovations induced among and revealed by other users. Being the first to reveal a given innovation increases a lead user's chances of having his/her innovation widely adopted. Accordingly, lead users may be induced to enter a race to reveal their knowledge first.

Apart from the positive effects of free revealing, there are also negative effects — also in an on-line setting — related to the fact that competing users may benefit from the knowledge or innovation without paying any of the costs of generation involved. However, without conflicting interests, the revealing lead user does not suffer as a consequence of the advantages he or she may provide to others (Lakhani and von Hippel 2003). Accordingly, and provided that conflicting interests between the users in the community may be deemed limited, we conjecture:

H3. Lead user characteristics increase with the motivation of the user to give knowledge to the community.

Learning by doing and learning by using are inherently time consuming activities (Arrow 1962; Rosenberg 1982; von Hippel and Tyre 1995). As a result of being lead users and expecting benefits from solving needs it is likely that such users will invest vast amounts of time in learning by doing. In this context, von Hippel and Tyre (1995) argue that "doing" — which by definition takes time — is unavoidable in the context of new product introductions, partly because of the inbuilt complexity of products. A defining characteristic of lead users is that they are ahead of the trend in terms of the sophistication of needs compared to the mainstream product users. To be ahead of the trend in a given area has been found in previous studies to be associated with spending time in a given area (Franke and Shah 2003) ("learning by user doing") and having accumulated experience about needs and possible solutions.

While in a static view lead users would be expected to maintain their demand and supply of knowledge, the experience of lead users will, we argue, tend to moderate this situation. Research on the dynamics of information seeking shows that when it comes to technical knowledge, newcomers are especially active in asking others such as their superiors in the organization (Morrison 1993), thus not only suggesting the view of newcomers as "proactive" information seekers, but also that attempts at knowledge take may be moderated by time or experience factors. The most basic explanation of why lead users' give and take of knowledge is moderated by experience is that experience signifies that people have learned by exploring a problem space or a given set of problems. As learning takes place, the need to draw on outside local knowledge declines because users will tend to become more knowledgeable about the specific knowledge domain and thus be more likely to have a solution to a given problem within reach. Therefore, we expect that "knowledge take" will drop with experience.

Furthermore, the increased likelihood of a lead user knowing a solution to a given problem as she gets more experienced will positively impact the probability of her giving knowledge to others, as that solution will be "in stock" already. When solutions are already possessed by a "lead user" it means that the cost of responding to, for example, a request by another community member will be extremely low (Constant et al. 1996). Studies of commons-based production systems (Lakhani and von Hippel 2003) found that one of the main reasons solution providers respond to problems held by other participants in open source software projects was that the solution was already known and therefore low cost to the provider. In sum, we propose:

H4. Higher levels of lead user characteristics combined with higher levels of experience of users, tend to reduce knowledge take, while increasing knowledge give.

## 4. Empirical analyses

### 4.1. Methodology

Our analysis is based on results from a survey in combination with data obtained from web-logs generated by active users in an online community. We sent out a web-based questionnaire to the community of users located in Propellerhead Software's community, Propellerhead Community. The 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 characteristics, particularly those regarding innovative and leading edge users. The object studied, innovative users located in an online community, favored the use of a web-based survey method. The community goers were asked questions about: their background, community participation information, innovative work carried out, motivations for community participation, and knowledge sharing inside and outside the community. The questionnaire appeared in a pop-up window when a community participant logged into the online community (posted at the Internet location Propellerheads.se). When finished, the respondent submitted the questionnaire directly to our database.

The questionnaire had a response rate of 62.7 percent (i.e. 62.7 percent of those offered the questionnaire responded). The total number of responses was 442. The first best choice for avoiding non-response bias is to achieve a high response rate (Armstrong and Overton 1977) — a 63 percent response rate must be considered to be very good in this respect. Nevertheless, we compared early respondents with late respondents, following the procedure suggested by Armstrong and Overton (1977). The assumption made in this analysis is that late respondents share similar characteristics and response biases with non-respondents. We compared the 20 percent of early respondents with the 20 percent of late respondents (88 observations in each group). A *t*-test was conducted on the lead user variable and Chi2 tests on the (discrete) explanatory variables, and we found no significant mean differences between early and late respondents for any of these variables, suggesting that non-response bias should not be a problem.

With respect to common method bias, the questionnaire was constructed in such a way that the respondents had to answer in different ways in various parts of the questionnaire. In other words, we used a mix of Likert scales, yes/no questions, estimates of time periods spent etc., throughout the questionnaire. Moreover, we combine the questionnaire-based data with simple measures of actual behaviors in terms of posting activities in the on-line community (more about this in section 4.2 below). Finally, we perform Harman's one-factor test on the items included in our regression model to examine whether common method bias may augment the relationships detected. Since we found multiple factors, and since the first factor does not account for the majority of the variance (the first factor accounts for 25 percent of the variance only), potential problems associated with common method bias are not indicated by the test (Podsakoff and Organ 1986).

Since our dependent variable is a count of scores (the degree of "lead user score") a Posisson regression would be an obvious candidate as the tool for estimation. However, the assumption underlying Posisson regression, that the conditional mean and variance of the dependent variable, given the set of regressors, are equal is strong and often fails to account for overdispersion present in many datasets (Cameron and Trivedi 1986: 31). This is a problem given that overdispersion produces downward biased standard errors. Since we find evidence of overdispersion for the data considered here, we apply a negative binomial regression model specification (Hausman et al. 1984).

### 4.2. Variables

*Dependent variable:* Our dependent variable is lead user characteristics: it is based on 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 to a large extent" 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 dependent variable — lead user — was constructed from those three items we chose to perform a standardized Cronbach's Alpha test. Since the standardized Cronbach's Alpha is 0.67, the variable has an acceptable degree of internal validity. Our decision to treat "lead user" as a non-dichotomous variable was motivated by some recent evaluations of the construct which found the non-dichotomous analog to its binary ancestor more appropriate due to its ability to deal with degrees of lead user characteristics (see, Morrison et al. 2004). Figure 1 plots frequencies of the index of lead user characteristics. It can be seen that the distribution is bell-shaped, with a tendency for the peak to be on the right hand side of the distribution.

A "user experience" measure is based on the following question: "I have been using Propellerheads products for: a) Less than one month, b) Less than 6 months, c) Less than 1 year, d) Between 1-4 years, or e) More than 4 years. We transformed these categories into "continuous" numbers, with a) to e) becoming 0.5, 3, 9, 24 and 72 months respectively (the results are not sensitive to this precise transformation). As the benefit of user experience is likely to peter off, we took the logarithm to the outcome. However, it may not only be the time period of having been using the product, but also the intensity of use, that should define "user experience", therefore we required that users should spend at least 5 hours a week on average time on "activities related to sound production or processing" in order not to get the lowest "user experience" score. We interact the lead user construct with the user experience measure and use the resulting variable as the dependent variable to assist in putting Hypothesis 4 under scrutiny.

[Figure 1, just about here]

*Key independent variables*: The "number of communities" variable is based on the following question on the questionnaire: "How many communities related to sound production and modding of virtual instruments do you participate in?" The values of the variable range from 1 to 9. The other key motivational variable of this study is aimed at measuring whether the user enjoys giving assistance as an expert ("knowledge give"). The variable is based on the following question on the questionnaire: "Check out the statements below and indicate on the 1 to 7 point scale if they fit your characteristics: I enjoy giving others advice as an expert, yes/no." It is common to infer actual behavior from surveys using self-reports without the ability to test how good a proxy for actual behavior such reports are. In order to validate our "knowledge give" variable, we correlated our variable with simple measures of actual behaviors in the on-line community. We got access to all postings (31,125 postings) by members of the community over the period February 14 2002 to March 9 2003. We asked two persons to rate whether the given members, in 1200 postings to the website (one person rated 500 postings and another rated 700 postings): 1) posed a question, 2) gave an answer, or 3) wrote something that was neither 1) nor 2). In order to check for inter-coder reliability, we had 100 postings double-rated by the two coders. We then calculated the coefficient of reliability and found that the two coders were in agreement 88 percent of the time. In order to account for agreement due to chance, we also calculated Scott's pi and found a value of 0.87, which is typically considered to indicate very good inter-coder reliability. Based on the ratings of the postings, we calculated a variable expressing the observed propensity to post answers (percentage of answers as a proportion of total postings) in the community. Since we did not have all postings rated over the period, we were only able to identify 155 individuals, who had also filled out the questionnaire with non-missing observations for all our variables. However, this variable correlates positively (0.1 percent level of significance) with the "knowledge give" variable (correlation coefficient of 0.4).[1] Another key independent variable is a variable gauging whether the user receives assistance ("knowledge take") and is based on the following question: "Check out the statements below and validate if they fit your characteristics: I usually have received assistance from people in the community when improving or developing products, yes/no."

*Control variables.* One key control variable is user innovation ("innovator"). 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? yes/no" By asking in this manner we were able to establish innovation as a discrete variable: If users had innovated, the innovation variable was set to the value of 1 and if no innovation was reported, the value of the innovation variable was set to equal 0. Another control variable is "focus on technological product improvements". The variable is discrete and is based on the following question: "I spend most of my time on technological product improvements, making mods, yes/no." Another set of control variables are based on a question pertaining to the primary occupation of the community member: "I spend most of my time as: a) professional programmer, b) hobby programmer, c) student, and d) other". Based on this question we create three binary variables ("professional programmer", "hobby programmer", "student") and use the "other" category as the benchmark in the estimations. The "do it for fun" control variable draws on the question: "What are the reasons for your participation in the community? For fun, yes/no", while the "peer recognition important" variable is based on the question: "Check out the statements below and indicate on the 1 to 7 point scale whether they fit your characteristics: Recognition from other community goers is my greatest reward."

*Descriptive statistics:* Table 1 gives descriptive statistics for the variables used in this study. It can be seen that the average lead user score is about 14, while the maximum value is 21 (corresponding to the theoretical maximum). The strongest correlations between the independent variables is between whether the users judge peer recognition to be important as a motivating factor on the one hand, and enjoying giving knowledge as an expert on the other ($r = 0.26$).

[Table 1, just about here]

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[1] We also correlated the propensity to post answers with our lead user construct and we found a positive and significant (1 percent level of significance) relationship between the two variables (correlation coefficient of 0.2).

**4.3. Regression results**

The results of our first set of estimations can be found in Table 2. Model 3 contains a model with all key independent and control variables included. From this model it can be seen that Hypothesis 1 ("Lead user characteristics increase with the number of on-line communities the user engages in.") finds some support since the parameter for the number of communities in which the user participates is positive and significant (at the one percent level) in affecting the level of lead user characteristics.

[Table 2, just about here]

Hypothesis 2 ("Lead user characteristics increase with the propensity of the user to take knowledge from the community") also finds powerful support, as the parameter for the "knowledge take" variable is positive and significant at the 0.1 percent level. Lead user characteristics also appear to increase with the motivation of the user to give knowledge to the on-line community (Hypothesis 3), since the parameter is significant at the 0.1 percent level as well. In order to test the robustness of this finding we replaced the "knowledge give" variable with the observed propensity to post answers to the community. The results of this experiment are reported in Model 5. We find that the proportion of answers over total postings has a positive and significant parameter (5 percent level). Although we have only 155 observations when we perform this analysis we find that results are similar to the results produced when using the entire sample in Model 3 (see also Model 4, where the variables are the same as in Model 3, but where we focus on the 155 observations for which we have registered postings).

To examine the size effects of the number of communities in which the user participates, "knowledge take" and "knowledge give" on the level of lead user characteristics we use the estimates from Model 3 and evaluate them at the median values of the independent and control variables, while varying the independent variables one at a time. For the negative binomial model the predicted value of the level of lead user characteristics can be expressed as exp($\mathbf{x}\beta$), where $\mathbf{x}$ is a set of regressors and $\beta$ represents the parameter estimates from Model 3 (Cameron and Trivedi 1986: 33). We find that participating in nine online communities, rather than one community, is associated with an increase in lead user characteristics of individual community members by 24 percent. Having the maximum value (7) for taking knowledge from the community, rather than the minimum value (1), increases lead user characteristics by 19 percent, while indicating the maximum value (7) for giving knowledge to the community, rather than the minimum value (1), is associated with an increase in lead user characteristics by 23 percent.

With respect to Hypothesis 4 ("Higher levels of lead user characteristics combined with higher levels of experience of users, tend to reduce knowledge take, while increasing knowledge give") we interacted the lead user construct with the user experience variable and used the resulting variable as the dependent variable. Since the new dependent variable is continuous, we apply ordinary least squares (OLS) as the means of estimation, and compare the OLS estimations of the interacted variable (Table 3, Model 7) with the OLS estimation with lead user characteristics alone as the dependent variable (Table 3, Model 6). In order to compare the estimations, we standardized the dependent variables, so that they get mean zero and standard deviation one (note that the OLS estimations presented in Model 6 are similar to the negative binomial estimation presented in Model 3, when it comes to sign and significance). Comparing the coefficients, from the regression where lead user is interacted with user experience in Model 7 to those of the pure lead user regression (Model 6), we find that more experienced lead users will tend to engage more in knowledge give, but less in knowledge take. In fact, we observe a "switchover", so that lead users in general have a higher parameter for knowledge take than for knowledge give — a coefficient of 0.11 for knowledge take as compared to a coefficient of 0.09 for knowledge give, while for the interacted dependent variable in Model 7, the situation is reversed so that experienced lead users have a higher parameter for knowledge give than for knowledge take — a coefficient of 0.14 for knowledge give as compared to a coefficient of 0.04 for knowledge take. In order to analyze whether the observed difference is statistically significant, we took the difference between the variable, lead user characteristics interacted with user experience on the one hand, and the pure lead user variable on the other. This analysis is reported in Model 8 and reveals that as user experience increases, lead users tend to reduce knowledge take (significant at the five percent level). Conversely, as user experience increases, lead users tend to increase knowledge give (however, significant at the ten percent level only).

[Table 2, just about here]

## 5. Discussion and conclusion

### 5.1. Findings

In this paper, we have analyzed knowledge sharing behavior in an on-line community and in this context put the role of lead users under scrutiny. We proposed a model portraying lead users as performing a boundary spanning and gate keeping role, exposing them to novel sources of valuable knowledge to their activities in the focal community. Lead users were also suggested to be augmenting their body of knowledge by actively seeking knowledge in their own focal community, and actively providing other users with their knowledge. The model found support in our empirical results since we have shown that lead user characteristics are associated with boundary-spanning across several on-line communities. Moreover — and still in agreement with our model — we found that lead user characteristics are associated with using knowledge from the community, but that users with a high degree of lead user characteristics at the same time tend to reveal (some of) their knowledge to other users. Finally, and adding to our model, we found that the relative propensity to give knowledge, in comparison with the propensity to take knowledge from the community, increases with the experience of lead users.

**5.2. Contribution to theory**

We have added to the growing body of literature on the phenomenon of innovative user communities and the relationship between key individuals and the participation in important knowledge sharing processes. Knowledge sharing is an important aspect of innovative communities of practice and a necessary condition for the ability of communities to become innovative in the first place. Theory on lead users suggests that such users are related to innovation. Our study suggests that the lead users are also a potentially interesting unit of analysis for explaining how new knowledge is integrated into communities and how it is diffused locally in the community. We suggest that in future models of distributed innovation and collaborative peer production, the unit of the community of practice would be a possible point of departure for studies of how knowledge spreads.

Our findings add to the literature on knowledge sharing by showing how this process works at the level of a community instead of firms, which so far have been the common focal point. While firms are usually treated as the locus of creation of novelty and the central level of analysis in studies of knowledge sharing, new organizational forms supporting innovative activity have been studied to a very limited extent. We have studied a setting that goes beyond the organizational context and emphasized the patterns by which knowledge is shared in the absence of formal authority and explicit incentives. Communities of practice are usually tied to occupations (in firms) and subject to such organizational context issues. We find that the fact that lead users span the boundaries of the community combined with a high level of sharing inside the community may well explain why innovative communities are effective (i.e., they can sometimes compete with state-of-the-art commercial products). If, on the contrary, the most leading edge individuals in the community were preoccupied with activities at the center of their fields (as in Kuhnian normal science 1970) they would fail to be exposed to ideas other than those already accepted and known in the field/community. However, the finding of gatekeeping activity indicates that lead users may be likely sources of adjustments, recombinations, or extensions of existing principles within the field and thus provide novel inputs to the community. Further, lead users tend not only to find and absorb knowledge outside the community; importantly, our findings also indicate that they share it inside the community, and that sharing increase with experience (this result is not strongly significant, though). Thus lead users may be described in a social setting as not only the motivated lead adopters and innovators, but also as gatekeepers, spanning the boundaries of the community and as linking his or her organization to the world at large.

Especially the fact that the "most sharing" individuals are also those who can be assumed to hold valuable knowledge (the lead users), and share it more the more experienced they get, is important news to both theory and practice. The finding that experience tends to reduce knowledge take while increasing knowledge give suggests that as individuals gain experience they build up stocks of needed knowledge which in turn reduce their need for new local knowledge (unless important advances in new technology increase this need). Since knowledge is then in stock it requires little investment to help others solve problems related to this knowledge. When problems are released openly in a community lead users can monitor the discussion and choose only to respond to problems to which they believe they have an answer. They can thus abstain from engaging in costly "from scratch" solution generation. The effectiveness of the knowledge sharing process and the outcomes resulting from this process crucially depend on the of motivations of lead users to give knowledge. This motivation may to a great extent by affected by the community being a low rivalry setting and the relatively low cost associated with solely responding to questions for which one is more or less sure to have an answer. The latter process is critically dependent on open and transparent information exchange as observed, for instance, in a setting such as the community we have studied. Furthermore, the innovation related activities in the community are also crucially dependent on the fact that it is experienced and knowledgeable individuals that release their knowledge in the community — if knowledge was released only by "average" individuals, in terms of knowledge of the specific dimensions in question, the usefulness of the knowledge provided would be much lower.

### 5.3. Practical implications

The finding that experience increases knowledge give means that longevity of communities and the retention of key individuals over time may be crucial to the functioning knowledge sharing environment. For example, the intensity of sharing of high value knowledge in open source communities can be expected to hinge on key coders as they get more experienced. In the related context of a firm-hosted community of practice, in which firms depend on input from innovative members of their community, managers and community moderators must realize that trying to identify and retain lead users is centrally important. Accordingly, managers and community moderators need to think about how they can motivate users not only to make contributions to the community, but also to identify key players and to create incentives for users to stay and keep on contributing.

Being part of a community of practice and having important experience with a specific technology will increase the likelihood of knowing the answer to a given question about that technology in an occupational context. This observation has implications for organizations in the sense that having employees involved in various communities of practice may increase their chances of upgrading their knowledge and thus the likelihood that they will share such knowledge within the organization. For instance, studies of open source software using firms have shown the importance of having staff involved in such development communities (Dahlander and Wallin 2006). As we have demonstrated, lead users are active in integrating knowledge from different communities into the focal community. Such a process may also be exploited by firms by having employees embedded in a diverse set of communities.

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**Table 1:** Descriptive statistics (n = 364)

| Variable | Mean | Std. Dev. | Min | Max | 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Lead user characteristics | 13.66 | 4.48 | 3 | 21 | | | | | | | |
| 2. Log user experience | 1.892 | 1.991 | 0 | 4.97 | 0.28 *** | | | | | | |
| 3. Number of communities | 2.49 | 1.60 | 1 | 9 | 0.19 *** | 0.19 *** | | | | | |
| 4. Enjoy giving assistance as an expert (“knowledge give”) | 4.87 | 1.79 | 1 | 7 | 0.25 *** | 0.23 *** | 0.03 | | | | |
| 5. Receive assistance (“knowledge take”) | 3.81 | 2.04 | 1 | 7 | 0.31 *** | 0.10 * | 0.16 ** | 0.23 *** | | | |
| 6. Innovator | 0.09 | 0.28 | 0 | 1 | 0.15 ** | 0.02 | 0.01 | 0.18 *** | 0.11 * | | |
| 7. Peer recognition important | 3.54 | 1.99 | 1 | 7 | 0.16 ** | 0.05 | 0.00 | 0.26 *** | 0.15 ** | 0.09 | |
| 8. Do it for fun | 0.67 | 0.47 | 0 | 1 | 0.08 | -0.12 * | -0.02 | 0.11 * | 0.06 | 0.09 † | 0.17 ** |

**Note:** Two-tailed test applied. † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

**Table 2:** Negative binomial regressions, explaining lead users' characteristics in the Propellerhead on-line community

| | Model 1 | | | Model 2 | | | Model 3 | | | Model 4 | | | Model 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Independent variables | Coef. | | Std. Error | Coef. | | Std. Error | Coef. | | Std. Error | Coef. | | Std. Error | Coef. | | Std. Error |
| Number of communities | 0.027 | ** | 0.010 | | | | 0.027 | ** | 0.010 | 0.015 | | 0.013 | 0.025 | * | 0.013 |
| Receive assistance ("knowledge take") | 0.039 | *** | 0.008 | | | | 0.035 | *** | 0.008 | 0.024 | * | 0.012 | 0.035 | ** | 0.012 |
| Enjoy giving assistance as an expert ("knowledge give") | 0.035 | *** | 0.009 | | | | 0.029 | *** | 0.010 | 0.060 | *** | 0.015 | | | |
| Number of answers as a proportion of total postings | | | | | | | | | | | | | 0.353 | * | 0.154 |
| Innovator | | | | 0.169 | ** | 0.059 | 0.113 | * | 0.055 | 0.106 | † | 0.066 | 0.152 | * | 0.067 |
| Focus on technological product improvements | | | | 0.249 | * | 0.123 | 0.203 | * | 0.114 | 0.264 | | 0.238 | 0.168 | | 0.244 |
| Professional programmer | | | | 0.047 | | 0.046 | 0.031 | | 0.043 | 0.181 | ** | 0.065 | 0.184 | ** | 0.067 |
| Hobbyist | | | | -0.036 | | 0.054 | -0.032 | | 0.050 | -0.161 | * | 0.073 | -0.141 | * | 0.074 |
| Student | | | | -0.084 | * | 0.050 | -0.068 | † | 0.047 | -0.028 | | 0.062 | -0.020 | | 0.064 |
| Peer recognition important | | | | 0.025 | ** | 0.009 | 0.013 | † | 0.008 | 0.004 | | 0.011 | 0.014 | | 0.011 |
| Do it for fun | | | | 0.022 | | 0.037 | 0.017 | | 0.035 | 0.023 | | 0.049 | 0.054 | | 0.049 |
| Constant | 2.219 | *** | 0.057 | 2.500 | *** | 0.041 | 2.201 | *** | 0.061 | 2.173 | *** | 0.086 | 2.312 | *** | 0.077 |
| No. of obs. | 364 | | | 364 | | | 364 | | | 155 | | | 155 | | |
| Chi-square | 55.74 | *** | | 24.97 | *** | | 68.31 | *** | | 55.08 | *** | | 45.42 | *** | |
| LR test of α = 0 | 10.78 | *** | | 22.06 | *** | | 7.41 | ** | | 0.05 | | | 0.13 | | |
| McFadden's pseudo R2 | 0.03 | | | 0.01 | | | 0.03 | | | 0.06 | | | 0.05 | | |
| ML (Cox-Snell) R2: | 0.15 | | | 0.07 | | | 0.18 | | | 0.31 | | | 0.27 | | |

***Note:*** One-tailed test applied. † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

**Table 3:** Ordinary least square regressions, explaining lead users' characteristics in the Propellerhead on-line community

| | Model 6 | | | | Model 7 | | | | Model 8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dependent variables | Lead user | | | | Lead user X User experience | | | | (Lead user X User experience) minus Lead user | | |
| Independent variables | Coef. | | Std. Error | Std. Coef | Coef. | | Std. Error | Std. Coef | Coef. | | Std. Error |
| Number of communities | 0.087 | ** | 0.03 | 0.14 | 0.135 | *** | 0.031 | 0.213 | 0.048 | † | 0.033 |
| Receive assistance ("knowledge take") | 0.086 | ** | 0.029 | 0.155 | 0.044 | * | 0.026 | 0.088 | -0.062 | * | 0.027 |
| Enjoy giving assistance as an expert ("knowledge give") | 0.106 | *** | 0.025 | 0.218 | 0.135 | *** | 0.030 | 0.238 | 0.049 | † | 0.031 |
| Innovator | 0.371 | * | 0.176 | 0.105 | 0.064 | | 0.182 | 0.018 | -0.307 | † | 0.192 |
| Focus on technological product improvements | 0.717 | * | 0.377 | 0.092 | 0.884 | * | 0.392 | 0.111 | 0.167 | | 0.411 |
| Professional programmer | 0.091 | | 0.132 | 0.034 | -0.159 | | 0.138 | -0.057 | -0.249 | † | 0.144 |
| Hobbyist | -0.101 | | 0.151 | -0.033 | -0.096 | | 0.157 | -0.031 | 0.004 | | 0.164 |
| Student | -0.200 | † | 0.139 | -0.072 | -0.085 | | 0.144 | -0.030 | 0.116 | | 0.151 |
| Peer recognition important | 0.040 | † | 0.026 | 0.081 | 0.010 | | 0.027 | 0.020 | -0.030 | | 0.028 |
| Do it for fun | 0.046 | | 0.104 | 0.022 | -0.202 | * | 0.108 | -0.094 | -0.248 | * | 0.113 |
| Constant | -1.199 | *** | 0.179 | | -1.034 | *** | 0.186 | | 0.165 | | 0.195 |
| No. of obs. | 364 | | | | 364 | | | | 364 | | |
| F | 7.80 | *** | | | 6.43 | *** | | | 2.31 | *** | |
| R2 | 0.18 | | | | 0.15 | | | | 0.06 | | |

***Note:*** One-tailed test applied. † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

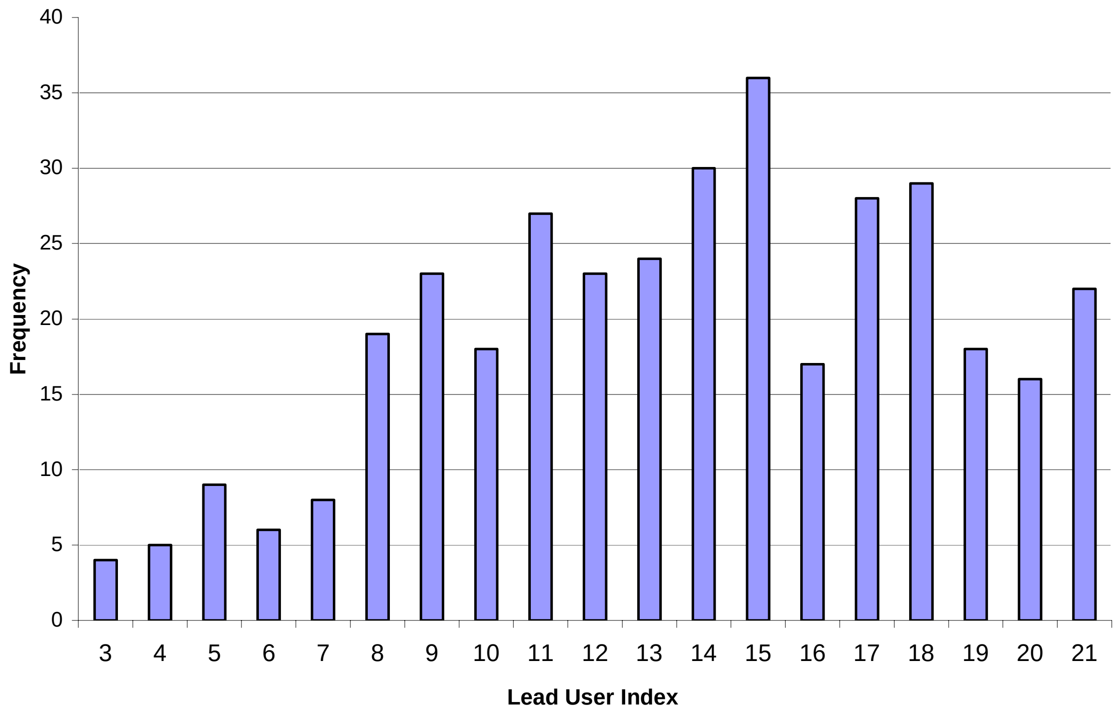


**Figure 1:** Frequencies of index of lead user characteristics