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How communities support innovative activities: an exploration of assistance and sharing among end-users

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Abstract

This study contributes to our understanding of the innovation process by bringing attention to and investigating the process by which innovators outside of firms obtain innovation-related resources and assistance. This study is the first to explicitly examine how user-innovators gather the information and assistance they need to develop their ideas and how they share and diffuse the resulting innovations. Specifically, this exploratory study analyzes the context within which individuals who belong to voluntary special-interest communities develop sports-related consumer product innovations. We find that these individuals often prototype novel sports-related products and that they receive assistance in developing their innovations from fellow community members. We find that innovation-related information and assistance, as well as the innovations themselves, are freely shared within these communities. The nature of these voluntary communities, and the "institutional" structure supporting innovation and free sharing of innovations is likely to be of interest to innovation researchers and managers both within and beyond this product arena.

Keywords: End-users; Innovation; Institutional structure; Communities

1. Introduction

Academics and practitioners alike express interest in uncovering, explaining, and potentially manipulating the sources of innovation. Research has shown that many important industrial product and process innovations are developed within firms where the product is used, rather than by firms who manufacturer the product for sale to others (von Hippel, 1988). Two recent studies focusing on innovation in sporting equipment document a parallel pattern in consumer products and bring attention to the fact that consumers also innovate. These two studies show that many major innovations in sports equipment are made by end-users rather than firms (Shah, 2000) and that a large fraction of consumers do innovate in some way (Lüthje, 2000).

Much research has focused on the provision of resources in product development organizations (Brown and Eisenhardt, 1995); inter- and intra-firm product development-related communications (Allen, 1971, 1984; Ancona and Caldwell, 1992); and even on the emergence of informal "skunk works" within the formal organization. The finding that users may also innovate in consumer product fields raises the question as to whether and how individual end-users who innovate receive resources and support from others. We reason that end-user-innovators, like their counterparts in firms, are likely to require the assistance

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of others in developing their innovations. The innovations in consumer products studied by Shah were made by end-users who had no formal organizational structure or resources from which to draw; however there is evidence that they often received assistance from and worked closely with others with whom they practiced the sport. For this reason, we suspect that members of communities of sports enthusiasts might be the source of the needed support. In this study we explore this possibility.[1] This study is the first to explicitly examine how user-innovators who belong to voluntary special-interest communities gather the information and assistance they need to develop their ideas.

This study investigates the innovation-related activities of members of four communities of sports enthusiasts who report having developed a novel sporting equipment innovation. A summary of major findings follows. Without exception, the innovating community members we surveyed do not innovate in isolation or secrecy; they receive important advice and assistance from other community members. Assistance is provided to innovators for free and innovators generally share their innovations to the community for free—although the levels of free support and access diminish somewhat as competitive pressures grew higher. Monetary profit is not a key motivator for either innovators or those who assisted them; instead, survey respondents cite having fun and viewing the giving of innovation-related assistance to community members as a social norm as the strongest factors influencing their decision to assist innovators. Receiving assistance appears to be a necessary, but not sufficient input into creating an innovation that diffused widely.

We propose that the phenomenon we report upon—innovation by end-users within voluntary user-communities—is a general and widespread phenomenon worthy of further study. The context in which the user-innovators in consumer product fields studied here innovate may serve as the functional equivalent of the multi-person innovation project teams often organized by firms to develop novel products and processes. This setting also appears to be quite similar to the context in which open source software (OSS) is developed. In the OSS context, individual programmers create and improve software within multi-person "project" groups; in doing so they receive free assistance from others and freely share the product of their efforts.

In the following sections of this paper, we review the related literature (Section 2) and describe our research sample and methods (Section 3). Next, we report our findings with respect to the number of innovators in our sample, how they interact with their community, and the characteristics of their innovations (Section 4). Next we report upon our findings regarding how innovators find assistance, the skills of those who provide assistance, satisfaction with assistance received, and how receiving assistance affects innovation diffusion (Section 5). We then discuss the factors that appear to be motivating and regulating behaviors related to the exchange of information and assistance and the free-revealing of innovation (Section 6). Finally, we discuss the implications of our findings (Section 7).

2. Literature review

2.1. The sources of innovation

Empirical research into the "functional" sources of innovation for industrial products and processes has shown that the actual developers of many industrial products and processes, which are often later produced and sold by manufacturers, are users. Manufacturer-innovators expect to benefit from their innovations by selling them to others; user-innovators expect to benefit by direct use (Enos, 1962; Knight, 1963; Freeman, 1968; Shaw, 1985; von Hippel, 1988). Studies continue to uncover the prevalence and importance of user-innovations in industrial products (von Hippel, 1988; Riggs and von Hippel, 1994; Morrison et al., 2000; and others) and methods by which to "harness" this innovative ability (von Hippel, 1986; Herstatt and von Hippel, 1992; Morrison et al., 2000;

[1] We chose to study the innovation-related behaviors of sports enthusiasts within communities rather than individuals innovators (who may or may not belong to a community) in order to better understand the composition and structure of the community with which each innovator was involved. We are unable to comment on the relative fraction of user-innovators who are members of voluntary communities versus who do not belong to such communities or on the process by which innovators outside of communities assemble resources. In fact, it is highly likely that innovators who are not members of such communities exist and innovate very effectively either completely on their own or with the assistance of other individuals. A similar study could be conducted by sampling individual sports enthusiasts to resolve these issues.

von Hippel et al., 1999). Recent research indicates that users also play an important role in the development of consumer product innovations (Lüthje, 2000; Shah, 2000).

2.2. Innovation within voluntary communities

The "communities-of-practice" literature (Lave and Wenger, 1991; Brown and Duguid, 1991) provides an interesting parallel to the volunteer communities we study. This literature argues that the ways people actually work usually differs fundamentally from the ways organizations describe that work in manuals, training programs, organizational charts, and job descriptions;[2] a great deal of learning and innovation occur in the informal communities-of-practice focused on simply getting work done (Brown and Duguid, 1991). "Communities-of-practice" exist in a variety of settings and may develop improvements or innovations in products, services, and work practices: some documented examples include photocopier repair technicians (Orr, 1996), clerical workers (Wenger, 1998), and radiology technicians (Barley, 1996). The communities-of-practice literature focuses on occupational and organizational communities, while we focus on (innovation in) voluntarily-assembled communities of end-users; both perspectives question commonly held beliefs about the nature of work, organization, learning, and innovation.

Open source communities are yet another example of a user-community in which information, assistance, and innovations are freely shared. OSS development projects are carried out by communities of volunteers from many different locations and organizations. These individuals develop and share code to create and improve programs. OSS development has resulted in the creation of software that may precede, displace, or serve as a substitute for commercially produced software. One benefit of participation in these communities that is often downplayed (Lerner and Tirole, 2000, footnote no. 21) is the fun, enjoyment, and intrinsic motivation that arise through engagement in the task and community (First Monday, 1998). The similarities between open source communities and sports communities are striking, despite the fact that one community produces physical products and is geographically concentrated, while the other produces software code and is geographically dispersed (von Hippel, 2001).

2.3. Reasons to freely share innovation-related information

One might expect users to guard any innovation-related information that they believe is valuable. However, Harhoff et al. (2000) argue that it may be more beneficial for an innovator to reveal such information and offer four theoretical reasons for why this might be the case: (1) it may induce improvements by others; (2) an advantageous standard might be achieved this way; (3) low rivalry conditions; and (4) expectations of reciprocity and reputation effects. Much empirical research lends support to this idea, showing that the sharing of such information occurs in a variety of commercial settings, leading us to expect similar, and perhaps stronger, patterns within user-communities. An overview of empirical findings is provided below.

Past research on information trading and sharing between rival firms offers limited insight into what types of information and assistance may be exchanged between user-innovators and why. Work on informal information trading argues and empirically demonstrates that, under certain conditions, it makes sense to exchange existing information, even among rivals (von Hippel, 1987; Schrader, 1991). These studies focus on reciprocal exchange relationships where the information exchanged has relatively low competitive value: the rival could obtain this information from other sources or could relatively easily uncover the information himself.

Other studies focus on the free-revealing of information or innovations, where the information or innovation is shared, but there is little or no expectation of receiving direct reciprocal benefits in exchange. Allen finds that many production techniques in the 19th century were developed by a process called "collective invention" (Allen, 1983). An essential feature of collective invention is the free-revealing of technical

[2] This is not a new observation: "the distinction between the "formal" and "informal" organization of the firm is one of the oldest in the literature, and it hardly needs repeating that observers who assume firms to be structured in fact by the official organization chart are sociological babes in the woods" (Granovetter, 1985, p. 502). The existence and importance of informal structures within organizations has been duly noted in many classic sociological studies (Blau, 1955; Dalton, 1959; Gouldner, 1954; Selznick, 1949).

information to actual and potential competitors. Allen argues that it is this behavior that allowed cumulative advance and suggests that firms might even desire such behavior. Rosenkopf and Tushman (1998) examine information and knowledge sharing in the context of inter-organizational networks formed by members of voluntary cooperative groups such as task forces, technical committees and standards groups in the flight simulation industry; they find that community networks and technology co-evolve. As we can see, the free-revealing of innovations and information between firms may occur in a variety of settings and contexts.

3. Study methods

3.1. Communities selected for study

We had two basic criteria for choosing communities[3] for our sample. First, in order to observe community-related innovation behavior, the community as a whole or some community members should be engaged in innovative activities. Second, we wanted to include communities that differed in their make-up (constituency) and structure in order to cover a broad range of community and user characteristics to make for more generalizeable findings. We screened for these criteria by speaking with community leaders and members.

Below you will find a short description of each of the four communities we studied. We are aware of no bias in our innovation pattern findings resulting from the selection of these particular communities.

3.1.1. Sailplaning community

Sailplaning, which originated in the second half of the 19th century, involves one or two people flying in a (closed) sailplane. The sailplaning community we studied consists of students of technical universities in Germany who share an interest in sailplaning and building their own sailplanes. They spend a great deal of time together and share a common "student" lifestyle.

3.1.2. Canyoning community

Canyoning is a new extreme sport, which is quite popular in the Alps. It combines mountain climbing, abseiling (rappelling), and swimming in canyons. It is extreme in that it requires significant skill and involves physical risk. Participants do not formally race against each other.

The community we analyzed was established in 1995 with the explicit objective of providing a forum in which to organize joint activities and trips, exchange information, and provide mutual help for people who shared an interest in the new sport. Members organize trips, take part in regular "pub social", make presentations to each other, and maintain a website. A normal trip is likely to involve 25–30 people; each trip generally includes a different combination of community members.

3.1.3. Boardercross community

"Boardercross" is a new extreme snowboarding sport in which six snowboarders compete simultaneously in a downhill race. Each racetrack varies, but is likely to incorporate tunnels, steep curves, water holes, jumps, etc. The (informal) community we studied consists of semi-professional athletes from all over the world who share an active interest in this sport. They meet in up to 10 competitions a year in Europe, USA/Canada, and Japan. Community members are competitive athletes and compete against one another. They spend a great deal of time together both training and taking part in leisure activities (parties). Community members are very close to one another and share very similar lifestyles.

3.1.4. Handicapped cycling community

Individuals with physical disabilities practice many sports; these individuals must often design or make improvements to their equipment to accommodate a variety of physical disabilities. We studied a community of semi-professional cyclists who had cerebral palsy or had had a limb amputated. This community is not a formal club, but community members know each other well from national and international competitions, training sessions, and seminars sponsored by the Deutscher Sportbund (German National Sports

[3] Our definition of community stems from that found in the communities of practice literature: communities of practice are seen as "groups of interdependent participants providing a work context within which members construct both shared identities and the social context that helps those identities be shared" (Brown and Duguid, 2000, p. 9). Such a definition can apply to both formal work communities, as well as communities organized around other goals.

Council) for selected athletes. The community is largely comprised of competitive handicapped cyclists who often compete against one another. Although the community members are distributed all over Germany they know each other well and members feel that they are a close community.

3.2. Data collection

After selecting the four communities described above, we conducted several qualitative interviews in order develop a deeper understanding of the role of communities in the innovation process.

We contacted community leaders and questioned them about the best way to contact individual members. As a result, paper questionnaires were mailed to members of the sailplaning, canyoning, and handicapped cyclist communities, while members of the boardercross community were sent an e-mail describing the nature of the study and containing a link to an on-line version of the questionnaire.

The questionnaires distributed to the different groups contained the same questions and information regarding the study. The questionnaire had four parts. In the first and final parts, all respondents were asked about their personal characteristics as well as their community behavior and attitude. The second part was for innovators only; we asked that the innovator focus on the most important innovation he or she[4] made. The third part of the study was for individuals who had assisted in the development of an innovation only.[5] The questionnaire was anonymous and respondents were assured that their innovative ideas would not be shared with manufacturers. All questionnaires were distributed in December 2000 and after 2 weeks all respondents were reminded to complete the survey via personal contact, telephone, e-mail, or mail. An overall response rate of 37.8% was obtained.

Despite the satisfactory response rate, there is a possibility of self-selection, e.g. in favor of individuals involved in the innovation process, because potentially proud innovators may be more likely to respond. Such self-selection would result in a disproportionately high rate of innovators (and innovations) in the sample. While we have no information about non-respondents, several things indicate that the data does not suffer from such bias. First, it has been argued that late respondents who answer only after receiving several reminders are similar to non-respondents (Hendricks, 1949). An analysis of early versus late respondents did not show any significant difference between these two groups. Second, in order to prevent non-innovators from feeling that the survey was not relevant to them and thus not responding, the first section of the questionnaire purposefully did not deal with innovation at all and focused on the individual and his relationship with the community. Third, the literature on user-innovation suggests that innovators are likely to have "lead user" characteristics that differentiate them from non-innovators. Thus, the possession of lead user characteristics by a large fraction of respondents might indicate bias within the sample.[6] Instead we find (third table) that there is no bias towards lead users in the sample: on average, innovators exhibit these characteristics more strongly than non-innovators (as would be expected), and the average values exhibited by non-innovators on these characteristics are above the middle of the scale (indicating less agreement with the characteristics) without exception. Fourth, while 39% of the respondents reported innovating and/or assisting in the innovation process (seventh table), a full 61% of respondents did not engage in these activities. Thus the sample consists of both individuals involved in the innovation process and individuals who were not involved. Finally, we would like to point out that even if all non-respondents had no involvement in the innovation process, our findings regarding the *process* of community-based innovation and the motivations of individuals involved in this process—the central focus of this paper—are unlikely to be affected.[7]

[4] In the remainder of the paper we will use the term "he" and "his" for simplicity, although both male and female innovators and non-innovators were present in the sample.

[5] For survey details, see Appendix A.

[6] We thank an anonymous referee for suggesting this "test".

[7] We do not believe that the relative novelty and culture of these sports are responsible for the innovation rate we observe (Section 4.1); a similar innovation rate is reported in a study of innovation among individuals involved in a very mainstream athletic activity, hiking and trekking (Lüthje, 2000). It is possible that the relative novelty and culture of these sports may increase the likelihood that an individual chooses to participate in a community, however, note that community participation is not at all unique to novel sports: for example, runners often join running clubs and tennis enthusiasts often join tennis clubs. Overall, we are not aware of any bias resulting from either the choice of these four sports communities or from self-selection that influence our findings.

Table 1
Communities

	Sailplaning	Canyoning	Boardercross (snowboard)	Handicapped cyclists	Total
Community characteristics					
Professional level	Moderate	Moderate	High	High	Varies
Location	All over Germany	Southern part of Germany	Worldwide	All over Germany	Varies
Formal ties (e.g. club)	Yes	Yes	No	No	Varies
Level of competition	Low	Low	High	High	Varies
Interaction level	Close	Close	Close	Varies	Quite close
Relative technical complexity of equipment	Very high	Low	Moderate	Moderate	Varies
Outside users who might provide information and assistance	Example, one of the other 552 sailplane clubs in Germany	Approximately 1000 at same level in same region	Approximately 800 at same level in same region	Unknown	Many
Average age of respondents (years)	25.1	39.3	22.8	33.5	Varies
Percentage of respondents who are female	10.5	25.6	48.8	10.5	Varies (23.1 total)
Sample characteristics					
Community size (N)	170	123	170	58	521
Response (n)	87	43	48	19	197
Response rate (n/N) (%)	51.1	35.0	29.4	32.8	37.8
Innovators as percentage of respondents	41.4	30.2	18.2	26.3	32.1

4. Findings: the innovators and their innovations

We find that almost a third of the community members in our sample (32.1%) report to have innovated (Table 1); innovation is a relatively common activity within the communities we analyzed. As one would expect many of these innovations were improvements to existing products, but a surprisingly high percentage of innovators created totally new products (Table 2). In this section, we report on these findings, as well as on findings that show that innovators and non-innovators differ significantly in their community-oriented behaviors (Table 3).

4.1. The innovations

Over 40% of the innovations reported in our sample solve urgent problems for their innovators and one in seven (14.5%) innovations is considered to be a completely new product by their innovator. Many of the innovators see potential for the sale of their innovation on the mass market and, moreover, almost one-quarter of the innovations are currently or will soon be produced for sale by a manufacturer, and can thus be thought of as having some mainstream or niche market appeal. We asked innovators to provide a short description of their innovations and assess them along several dimensions; the results are shown in Table 2.

Since we asked each innovator to tell us about his most important innovation: (1) the proportion of commercialized or soon to be commercialized innovations, given the complete set of innovations produced by members of these communities, might be overestimated; (2) while the total number of commercialized user-innovations might actually be underestimated, since it is possible that some user(s) developed more than one innovation that was subsequently commercialized.

Table 2
Characteristics and examples of user-innovations

Characteristic	Descriptive statistics			Example
	Mean	Median	High agreement (%)	
Newness[a]	3.56	3.5	14.5	Completely new product, e.g. new emergency system where pilot gets out of the cockpit with a rocket (sailplane) Small improvement, e.g. better rucksack (canyoning)
Urgency[b]	4.79	5	41.9	High urgency, e.g. new brake system for arm-amputated (handicapped cyclists) Low urgency, e.g. new ventilation system for cockpit (sailplane)
Market potential[c]	3.44	4	24.2	High market potential, e.g. improved boots and binding (snowboard) Small market potential, e.g. disrupt fixed rope with chemical (etching) (canyoning)
Commercialization	23.1% of the innovations are currently or will soon be produced for sale by a manufacturer			Example, new shoe which is seamless, high-frequency welded and offers better protection of the leap joint

[a] Self-rating, seven-point rating scale: 1 small improvement of existing product; 7 completely new product); $n = 60$.
[b] Self-rating, seven-point rating scale: 1 solves minor problems; 7 solves acute problems); $n = 60$.
[c] Self-rating, seven-point rating scale: 1 very small; 7 very big); $n = 60$.

Table 3
Innovators vs. non-innovators

Characteristic	Innovator[a]	Non-innovator[b]	Difference (P-value)[c]
Lead user characteristics (1): being ahead of the trend[d]			
I usually find out about new products and solutions earlier than others	2.71	4.03	<0.001
I have benefited significantly by the early adoption and use of new products	3.58	4.34	<0.01
I have tested prototype versions of new products for manufacturers	4.94	5.65	<0.05
In my sport I am regarded as being on the "cutting edge"	4.56	5.38	<0.01
I improved and developed new techniques in boardercrossing	4.29	5.84	<0.001
Lead user characteristics (2): high benefit from innovation[d]			
I have new needs which are not satisfied by existing products	3.27	4.38	<0.001
I am dissatisfied with the existing equipment	3.90	5.13	<0.001
Time in community			
Years as a community member	4.46	3.17	<0.01
Days per year spent with community members	43.07	32.73	<0.05
Days per year spent participating in the sport	72.48	68.71	n.s.
Role in community[d]			
I am a very active member of the community	2.85	3.82	<0.01
I get together with members of the community for activities that are not related to the sport (movies, dinner parties, etc.)	3.39	4.14	<0.05
The community takes my opinion into account when making decisions	2.89	3.61	<0.05

[a] All values are means; $n = 60$.
[b] All values are means; $n = 129$.
[c] Two-tailed t-tests for independent samples.
[d] Seven-point rating scale: 1 very accurate; 7 not accurate at all.

4.2. The innovators

Innovators appear to be different from non-innovators at both the individual and community level. At the individual level, innovators in our sample possess "lead user" characteristics that differentiate them from non-innovators (Table 3). Lead users are a relatively small fraction of users who are highly likely to innovate, are ahead of product or service trends, and would benefit greatly from the advent of new products or services (von Hippel, 1986).

The way in which an innovator interacts with his community and how he thinks the community perceives him also differentiates the innovator from the non-innovator (Table 3). Innovators spend significantly more time with other community members than do non-innovators; specifically they spend 32% (10 days per year) more time per year in the community. In addition, innovators have been members of the community 30% (1.3 years) longer than non-innovators. It appears that time with the community is associated with the likelihood of innovating. This interpretation is supported by the findings that innovators report taking a more active part in the community, partake in more non-sport related activities with other community members, and feel more strongly that the community takes their opinion into account when making decisions than do non-innovators.[8]

These findings alone do not necessarily mean that community has a causal impact on the likelihood of innovation; it could be the case that innovators work in total isolation and developed a reputation for their efforts among their peers, which led to a more central position in the community. Section 5 addresses this concern.

5. Findings: the sources and importance of assistance

An individual may develop an idea, but developing this idea into a functioning prototype often requires the assistance of others. We find that, within user-communities, user-innovation is not an individual task but a joint effort; all the innovators in our sample receive assistance from other individuals during the innovation process. Receiving assistance from three to five people is most common (Table 4). In Sections 5.1 and 5.2 we show that belonging to a community gives the innovator clear and tangible benefits in obtaining quality innovation-related assistance and that this assistance often comes from other innovative individuals. In Section 5.3 we show that innovators report high levels of satisfaction with the assistance they received. In Section 5.4 we discuss the impact of assistance of the diffusion of the innovation.

Table 4
Innovators receive assistance

Innovators receive assistance from people	Number of case	Percentage
0	0	0
1	3	6
2	14	26
3–5	25	47
6–10	8	15
Over 10	3	6
Total	53	100

5.1. Community membership helps innovators find assistance

Belonging to a community offers the innovator two key benefits in finding innovation-related assistance: (1) other community members offer assistance directly; and (2) other community members refer the innovator to individuals they know outside of the community.

Specifically, 63.5% of innovators report that belonging to the community helped them find individuals who made contributions to their innovation (Table 5). The most important assistance received was as likely to come from individuals outside the community as it was to come from community members.

We find that 11.4% of the innovators report that the most important information and assistance they received came from individuals who were initially strangers; 32.4% report that this came from individuals who were initially close friends (Table 5). This indicates that community members introduce the

[8] The *t*-tests clearly show that the innovators have significantly higher needs for new products and are far ahead of the trend. They are lead users (von Hippel, 1986).

Table 5
Relationships with those who give assistance

Variable	Mean	Median	High agreement (%)	Low agreement (%)
Community membership helps in finding assistance (belonging to the community helped me find people who contributed to my idea/improvement; seven-point rating scale: 1 very accurate; 7 not accurate at all); $n = 52$	2.88	2	63.5	19.2
Community members as a source of information (seven-point rating scale: 1 most of the important information came from community members; 7 non-community members); $n = 44$	3.70	3	47.7	29.5
Friendship status (seven-point rating scale: 1 most of the important information came from initially close friends; 7 initially strangers); $n = 53$	3.30	3	32.4	11.4

innovator to other individuals who may be able to provide assistance—community actively helps the innovator find the assistance he needs and innovators are therefore not "restricted" to working with individuals with whom they have a personal relationship (friendship), have worked with before, or have assisted before.

5.2. Skills of those who gave assistance

Most innovators report receiving assistance from individuals who are creative and innovative, possess skills complementary to their own, and often have expertise that was useful in developing the innovation (Table 6).

If those who give assistance are in fact as creative and innovative as innovators report, we should observe innovating behavior among those who assist. We do indeed find statistically significant evidence to support this: of the 41 individuals who gave assistance, over two-thirds were also innovators (Table 7). And, of the 60 innovators, almost half gave assistance to others.

The high satisfaction expressed by innovators who received help, the highly regarded skills of those who gave assistance, and the relatively high number of individuals taking part in assisting and/or innovating

Table 7
Relationship between innovating and giving innovation-related assistance[a]

	Innovator	Non-innovator	Total
Gave assistance	28	13	41
Did not give assistance	32	115	147
Total	60	128	

[a] $n = 188$; $\chi^2 = 31.93$; $P < 0.0001$.

Table 6
Skills of those who give assistance

Variable	Mean	Median	High agreement (%)	Low agreement (%)
Creative and innovative: the people who helped me are creative and innovative themselves (seven-point rating scale: 1 very accurate; 7 not accurate at all); $n = 53$	2.11	2	71.7	1.9
Complimentary skills: the people who helped me have skills that are complementary to mine (seven-point rating scale: 1 very accurate; 7 not accurate at all); $n = 53$	2.15	2	71.7	0.0
Expert status (seven-point rating scale: 1 most of the important information came from experts; 7 non-experts); $n = 53$	3.09	3	41.5	7.6

Table 8
Innovators are satisfied with the assistance they received

Satisfaction with assistance received	Mean	Median	High agreement (%)	Low agreement (%)
If I had a similar problem I would ask the same people again (seven-point rating scale: 1 very accurate; 7 not accurate at all); $n = 53$	1.89	2	79.2	3.8

activities (38.8%) shows that the system of mutual help in the communities works well.

5.3. Innovators are satisfied with the assistance they receive

Innovators report being very satisfied with the assistance they receive: 79.2% of innovators report that they would ask the same people for help again (Table 8). This is a preliminary indicator that assistance is not only frequently observed, but is also very important.

5.4. Findings: receiving assistance impacts innovation diffusion

Diffusion is an important element of innovation performance. It reflects the number of users interested in the innovation and the time it needs to win recognition among the users. The features of an innovation largely impact the extent and speed of its diffusion (Rogers, 1983). From a manufacturer's perspective, the extent of diffusion, combined with the amount of money each user is willing to pay and the costs of producing and selling it, constitute the profit a firm can expect from manufacturing the innovation.[9] In addition, it could be the case that innovators report such a high degree of satisfaction with assistance received (see Section 5.3) because of social reasons rather than the quality of the assistance itself. In this section we address this objection by showing that the amount of assistance received positively affects innovation diffusion both inside and outside the community.

5.4.1. Method: measuring innovation diffusion

The extent to which an innovation has diffused is based on information self-reported by the innovator; we asked each innovator to report how many individuals within the community and how many individuals outside the community were using their innovation (seven-point rating scales). Correlation analysis shows that an innovation used by many members of an innovator's community is likely to be used by many individuals outside of that community as well ($r = 0.579$, $P < 0.001$, $n = 49$). Thus, diffusion inside the community might be considered an early indicator of later diffusion outside the community. This high correlation allows us to aggregate these two scales and construct a "total diffusion" index without suppressing major effects. This new variable (total diffusion) is our dependent measure of innovation diffusion.

5.4.2. Threshold or linear relationship?

Our findings suggest that receiving assistance from the community is a necessary but not sufficient precondition for innovation diffusion: a threshold pattern, rather than a linear pattern, describes the relationship between the level of assistance by the community and the diffusion of the innovation. In order to analyze the relationship between assistance and diffusion, crosstab analyses for different measures of assistance and diffusion are performed.

An example of a crosstab analysis is displayed in Table 9. When reading the table, note that a clustering of cases along the diagonal would indicate a linear relationship; a clustering above the diagonal a necessary, but not sufficient threshold relationship; and cases below the diagonal tell that the innovation diffused although the innovator received little assistance. The crosstab results for the level of encouragement

[9] Diffusion is related to other measures of innovation performance. There are three other variables which can be regarded as partial measures of innovation performance, which we expect and find to be correlated with total diffusion: the newness of the innovation as assessed by the innovator ($r = 0.298$, $P < 0.05$), the market potential of the innovation as assessed by the innovator ($r = 0.259$, $P < 0.05$), and whether or not the innovation has yet been commercialized ($r = 0.368$, $P < 0.01$).

Table 9
Crosstab: encouragement received vs. innovation performance (example)[a]

Variable	Diffusion of innovation (total diffusion)											
	High				Medium				Low			
High level of encouragement received	**1**		**1**		**1**	**2**	**2**	**3**				
	2	**1**				**2**	**6**	**4**				
					1	**3**	**2**	**3**				
Some support	1				**1**	**1**	**2**	**3**				
							2	**1**				
								1				
No encouragement received					1		1	**1**				

[a] Summary of crosstab: position below diagonal, 5 innovations; above diagonal, 40 innovations; exactly on diagonal, 4 innovations. Linear regression analysis: coefficients: encouragement: $B = 0.219$ (0.155), not significant; constant: $B = 4.665$ (0.515), $P < 0.001$, $R^2 = 0.041$, adjusted $R^2 = 0.020$, $F = 1.988$, not significant, $n = 51$.

received versus diffusion (Table 9) indicate that there is virtually no linear relationship between these two variables.[10] An OLS regression supports this point.

A clear relationship does exist in the data (Table 9) in the form of a striking threshold pattern.[11] The amount of assistance appears to form an upper bound for diffusion: the relationship is "assistance is necessary, but not sufficient for innovation diffusion" not "the more assistance, the better the innovation diffuses". This makes sense because assistance will improve the quality of an innovation to a limited degree, but even an unlimited amount of assistance will not turn a poor idea into a breakthrough innovation or turn an idea with limited consumer interest into a blockbuster. We perform this analysis for other forms of assistance as well and find similar patterns (Table 10). Results show clearly that assistance by the community does not "guarantee" diffusion, but less assistance might be associated with more limited diffusion.

We find the threshold pattern to be prevalent in all the variables we tested. Thus we can say that (1) more assistance coming from community members relative to outsiders; (2) the use of the community as a network; (3) the number of assistants in the project; and (4) the frequency of all specific assistance activities that were provided, all have an "enabling" impact on total diffusion. More problems or potential improvements might be identified and solved when more people are involved,[12] but if the innovative idea itself is unfeasible or too difficult to realize the assistance will not have an effect on diffusion. Feedback from community members is more relevant than feedback from outsiders (as they might, for example, have a common favorite terrain or conditions in which they do their sport); this finding is similar to the idea that the most relevant information an engineer can seek out is often found within his firm (Allen, 1984).

For two of the eight variables tested we also found a linear relationship with diffusion: the greater the number of assistants and the more testing conducted and feedback received, the more widely the innovation diffuses. This means that these two variables have a direct impact, as well as an enabling effect on innovation diffusion.

Two primary interpretations *addressing* how community assistance impacts innovation diffusion are possible. The first is that assistance by the community helps to improve the functionality and quality of the innovation and this leads to higher diffusion (assistance → quality → diffusion). The second interpretation is that the more individuals who assist in the development of the innovation, the more

[10] There are almost no innovations along the diagonal of the crosstab and other forms of linearity are not visible.

[11] Almost all data points (40 out of 49) are located above the diagonal (gray field); hardly any are on (4 out of 49) or below the diagonal (5 out of 49). Within the gray field, the data points are dispersed and do not show a clear pattern.

[12] "Given enough eyeballs all bugs are shallow" (Raymond, 1999) illustrates this idea in the case of open source software development.

Table 10
Crosstab summaries: assistance received vs. innovation diffusion

Variable	Crosstab analysis			Regression analysis	
	Above diagonal interpretation: assistance necessary but not sufficient for diffusion	Below diagonal interpretation: diffusion is independent from assistance	On diagonal interpretation: the more assistance, the better diffusion	Interpretation: same as on diagonal crosstab analysis	
More general activities					
Most assistance came from community relative to outsiders	23	6	13	−0.180 (0.160)	n.s.
Community helped by serving as a network to others	30	6	12	−0.005 (0.165)	n.s.
Number of individuals giving assistance	27	7	14	−1.048 (0.316)	$P < 0.01$
More specific activities					
Frequency of testing and getting feedback	26	8	15	0.208 (0.115)	$P < 0.05$
Frequency of getting assistance in technical details	39	3	7	0.139 (0.171)	n.s.
Frequency of talking about the problem	44	2	2	−0.229 (0.291)	n.s.
Frequency of getting advice and suggestions for improvement	41	5	2	−0.216 (0.218)	n.s.
Frequency of confirmation and encouragement	40	5	4	−0.129 (0.157)	n.s.
Total (%)	270 (70.9)	42 (11.0)	69 (18.1)	Coefficients are B-values, standard error in parenthesis; constant: $B = 10.330$ (1.860), $P < 0.001$, $R^2 = 0.436$, adjusted $R^2 = 0.295$, $F = 3.094$, $P < 0.05$, $n = 40$	

individuals there are who might tell others about the innovation (assistance → diffusion), thus having a positive impact on diffusion without improving quality. Due to the cross-sectional nature of the data we cannot provide direct statistical evidence indicating which path model is correct. However, there are strong indicators that the first interpretation is the main effect. First, nearly 80% of the innovators were very satisfied with the assistance they received (Section 5.3) and it would seem very plausible that satisfaction is so high, because the assistance was actually helpful in improving the innovation. In addition, it would appear unlikely that an individual who assists would promote an innovation to others that they consider to be of little use or low quality, especially since no pecuniary rewards are at stake. Further research on this issue, however, is needed.[13]

These findings strongly confirm our interpretation that community supports user-innovation. Not only do innovators have a stronger relationship to the community than do non-innovators and receive assistance in every case in our sample; but the relative amount of community interaction impacts the diffusion of the innovation, with assistance being a necessary, but not sufficient condition for innovation diffusion.

6. Findings: "community-based innovation systems"

Community members assist innovators in developing their innovations for free. In this section we report on the reasons given for this behavior. We also show that innovations are shared freely within the community, but that competition lessens both the likelihood of assistance and innovations being freely revealed.

[13] Note that a third interpretation that cannot be fully dismissed also exists: quality → assistance → diffusion. In such a case, an individual might actively offer his assistance if he thinks the innovative idea is very promising and of use to himself or an individual might refuse to help if he thinks the idea is hopelessly stupid or cannot be carried out at all. But it seems unlikely that such a quality screen for providing assistance exists, because data indicates that many individuals provide assistance even though they have no personal interest in using the innovation.

6.1. Assistance is freely given

Community members who provided innovators with innovation-related assistance were rarely paid for their assistance and believe that community members should assist each other free of charge. In Table 11 we report some descriptive statistics regarding the reasons for giving assistance and present the results of a factor analysis conducted to better understand the underlying structure of the data.[14]

6.1.1. Community-based motives versus personal benefit motives

The variables separate into two factors. We call the first factor the "community" factor, because it includes the motivations and benefits that support the free sharing of assistance and information between community members. The assigned items contain the norm that assistance should be given freely ("one should assist others", "in the community there is the norm to assist each other free of charge") as well as the belief—related to both fairness and norms—that "if I assist others today, I will receive assistance in the future". In addition to this, the person who assists enjoys the process of creating something jointly ("it is fun to create something jointly", "I enjoy giving advice").

We call the second factor the "personal benefit factor", because it contains motives that emphasize receiving individually-focused benefits in direct exchange for giving assistance. These motives include receiving material rewards ("I was paid", "I wanted to use the product") as well as the psychological reward of being flattered, which may also

[14] We identified possible motivations for assisting by conducting exploratory qualitative interviews at the beginning of the study; we chose the eight most promising to be included in the questionnaire (Table 8). In order to better understand the structure of the relationships between these possible motivations we performed a principal component analysis. To determine the number of factors we followed the method of Horn (1965) who proposed to extract all factors that have an eigenvalue that is higher than the highest eigenvalue of a factor analysis of random numbers. The frequently used Kaiser criterion suggests that all factors with an eigenvalue >1 be extracted. This is likely to overestimate the "true" number of factors (Lee and Comrey, 1979; Zwick and Velicer, 1986). To rule out the probability of meaningless factors we compared the eigenvalues of our factors with the eigenvalues drawn from a sample with random numbers (8 variables, 1000 cases). The results clearly advised us to extract two factors.

Table 11
Reasons for giving assistance within the community

Rank	Variable[a]	Descriptive statistics			Principal component analysis[b]	
		Mean	Mean	High agreement (%)	Factor 1: community factor	Factor 2: personal benefit factor
1	It is my opinion that in a community, one should assist others	1.48	1	92.6	**0.798**	−0.157
2	It is fun to create something jointly	1.79	1	78.6	**0.582**	0.225
3	In my community there is the norm that members should assist each other free of charge	2.11	2	74.1	**0.785**	−0.323
4	If I assist others today, I will receive assistance in the future	3.11	3	35.7	**0.600**	0.123
5	I enjoy giving others advice as an expert	3.28	3	32.0	**0.438**	−0.219
6	I wanted to use the product myself	3.41	3	40.7	0.082	**−0.696**
7	It was nice to receive recognition	4.61	4	10.7	0.512	**0.537**
8	I was paid well for my assistance	6.39	7	7.1	−0.097	**0.833**

[a] Seven-point rating scale: 1 very accurate; 7 not accurate at all); $n = 28$ (individuals who provided assistance to others within the community).

[b] Factor analysis: KMO = 0.517, Bartlett's test of sphericity = 0.000, Kaiser-normalization, 51.6% variance explained, varimax rotation.

lead to reputation effects ("it was nice to receive recognition"). All these items reflect direct reciprocal rewards an individual receives in exchange for his assistance.

The accuracy ratings (means) of the individual variables shows that respondents believe the community-factor variables to more accurately reflect their motivations for assisting than do the "personal benefit" variables.[15] Respondents view the variables related to the giving of free assistance (mean of 1.48 and 2.11) and enjoying the innovation process (mean 1.79) as accurate reflections of their motivations for assisting. In contrast, the variables constituting factor 2 are viewed as much less accurate and, in particular, receiving financial compensation is clearly rejected as a motive (mean 6.39). This lends support to the idea that there is more than an assessment of direct personal benefit motivating assistance-giving behavior in these communities.

6.1.2. The impact of competition on assistance

The likelihood of giving away innovation-related information may be affected by the level of rivalry within the community. If an innovator believes that revealing innovation-related information will allow a rival to outperform him, the likelihood that the innovator will reveal this information will decrease unconditionally. This hypothesis is clearly confirmed in the communities studied here: assistance is given less often in more competitive settings.

We compare the likelihood of assisting between the two less competitive communities (canyoning and sailplaning) and the two more competitive communities (boardercrossing and handicapped cycling) in our sample (Table 12). In the two less competitive communities, 21.7% of community members have assisted other community members on innovation projects; in the more competitive communities, only 6.7% assisted ($P < 0.01$).[16] This makes sense as one would not want

[15] The fact that the four most important variables and the three least important ones are grouped together is rather surprising and by no means a common pattern of the method. Principal component analysis is based on correlations, not on mean differences. Thus, variables with similar patterns are grouped and not variables with similar means.

[16] Even if we take into account that among the low competition communities more user innovations could be observed (34.7%) than in the high competition communities (19.7%) and thus the users have more opportunities to assist in a user innovation project, the difference is still striking. It can also be argued that the lower level of assistance and free sharing of important information in competitive surroundings causes these differences in innovative activities, because of less exchange there are less innovations.

Table 12
Impact of rivalry level on assisting behavior

Community	Percentage of users who assisted other community members in innovation project
Less competitive (sailplaning and canyoning); $n = 129$	21.7
More competitive (boardercrossing and handicapped cycling); $n = 62$	6.7
Difference (P-value)	<0.01 (χ^2-test)

Table 13
Sharing of innovation

Variable[a]	Mean	Median	High agreement (%)
The innovation is being used by many members of community	4.73	5	17.6
Share(d) innovation free of charge within the community	2.63[b]	1	66.7
Have sold the innovation to many inside the community	6.76[b]	7	0.0

[a] Seven-point rating scale: 1 very accurate; 7 not accurate at all); $n = 40$.
[b] Difference in means between sharing the innovation free of charge and selling the innovation is significant at $P < 0.001$ (t-test for dependent samples).

to help a direct competitor improve his performance. In spite of this, we still observe some free assistance being given in the high rivalry communities.

6.2. The innovation is freely shared in the community

We find that fully developed innovations, like assistance, are freely shared within the community and that the likelihood of free-sharing decreases as the level of competition within the community increases.

6.2.1. The innovation is shared—not sold—within the community

We observe that once the innovation (or part of it) is developed most innovators share it with the entire community free of charge (Table 13), not just with the people who assisted. Innovations are rarely sold within the community. In these communities both assistance and access to completed innovations are freely shared; the communities do not appear to operate like traditional reciprocal exchange markets.

6.2.2. The impact of competition on the free-sharing of the innovation

We find that innovations are freely revealed within the community, but the likelihood of free-revealing decreases just like giving assistance with increased levels of competition within the community. There is significantly higher agreement with the statement "I shared my innovation free of charge" in the less competitive communities (Table 14).

Despite lower levels of free assistance and the free-revealing of innovations, the community innovation

Table 14
Impact of rivalry level on sharing behavior

Community	Share(d) innovation free of charge within the community[a]	Have sold the innovation to many inside the community[a]	Difference (P-value)
Less competitive (sailplaning and canyoning)	2.05	7.00	<0.05[b]
More competitive (boardercrossing and handicapped cycling)	4.73	6.55	<0.05[b]
Difference (P-value)	<0.001[c]	n.s.[c]	

[a] Seven-point rating scale: 1 very accurate; 7 not accurate at all.
[b] The t-test for paired samples
[c] The t-test for independent samples.

system operates even in communities characterized by high rivalry conditions. In the highly competitive communities innovations assistance is given and innovations are freely revealed—just not as often as in the less competitive communities.

7. Discussion

7.1. Community-based innovation systems: the foundation for end-user-innovation

Studies of the innovation process often focus on firms and groups within firms. In this paper we describe an alternative form of organization that also produces valuable products: a "community-based innovation system". The community-based system provides the user-innovator with information, assistance, and links to other individuals; simply put, it provides the innovator with access to resources. In contrast, innovators in firms access such resources through the firm at large, through product development teams and other structures within firms, or through sources external to the firm. Behavioral patterns reflecting the free-revealing of assistance, information, and innovations are central to innovation in the communities we study.

We argue that this community-based innovation system works on the basis of generalized exchange. In order to understand how and why such a mechanism operates, we need to better understand the reasons why community members freely provide innovation-related information and assistance and why the resulting innovations are freely revealed. Earlier in this paper (Section 2.3), four theoretical reasons for why it might make sense to freely reveal innovation-related information (Harhoff et al., 2000) were suggested. In the remainder of this section, we discuss those reasons in light of our empirical findings[17] and also suggest a fifth reason that appears to be overlooked in the existing literature.

1. To induce improvements by others

   Freely revealing innovations is likely to induce improvements by others, because receiving assistance appears to be important in improving innovations (Sections 5.3 and 5.4), thereby benefiting the innovator and the community by further advancing the sport. Innovators may be partially motivated by this intent, however, those who provide assistance do not appear to be overly motivated by an interest in using or improving the resulting innovation themselves (Table 11). While it is possible that those who assist or those who simply use the innovation do make improvements that ultimately advance the sport, this appears to be a consequence of their behavior, rather than a motivating reason for their behavior.
2. Setting an advantageous standard

   It is unlikely that the innovators in this sample are interested in setting a standard since they do not intend to commercialize their innovations themselves. It may be the case that some innovators are interested in using their innovations during competitive events and thus would like the innovation to be approved for use in competitions, however, this motivation is most likely a rarity in the amateur communities we study.
3. It makes sense to freely-reveal only in low-rivalry conditions

   We find that the level of rivalry moderates the level of revealing, but that free-revealing can be observed in both high and low rivalry conditions.
4. Reputation effects and expectations of reciprocity may induce and promote free-revealing

   In this study, reputation effects do not appear to be an important factor in an individual's decision to freely-reveal information when offering innovation-related assistance (Table 11). The expectation of reciprocity, on the other hand, appears to be a strong reason for why individuals freely-reveal innovation-related information.

The form of reciprocity observed in these communities is of a different type than that of the two-party, "quid pro quo" form that is common in many markets. In these communities, individuals often assist innovators who they may or may not know and often assist even when not motivated by the possibility of directly using the innovation themselves or receiving anything in return. In fact, the strongest motivations for assisting—enjoyment gained from working with others, the presence of community norms supporting providing assistance for free, and the idea that

[17] While we cannot reject or verify these hypotheses in a statistical sense, our findings can contribute to our understanding of these potential mechanisms.

helping others in the community is what should be done (Table 11)—are reflective of social processes not personal benefit. These patterns suggest that generalized,[18] rather than restricted,[19] exchange behavior governs the exchange of information and assistance within these communities.

While generalized exchange is not conditional, there is an expectation that if a community member provides assistance today, someone else will provide him with assistance when he needs it. From the viewpoint of rational choice, social exchange, or evolutionary theory, the existence of generalized exchange is somewhat of a puzzle, because any member of the exchange system can free-ride since there is no guarantee of reciprocity (Takahashi, 2000). In order to address the free-riding issue, researchers have argued that generalized exchange stems from altruism (Sahlins, 1972) or collective norms (Ekeh, 1974; Levi-Strauss, 1969). A recent article proposes a compelling alternative to these explanations: a fairness-based selective-giving strategy (Takahashi, 2000). In such a system, an actor offers help to those whose behaviors are in-line with the actors own notions of fairness.[20]

In light of our empirical findings, it appears that one very important motivator for participation, contribution, and sharing in these communities is overlooked in the Harhoff et al. framework: the fun and enjoyment that arise through engagement in the task and community (Table 11). From this perspective, the individual does not view participation and contribution as a cost that needs to be compensated, rather these activities are enjoyable in and of themselves.

Community matters not only in the direct provision of resources for innovation development, but it also influences the process by which these resources are shared and exchanged. Information and innovations are freely-revealed in the community-based innovation systems in our sample and we propose that this behavior is supported by a system of generalized exchange within these communities.

7.2. Why a community system and not a market system?

Our data clearly shows that, within these sports communities, innovation-related assistance and information is given for free, as are the actual innovations. These communities clearly do not operate as markets in which innovators pay for the assistance they receive—instead, a community-based system appears to be an effective form of organization within these user-communities. In this section we explain why we think this is the case. In brief, a community-based innovation system compared to a market system seems to offer significant advantages.

7.2.1. Difficulty in placing a value on assistance and information

One reason a market system might lead to significant disadvantages and might even inhibit the exchange of innovation-related assistance is that it may be difficult or impossible to value the information that is being shared in the context of its potential use—it is often not known if a functioning prototype will be developed, if the product will be used by even one individual, if the product will be used by many, and what the value of the product will be for those who use it. In addition, the perception of the individual who has the information and the individual who needs the information might differ. Thus, the process of finding and negotiating a price could induce prohibitive transaction costs (Bhagat et al., 1994).

7.2.2. The effect of intrinsic motivation on innovation-related activities

Another reason favoring community systems over market systems in the context of the user-innovation process is related to intrinsic motivation. It has been found that if activities are rewarding in and of itself, individuals may perform the activity, as well as exchange information and assistance related to that activity, even in the absence of financial or other

[18] In the context of generalized exchange, if an individual gives to someone, the giver is generally reciprocated by someone other than who they originally gave to (Ekeh, 1974). For example, a generalized exchange explanation for why stranded motorists receive help from strangers would argue that the person who assists the stranded motorist believes that someone else will help them when they need help in a similar situation, and thus they help the stranded motorist.

[19] In restricted exchange there are only two parties in the exchange transaction and the parties transact conditionally "A only assists B, if B assists or rewards A".

[20] The results of computer simulations show that pure generalized exchange can emerge and be maintained in a system where each actor selects a recipient whose previous behavior satisfies the actor's own notion of fairness (Takahashi, 2000).

types of rewards (Amabile, 1983; Cziksentmihalyi, 1996). Challenge and mental stimulation, control, curiosity, and fantasy are all likely to enhance and individual's intrinsic motivation towards an activity (Malone and Lepper, 1987); these elements are very prevalent in innovation-related activities. On the other hand, adding a financial or other type of reward for engaging in an activity may decrease an individual's intrinsic motivation towards that activity. Such shifts in motivational orientation from intrinsic to extrinsic have been shown to negatively affect the nature of interpersonal interactions (Pittman, 1982; Pittman et al., 1992) and decrease creativity (Amabile, 1985). A market based on restricted exchange or external rewards might decrease the innovation-related benefits of intrinsic motivation.

7.2.3. Communities guard against free-riding

Theoretically, one major disadvantage of a voluntary community system, as compared to a market system, is that it is vulnerable to opportunism and free riding. It is argued that it pays for a person who received some important assistance in the past (and thus has a "net gain") to reject to pay his part back if he is asked to give assistance. In response, generalized exchange theorists have introduced the concepts of norms (Sahlins, 1972), altruism (Ekeh, 1974; Levi-Strauss, 1969), and fairness-based selection mechanisms (Takahashi, 2000). By not assisting, an individual may violate community norms and be reprimanded or penalized, and in an extreme situation be excluded from the community (Turner and Killian, 1957). On the other hand, by not assisting, an individual may be viewed by others in the community as someone who does not "play fair" and thus increase his likelihood of being denied help when he needs it (Takahashi, 2000).

7.2.4. "Appropriation" of rents by user-innovators

We show that innovating users often freely-reveal their innovations both within and outside the community; one might wonder how the innovating-user benefits from his labor if he does not sell his innovation. The innovating users generally do not benefit financially from their innovations; in fact, it appears that they derive few benefits beyond those generated from in-house use. This pattern fits findings regarding the significant costs and low probability of success associated with efforts to protect and license intellectual property in many fields (Taylor and Silberston, 1973; von Hippel, 1988; Shah, 2000).

Given that an innovator has chosen to freely reveal an innovation, whether or not it is considered appropriate for another party to financially profit from that innovation remains an open question. In our sample, 23.1% of innovators report that their innovation has been or is likely to be commercialized by another party, however, it does not appear that the innovators will share in any profits that may be generated. We suggest that another party may be more likely to appropriate financial benefits from an innovation in fields with a weak intellectual property regime and/or in fields where the community does not mobilize against the commercializing entity. In the domain of sports-innovations, the likelihood of appropriating rents through patenting or licensing appears weak for a variety of reasons (Shah, 2000) and the likelihood of the community mobilizing to protest the commercial use of a community-developed innovation is likely to be low.[21] A strong community "voice" may affect the actions of commercializing entities acting against the spirit of these communities.

7.2.5. Collective invention

In addition, users may derive many benefits from revealing (and not selling) their innovations to the community as a whole. These benefits might include psychological benefits derived from engaging in altruistic actions (Staub, 1977) as well as inducing further improvements to the innovation by users as well as manufacturers—improvements that benefit the innovators as well as other users (Allen, 1983). This mechanism is also considered to be a driving force of the free-revealing of user-innovations in OSS (Raymond, 1999).

Also consider the following possibility: an innovator may not be concerned about the possibility of others "free-riding" and using his innovation, this is especially true of an innovator who cannot or chooses not to commercialize his innovation himself. In that case, freely-revealing would create no negative

[21] In contrast, the OSS community possesses both a strong "voice" and relies heavily on licenses (Raymond, 1999) (although the legal validity of these licenses has yet to be tested in court).

consequences for the innovator, while increasing the likelihood of further improvements, standardization, and adoption of the innovation, and be seen as the most sensible behavior.[22]

7.3. Implications for managers/manufacturers

In order to obtain innovative ideas for new products von Hippel (1986) suggests to adopt concepts and prototypes already developed by users. This method, specifically designed, tested, and successful in industrial markets, has its drawbacks when applied to consumer markets with millions of users. Our findings suggest that monitoring some innovative user-communities may be an efficient method for identifying commercially appealing innovations made by users.[23]

There are two critical steps in this process: (1) selecting promising communities; and (2) gathering information from community members. Conventional wisdom would suggest picking professional, competitive communities to study. While these individuals have a need for innovations to improve their performance, professionalism often goes together with competition and we show that competition decreases the free flow of innovation information. Thus looking at highly demanding, but not necessarily competitive communities of users may make more sense; for example, a ski manufacturer is likely to be better off monitoring a community of ski fanatics in a technically and environmentally demanding region who have found ways to improve their ability to ski in such conditions rather than a group of World Cup racers. Our findings indicate that central members of the community are likely to both innovate and to have an exceptionally good knowledge of user-innovations developed by other community members; thus it is not necessary to incur the high cost of contacting every community member in the process of seeking out promising innovations.

8. Suggestions for future research

This study provides four examples of "community-based innovation systems" and investigates the processes at work in these systems. In the course of this research, we uncovered many interesting puzzles and questions some of which we were able to investigate in detail and some of which we now propose as suggestions for future research.

Four sets of empirical questions stand out. (1) *Exchange relationships*: a refined understanding of the mechanisms that govern exchange relationships within these communities needs to be developed from two primary perspectives: relationships between community members (fairness, trust, generalized and reciprocal exchange) and relationships between the community and commercial entities (licensing and appropriation). (2) *Social structures of communities*: what types of hierarchies or governance structures exist within voluntary communities? How do social and "innovation" networks develop and evolve? What is the relative importance of skill level versus pre-existing relationships in determining an individuals position in the network, etc. (3) *Competition*: in this study we look at the overall level of competition within the community, however, a more nuanced understanding of the mechanisms involved would allow us to better understand the innovation process in these communities. We propose three factors that may affect the types of information and assistance likely to be exchanged under varying degrees of competition within a community: (a) assistance is likely to be given freely for innovations which do not directly affect performance and instead improve other factors such as safety; (b) even within competitive communities, there are likely to be smaller groups which are close-knit and provide assistance to one another; (c) the athletes may separate into tiers in ability and be more likely to provide assistance to those who are not close to their own ability level. (4) *Existence and survival*: the question of how these community-based user-innovation systems are initiated and evolve has yet to be addressed, as does the question of what happens if the shared practices of giving

[22] The authors are indebted to Carliss Baldwin, Larry Stanley and Mike Horgan for this idea.

[23] It is important to remember that the free-revealing and sharing of innovations is important in these communities. While an innovator may not mind a manufacturer producing an innovation for individuals who are unable or unwilling to build it themselves, they might object to aggressive patenting, excessive price mark-ups above cost, or not giving the innovator credit for developing the innovation if the identity of the innovator is known. More research on this area is needed.

free assistance and freely revealing innovations are breached.

Finally, this investigation only examines innovations by individuals who are members of voluntary communities. However, individuals outside of communities are likely to innovate as well and the process they experience has yet to be investigated. Innovators outside of communities may or may not work with the assistance of others and are likely to have different methods for finding individuals to assist them compared to innovators who belong to communities. If significant differences in process exist, it would be interesting to examine potential differences or similarities in process outcomes such as the frequency, type, quality, and diffusion of innovations; and to understand when innovators within communities more likely to and more effective in innovating than innovators outside communities (and vice versa).

9. Conclusion

In this study we investigate the process by which innovators outside of firms who belong to voluntary user-communities obtain innovation-related resources and assistance. We examine and provide insight into the structure of four user-communities, finding that innovation-related resources, assistance, and the resulting innovations are freely and openly shared in the communities. We believe the findings of this study to be quite generalizable; but formal studies in other consumer and industrial markets are necessary and many exciting questions have yet to be addressed.

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Appendix A. Sample questionnaire

Below, you will find a shortened version of the questionnaire distributed to members of all four sports communities. The sample refers to the boardercross community in particular.

A.1. Sports community

How long have you been a member of the boardercross community? (open). How long have you been participating in boardercrossing? (open). On how many days per year do you participate in this sports? (approximately (open) days total, of which approximately (open) days are spent with the boardercross community).

Please tell us more about your involvement with boardercrossing community. Items: "I get together with members of the boardercross community for activities that are not related to boardercrossing (movies, dinner, parties, etc.)"; "the boardercross community takes my opinion into account when making decisions"; "I am a very active member of the boardercross community" (each seven-point rating scale).

A.2. Own ideas for improved or new (adaption to specific sport) products

Have you improved existing products or had ideas for new products that were not offered on the market before? (yes/no). Please briefly describe your product idea/improvement (open). Please rate your product idea/improvement on the following dimensions: newness, urgency, market potential (each seven-point rating scale).

Products are often developed by individuals working together. Often one receives assistance from other people (advice, use of resources, etc.). We are interested what it was like with your product idea/improvement. Items: "talking with others about the problem that should be solved was of assistance to me"; "others assisted me by giving competent advice and suggestions for improvement"; "others assisted me by advising on technical details"; "others assisted me by testing and giving feedback"; "the confirmation and encouragement of others was of help to me" (each seven-point rating scale).

If others assisted you, we would like to know more about it. Most of the important information and assistance came from ... (seven-point rating scale: community members versus non-community members; initially close friends versus initially strangers; experts

versus non-experts); "belonging to the boardercross community helped me find people who contributed to my product idea/improvement" (seven-point rating scale). How many people, other than yourself, have assisted you in your product idea/improvement? (0, 1, 2, 3–5, 5–10, more than 10).

Which statements apply to the people who assisted you with your product idea/improvement? Items: "the people who assisted me are creative and innovative themselves"; "the people who assisted me have skills that are complementary to mine"; "if I had a similar problem I would ask the same people again" (each seven-point rating scale).

New product ideas/improvements often are interesting to many people. We are interested what you have done to let others know of your product idea/improvement. What have you been doing? Items: "I share(d) my product idea/improvement with the (adapted to specific community) community free of charge or at cost"; "I have sold my product idea/improvement to many members of the (adapted) community"; "I share(d) my product idea/improvement with individuals outside the (adapted) community free of charge or at cost"; "I have sold my product idea/improvement to individuals outside the (adapted) community"; "the product idea/improvement is used by many members of the (adapted) community"; "the product idea/improvement is used by many individuals outside the (adapted) community" (each seven-point rating scale); has you product idea/improvement been produced for sale by a manufacturer or will it be in the foreseeable future? (yes/no).

A.3. Your assistance with ideas from others (for improved or new boardercross products)

Have you assisted another boardercrosser who developed ideas for new or improved products (that were not offered on the market before)? (yes/no); if yes: please briefly describe the product idea/improvement (open). The person who I assisted can be characterized as ... (community member or non-community member).

There are numerous reasons for assisting others in their projects. Why have you been assisting them? Items: "I wanted to use the product idea/improvement myself"; "if I assist others today, I will receive assistance in the future"; "I was paid well for my assistance"; "it was nice to receive recognition"; "it is fun to create something jointly"; "it is my opinion that in a community, one should assist others"; "in the boardercross community there is the norm that members should assist each other free of charge"; "I enjoy giving others advice as an expert" (each seven-point rating scale).

References

Allen, T.J., 1971. Communications, technology transfer, and the role of the technical gatekeeper. R&D Management 1, 14–21.

Allen, R.C., 1983. Collective invention. Journal of Economic Behavior and Organization 4, 1–24.

Allen, T.J., 1984. Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the R&D Organization. MIT Press, Cambridge, MA.

Amabile, T.M., 1983. The Social Psychology of Creativity. Springer, New York.

Amabile, T.M., 1985. Motivation and creativity: effects of motivational orientation on creative writers. Journal of Personality and Social Psychology 49, 393–397.

Ancona, D.G., Caldwell, D.F., 1992. Bridging the boundary: external activity and performance in organizational teams. Administrative Science Quarterly 37, 634–665.

Barley, S., 1996. Technicians in the workplace: ethnographic evidence for bringing work into organization studies. Administrative Science Quarterly 41 (3), 401–444.

Bhagat, S., Brickley, J.A., Coles, J.L., 1994. The costs of inefficient bargaining and financial distress: evidence from corporate lawsuits. Journal of Financial Economics 35 (2), 221–247.

Blau, P., 1955. The Dynamics of Bureaucracy. University of Chicago Press, Chicago.

Brown, J.S., Duguid, P., 1991. Organizational learning and communities-of-practice: toward a unified view of working, learning and innovation. Organization Science 2 (1), 40–57.

Brown, S.L., Eisenhardt, K.L., 1995. Product development: past research, present findings, and future directions. The Academy of Management Review 20 (2), 343–379.

Brown, J.S., Duguid, P., 2000. Knowledge and organization: a social practice perspective. Organization Science, July.

Cziksentmihalyi, M., 1996. Creativity: Flow and the Psychology of Discovery and Invention. Harper Collins, New York.

Dalton, M., 1959. Men Who Manage. Wiley, New York.

Ekeh, P.P., 1974. Social Exchange Theory: the Two Traditions. Harvard University Press, Cambridge, MA.

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

First Monday, 1998. First Monday interview with Linus Torvalds: what motivates free software developers? First Monday (on-line journal) 3 (3).

Freeman, C., 1968. Chemical process plant: innovation and the world market. National Institute Economic Review 45, 2957.

Gouldner, A., 1954. Patterns of Industrial Bureaucracy. Free Press, New York.

Granovetter, M., 1985. Economic action and social structure: the problem of embeddedness. American Journal of Sociology 91, 481–510.

Harhoff, D., Henkel, J., von Hippel, E., 2000. Profiting from voluntary information spillovers: how users benefit by freely revealing their innovations. Sloan School Working Paper #4125.

Hendricks, W.A., 1949. Adjustment for bias caused by nonresponse in mailed surveys. Agricultural Economic Research 1, 52–56.

Herstatt, C., von Hippel, E., 1992. From experience: developing new product concepts via the lead user method: a case study in a low tech field. The Journal Of Product Innovation Management 9 (3), 213–222.

Horn, J.L., 1965. A rationale and test for the number of factors in factor analysis. Psychometrika 30, 179–185.

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

Lave, J.C., Wenger, E., 1991. Situated Learning: Legitimate Peripheral Participation. Cambridge University Press, New York.

Lee, H.B., Comrey, A.L., 1979. Distortions in a commonly used factor analytic procedure. Multivariate Behavioral Research 14, 301–321.

Lerner, J., Tirole, J., 2000. The simple economics of open source. NBER Working Paper #7600.

Levi-Strauss, C., 1969. The Elementary Structures of Kinship (originally published as Les Structures Elementaires de la Parente, 1949). Eyre & Spottiswoode, London.

Lüthje, C., 2000. Characteristics of innovating users in a consumer goods field. Working Paper, University of Hamburg, Hamburg (luethje@tu-harburg.de).

Malone, T.W., Lepper, M.R., 1987. Making learning fun: a taxonomy of intrinsic motivations for learning. In: Snow, R.E., Farr, M.J. (Eds.), Aptitude, Learning and Instruction: Cognitive and Affective Process Analysis, Vol. 3. Lawrence Erlbaum, Hillsdale, NJ.

Morrison, P.D., Roberts, J.H., von Hippel, E., 2000. Determinants of user innovation and innovation sharing in a local market. Management Science 46 (12), 1513–1527.

Orr, J., 1996. Talking About Machines: An Ethnography of a Modern Job. IRL Press, Ithaca, NY.

Pittman, T.S., 1982. Intrinsic and extrinsic motivational orientations towards others. In: Gilbert, D.T., Fiske, S.T., Lindzey, G. (Eds.), The Handbook of Social Psychology, Vol. 1, 4th Edition. Oxford University Press, New York, 1998 (Chapter 12).

Pittman, T.S., Boggiano, A.K., Main, D.S., 1992. Intrinsic and extrinsic motivational orientations in peer interactions. In: Gilbert, D.T., Fiske, S.T., Lindzey, G. (Eds.), The Handbook of Social Psychology, Vol. 1, 4th Edition. Oxford University Press, New York, 1998 (Chapter 12).

Raymond, E., 1999. The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary. O'Reilly, Cambridge, UK.

Riggs, William, von Hippel, E., 1994. Incentives to innovate and the sources of innovation: the case of scientific instruments. Research Policy 23, 459–469.

Rogers, E.M., 1983. Diffusion of Innovations, 3rd Edition. Free Press, New York.

Rosenkopf, L., Tushman, M., 1998. The coevolution of community networks and technology: lessons from the flight simulation industry. Industrial and Corporate Change 7, 311–346.

Sahlins, M., 1972. Stone Age Economics. Aldine Press, Chicago.

Schrader, S., 1991. Informal technology transfer between firms: cooperation through information trading. Research Policy 20 (2), 153–170.

Selznick, P., 1949. TVA and the Grass Roots. University of California Press, Berkeley.

Shah, S., 2000. Sources and patterns of innovation in a consumer products field: innovations in sporting equipment. Sloan Working Paper #4105.

Shaw, B., 1985. The role of the interaction between the user and the manufacturer in medical equipment innovation. R&D Management 15 (4), 283–292.

Staub, E., 1977. Positive Social Behavior and Morality. I. Social and Personal Influences. Academic Press, New York.

Takahashi, N., 2000. The emergence of generalized exchange. American Journal of Sociology 105 (4), 1105–1134.

Taylor, C.T., Silberston, Z.A., 1973. The Economic Impact of the Patent System: A Study of the British Patent System. Cambridge University Press, Cambridge, UK.

Turner, R.H., Killian, 1957. Collective Behavior. Prentice-Hall, Englewood Cliffs, NJ.

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

von Hippel, E., 1987. Cooperation between rivals: informal know-how trading. Research Policy 16, 291–302.

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

von Hippel, E., 2001. Open source shows the way: innovation by and for users—no manufacturer required. Sloan Working Paper #4163.

von Hippel, E., Thomke, S., Sonnack, M., 1999. Creating breakthroughs at 3M. Harvard Business Review 77 (5), 47–57.

Wenger, E., 1998. Communities of Practice. Cambridge University Press, New York.

Zwick, W.R., Velicer, W.F., 1986. Comparison of five rules of determining the number of components to retain. Psychological Bulletin 99, 432–442.