Determinants of User Innovation and Innovation Sharing in a Local Market

Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Determinants of User Innovation and Innovation Sharing in a Local Market

Pamela D. Morrison, John H. Roberts, Eric von Hippel,

To cite this article:
Pamela D. Morrison, John H. Roberts, Eric von Hippel, (2000) Determinants of User Innovation and Innovation Sharing in a Local Market. Management Science 46(12):1513-1527. https://doi.org/10.1287/mnsc.46.12.1513.12076

Determinants of User Innovation and Innovation Sharing in a Local Market

Pamela D. Morrison • John H. Roberts • Eric von Hippel
Faculty of Commerce and Economics, School of Marketing, University of New South Wales, Sydney, Australia 2052
Australian Graduate School of Management, University of New South Wales, Sydney, Australia 2052
Sloan School of Management, Massachusetts Institute of Technology, 38 Memorial Drive, Cambridge, Massachusetts 02139
pamm@unsw.edu.au • johnr@agsim.unsw.edu.au • evhippel@mit.edu

It is known that end users of products and services sometimes innovate, and that innovations developed by users sometimes become the basis for important new commercial products and services. It has also been argued and to some extent shown that such innovations will be found concentrated in a "lead user" segment of the user community. However, neither the characteristics of innovating users nor the scope of the community that they "lead" has been explored in depth.

In this paper, we explore the characteristics of innovation, innovators, and innovation sharing by library users of OPAC information search systems in Australia. This market has capable users, but it is nonetheless clearly a "follower" with respect to worldwide technological advance. We find that 26% of users in this local market nonetheless do modify their OPACs in both major and minor ways, and that OPAC manufacturers judge many of these user modifications to be of commercial interest. We find that we can distinguish modifying from nonmodifying users on the basis of a number of factors, including their "leading-edge status" and their in-house technical capabilities. We find that many innovating users freely share their innovations with others, and find that we can distinguish users that share information about their modifications from users that do not. We conclude by considering some implications of our findings for idea generation practices in marketing.
(Lead Users; Idea Generation; New Product Development)

1. Introduction and Overview

Empirical research in a number of fields has shown that users are frequently the first to develop and use prototype versions of what later became commercially significant new products and processes (Enos 1962; Knight 1963; Freeman 1968; Lionetta 1977; von Hippel 1976, 1977, 1988; VanderWerf 1990; Shaw 1985). It has also been argued and to some extent shown that innovation by users will tend to be concentrated among "lead users." (*Lead users* are defined as those who combine two characteristics: (1) they expect attractive innovation-related profits from a solution to their needs, and so are likely to innovate; and (2) they experience needs ahead of the majority of a target market (von Hippel 1986, Urban and von Hippel 1988).)

Since innovation is known to be an economically motivated activity (e.g., Schmookler 1966, 1972), it is reasonable that those users in a user population expecting relatively higher benefit from developing an innovation—one of the two characteristics of lead users—are more likely to innovate. Also, as lead users are by definition ahead of the bulk of a target market with respect to their needs, an attractively sized market for products and services that lead users need today may not yet exist from a manufacturer's point

0025-1909/00/4612/1513$05.00
1526-5501 electronic ISSN

of view. When this is so, it is reasonable that manufacturers would be less likely to innovate, thus increasing the likelihood that lead users will develop their own innovative solutions for their own leading-edge needs (Gans and Stern 1999, Urban and von Hippel 1988).

Up to this point, work on lead users has left undefined the scope of the communities they "lead." Should we expect innovation to occur only among the users that lead the world with respect to a particular area of application and trend? Or, should we expect innovation among users that are at the leading edge of more local populations of users? We argue that innovation will occur among lead users in local communities when either or both of two conditions hold: first, when a local community has unique needs, and second, when it is cheaper to invent anew than it is to search for and acquire a needed innovation that may exist elsewhere.

In this study, we explore these ideas by examining the occurrences of innovation, the characteristics of innovators, and innovation-sharing patterns in a relatively large "local" user community—Australia—containing users that are capable but not globally leading edge with respect to OPACs—a computerized information search system used by libraries. Our contributions to the literature are findings regarding user innovation and the characteristics of innovating users in a local market, findings regarding manufacturer reaction to user innovation, and findings regarding user innovation sharing as a phenomenon.

An overview of the organization of our paper and a preview of our main findings is as follows. First, we discuss our research sample and methods (§2). We then explore the types of user innovation activity taking place in our sample, finding that 26% of users have indeed modified their OPAC in some way. We also find that OPAC suppliers judge a significant fraction of these user innovations to have commercial value from their perspective (§3). Next we provide and explain a list of user characteristics that we hypothesize will distinguish innovating from noninnovating users (§4). We test these hypotheses and find, first, that innovating users do indeed fit the profile of lead users—they have high "leading edge status" (Morrison 1995). Second, we find that innovating users have several additional characteristics that distinguish them from noninnovating users, such as higher in-house technical capability.

Next, we explore patterns in user sharing of innovation-related information with manufacturers and users (user innovations that cannot be shared are of little use to manufacturers), and find widespread sharing. We next propose some characteristics of users and their innovations that we hypothesize will be associated with innovation sharing and find these hypotheses supported by the data (§5). Finally, we discuss the implications of our findings, such as the implications of the high levels of user desire to modify —and actual user modifications made to—OPACs that we have found in the local market of Australia. We conclude by briefly discussing the desirability and possibility of incorporating information from lead user innovations into manufacturer idea generation processes (§6).

2. Study Sample and Research Methods

Our empirical study of users that innovate or modify products to better fit their needs is focused on a type of computerized information search system called an "OPAC." OPACs, or Online Public ACcess systems, are computerized information search systems used by libraries. They were initially developed as a replacement for and improvement upon the "card catalog"-–a system in which information on the contents of a library's collection is provided to patrons in the form of an index made up of small paper cards. Later advances built important additional functionality into OPACs, ranging from better information search capabilities to the ability to perform library administration-related tasks. Thus, many present-day OPACs can be used both to search the Internet for information and to register borrowers seeking to become eligible to use a library.

OPACs were initially developed by advanced and technically sophisticated users. Development began in the United States in the 1970s with work by major universities and library institutions such as the United States Library of Congress, with support provided by United States government grants (Tedd 1994). Until

roughly 1978, the only OPACs in use were those that had been developed by libraries for their own use. In the late 1970s, the first commercial providers of OPAC systems appeared in the United States, and by 1985 there were at least 48 OPAC vendors in the United States alone (Matthews 1985).

The population of OPAC users from which we draw our sample consists of all OPAC-equipped public and private libraries located in Australia. Although Australia does have a number of sophisticated and technically capable libraries, the United States is clearly the world leader in OPAC development. Some indicators: In Australia OPAC adoption began about eight years later than in the United States, spurred by a 1981 demonstration of a commercially manufactured OPAC that was installed at the University of-Adelaide (Tedd 1994); key OPAC innovations, such as advances in Internet search procedures, were devel--oped and tried first in the United States; most major OPAC suppliers today are based in and have their primary R&D facilities in the United States. Therefore,-Australia provides a good environment in which to study innovation in a local market.

Our sampling frame was 464 Australian libraries selected using stratified random sampling. These organizations accounted for 56.5% of staff employed and 50% of the total spending in the overall population of interest. (Reference librarians are end users, along with library patrons, of the search capabilities of OPACs. Library staff are also the end users of the administrative capabilities of OPACs. In this report, we refer to libraries and the staff they employ as OPAC users.) With the exception of a few custom systems built completely by users, all OPAC systems in our sample are the products of commercial OPAC vendors. Our selection of participants in the present study proceeded as follows. First, all libraries within the sampling frame were prescreened via phone to establish whether they had an OPAC system and to identify an appropriate key informant who, because of his or her particular knowledge, would be in a good position to respond accurately to our questions. On the basis of these phone contacts we identified 166 individuals (36% of the 463) in libraries owning an OPAC system who met our criteria for key informant. These individuals were then asked if they would be willing to participate in the study. All agreed to do so. This "selected sample" includes libraries of all sizes, spanning the public, private, and education sectors. Twenty-five percent of the sample had 10 or fewer employees, 50% fewer than 25, and 75% fewer than 60.

Our next step in data collection was to send each respondent a questionnaire with a stamped, preaddressed return envelope. A follow-up letter was sent three weeks later to those respondents who had yet to reply. After the second mailing we obtained a total of 122 completed surveys (a 73% return rate—a very high response rate relative to other studies using similar approaches to data collection). In our final sample, respondent libraries had their current OPAC system installed for an average of about five years, and key informants' mean familiarity with those OPACs was high—6.3 on a 7-point scale.

The survey instrument we used was developed via the following procedure. First, a number of personal interviews were conducted with actual OPAC system manufacturers and with users responsible for the maintenance/usage/upkeep of the OPAC within their library (generally these were systems librarians). We then developed a draft questionnaire based on these exploratory investigations and the findings of previous research on our study topic. This was administered to a pilot sample of five librarians who were asked to complete the survey instrument and provide feedback on its content. Changes were then made to a number of questions to increase their clarity. The final survey consisted of seven pages of questions and a one-page cover letter.

Perceptual measures in the survey included level of satisfaction with and customization of existing equipment, possible barriers to innovation, uniqueness of the needs of the organization, and organization measures relating to leading-edge status, opinion leadership, innovativeness, and culture. Objective measures included details on recently undertaken innovations including their development, sharing, and receipt, as well as background information on the responding organization, including employees, membership of user groups, etc. In a second survey, we contacted two manufacturers of OPAC systems and asked them to evaluate user innovations based on the value of the solution content to them.

Detailed descriptions of operationalization of variables used in both questionnaires are provided in the appendix.

A final data collection was initiated after initial analysis of our questionnaire data allowed us to identify the 26 members of our sample who had made modifications to their OPACs. We followed up with each of these respondents via telephone, and carried out a half-hour semistructured interview with each to elicit more details regarding the nature of their modification and the circumstances surrounding it.

3. Local Users Do Modify OPACs

Approximately 26% (26 out of 102 usable responses) of our respondents in our "local" OPAC market reported that they had modified their OPACs one or more times after initial installation. The total number of modifications reported was 39, with 19 users reporting making 1 modification each, 3 reporting 2, 3 reporting 3, and 1 reporting making 5 modifications. In addition, fully 54% of our respondents agreed with the statement that "We would like to make additional improvements to our OPAC functionality that can't be made by simply adjusting the standard, customer-accessible parameters provided by the supplier." This is a strikingly high percentage, and reflects a widespread latent need to customize OPACs according to users' novel ideas and local settings.

The wish by many respondents to make modifications to their OPACs does not appear to reflect a global dissatisfaction with the equipment as is—72% of respondents agreed that they are "satisfied with the performance of their OPAC." Nor does the present wish to make modifications imply that the OPACs purchased were a poor fit to library needs from the start. Suppliers know that libraries' needs for OPAC functionality vary, and they therefore incorporate a number of user-adjustable parameters into the systems they sell. Also, suppliers often additionally customize OPAC systems during initial installation. Reflecting this practice, approximately 30% (32 of the 108 usable responses) of our respondents agreed with the statement that their OPAC had been "highly customized in-house during installation to meet the needs of our library." The most likely reason that many of our respondents had current wishes to modify their OPACs is that additional needs for modifications to OPAC functioning arise over time or are newly perceived after the initial installation of the system.

3.1. Nature of User-Developed OPAC Modifications

Modifications to OPACs reported by users in our sample spanned the full range of OPAC functionality, affecting both general library management and the conduct of information searches (Table 1). Some of the user-developed modifications were judged by their developers to be of likely interest to many other libraries. An example of a modification in this category would be developing an interface between an OPAC and the Internet to allow library patrons to access that very rich lode of information in conjunction with library data. Other modifications were judged by their user-developers as likely to be of interest to their own library only, due to relatively unusual local conditions. For example, the library that modified its OPAC to display "book retrieval instructions for staff and/or patrons" (see Table 1) did so because its book stacks were distributed in a very complex way across a number of buildings—making it difficult for staff and patrons to find books without precise directions.

Are the modifications reported by users in our sample new to the world? Absent an exhaustive worldwide study of OPAC innovations, we cannot be sure. However, we did ask all users reporting modifications what their best information was regarding the novelty of what they had done, and in 22 cases, users responded. In 16 of these cases, users indicated that they thought that the modification they had developed had been new to the world at the time it was developed. In 6 cases they said that a modification of similar function certainly was or probably was offered by one or more OPAC suppliers at the time they had developed it for themselves although it was not offered by their own supplier.

Table 1 Functionality of OPAC Modifications Created by Users

Improved Library Management	Improved Information Search Capabilities
• Add library patron summary statistics (S)	• Integrate images in records (2) (1S)
• Add library identifiers (S)	• Combined menu/command searches (S)
• Add location records for physical audit (S)	• Add title sorting and short title listing
• Add book retrieval instructions for staff/patrons	• Add fast access key commands (S)
• Add CD-ROM System backup (S)	• Add multilingual search formats
• Add book access control based on copyright	• Add key word searches (2) (1S)
• Patrons can check their status via OPAC (S)	• Add topic linking and subject access (S)
• Patrons can reserve books via OPAC (2) (1S)	• Add prior search recall feature
• Remote access by different systems (S)	• Add search "navigation aids"
• Add graduated system access via password	• Add different hierarchical searches
• Add interfaces to other library IT systems:	• Access to other libraries' catalogs (2) (2S)
– Word processing and correspondence (2) (IS)	• Add or customize web interface (9) (5S):
– Umbrella for local information collection (2) (1S)	– Hot links for topics
– Local systems adaptation (S)	– Extended searches
	– Hot links for source material

Note. Numbers in parentheses indicate the number of user modifications developed to provide the described functionality. The letter S in parenthesis indicates that information about an innovation having that functionality was shared by the user developing it with other users and/or OPAC suppliers.

3.2. Costs of User-Developed OPAC Modifications

As a rule, libraries do not have formal cost and time-expenditure tracking systems for individual projects undertaken by their staff. Concept formulation stages of a project tend to be only vaguely recalled, with informants typically only able to say something like, "We had been thinking about the need to do X, and had been mulling over possible solutions for a while… ." However, we were able to obtain project time and cost-expenditure estimates regarding project execution, based on the unaided recall of library managers, for 24 of the 39 user modification projects reported to us. In 20 of these cases, in-house library staff wrote the custom software needed to implement their projects. In 4 cases, users arranged with outside contractors to write the custom software code needed to implement their modifications (Table 2).

Table 2 Cost of User Modification Projects

Project carried out by in-house library staff:	
Staff Time Expended[a]	Number of Projects
One day or less	13
One month or less	4
Three months or less	2
Sixty months	1
Project software written by contract programmers:	
Project Price[b]	Number of Projects
$6,500	1
$120,000	1
$0[c]	2

Note. [a]Internal staff time estimates given in dollars were converted to time @ $U.S. 650 = 1 week.
[b]Project prices shown in U.S. dollars.
[c]Modification project costs included in OPAC maintenance contract fee.

As can be seen in Table 2, the costs reported for executing more than half of the user modification projects were quite low—13 required one day of staff time or less. Innovating users reported that all projects using in-house library staff—programmers or others—were incorporated within existing budgets by drawing upon what they viewed as organizational slack. That is, existing in-house technical support staff simply incorporated these projects into their overall workload on a time-available basis. (Library managers reported that this was a highly preferred route, because projects involving expenditures for outside programmers typically would require managers to deal with complex budgetary authorization procedures.)

We also asked each user who had developed a modification—or paid for having it developed by a third party—why they had done this rather than asking their OPAC supplier to develop it. This question was answered in 18 instances, with quite uniform results. The general answer was that OPAC suppliers are only interested in developing modifications that they think a number of users will want. If a supplier thinks this is not the case in a given instance, it either will refuse to create the modification outright, or will offer to do it at a price that is higher and/or with a delivery time that is longer than the user can achieve without OPAC supplier involvement in the project. Supplier opinions on the general utility of a modification can change, and a few users spontaneously noted that their OPAC supplier did eventually offer a commercial version of the modification they had pioneered.

3.3. Manufacturer Evaluation of User OPAC Modifications

Manufacturers will only find it worthwhile to identify user innovations or modifications if they think that some are likely to offer profit potential from their perspective. Because, as was noted earlier, innovations by users are the basis for many commercially important products, it is reasonable that this will sometimes be the case. In addition, in the one study of the commercial attractiveness of lead user innovations, high commercial attractiveness was documented.[1] We explored the commercial attractiveness of the user-developed OPAC modifications in our sample by asking two local Australian development managers employed by two large OPAC suppliers to evaluate a brief description of the function performed by each modification. For each, the suppliers were asked: (1) How important commercially to your firm is the functionality added to OPACs by this modification? (2) How novel was the information contained in that modification to your manufacturing firm at the time it was developed? For each question, the rating scale was from 1 to 100 (where 1 was *none–very little*, 100 *=very valuable–a lot*). Responses from both suppliers indicated that about 70% (25 out of 39) of the user modifications provided functionality improvements of at least "medium" importance to OPACs from the point of view of these commercial systems vendors (see Table 3). Both suppliers also felt that a number of these modifications (7 out of 39 or 20% in the case of one supplier, and 15 out of 39 or 44% in the case of the second) contained information that was novel to their company at the time the modifications had been made, and that this information would have been useful to their product developers with respect to functionality desired by users, and/or means for achieving that functionality.

4. Characterizing Users Likely to Modify OPACs

In this section, we empirically explore the ability of a number of variables to discriminate between innovating and noninnovating users in our sample. We begin by discussing each of the variables to be tested (§4.1) and then present our empirical results (§4.2).

4.1. Variables Likely to Characterize Innovating Users

Empirical research on the determinants of user innovation has to this point found two variables to be associated with the frequency of innovation by users: user expectations regarding the likelihood of appropriating attractive amounts of profit from developing a given innovation (Mansfield 1968, von Hippel 1988), and the "stickiness" of local information held by users and manufacturers that would

[1] Urban and von Hippel (1988) tested the commercial attractiveness of a product concept for a specialized computer-aided design system containing key novel features prototyped by innovating users of that type of product. The attractiveness of this concept was then evaluated by a sample of 173 users of that type of product relative to three other concept choices—one of which was a description of the best system then commercially available. Over 80% of the target market users were found to prefer the concept incorporating the features developed by innovating users. Their reported purchase probability was 51%, over twice as high as the purchase probability indicated for any other system.

Table 3 Supplier Judgment of Commercial Value of User Modifications

	Manufacturer 1		Manufacturer 2	
Importance Novelty	Importance of function implemented by user	Novelty of information provided by user	Importance of function implemented by user	Novelty of information provided by user
High (71–100)	17	6	7	5
Med (50–70)	8	1	17	10
Low (1–49)	9	27	10	24
Not available	5	5	5	0
Total	39	39	39	39

be drawn upon to develop that innovation (von Hippel 1994, Ogawa 1998).[2] Although both have been shown to influence user's decisions to innovate, it is difficult to collect reliable data on these variables with respect to innovations that have not yet been developed. (Users do not have information on hand about likely benefits to be derived from innovation opportunities they have not considered, nor on stocks of sticky local information that might be required to develop innovations responsive to those opportunities.) In turn, this means that measures of appropriable benefit and sticky information are unlikely to offer a basis for practical, robust methods for identifying users who have innovated or are likely to do so. Accordingly, in the study reported upon here, we test other variables that we hypothesize should discriminate between innovating and noninnovating users and that we think can be reliably measured via questionnaire.

The first variable to be tested is the Leading Edge Status (LES) of users. This construct was developed by Morrison (1995), based on prior research into innovation by lead users. As noted earlier, lead users are defined as those who have two characteristics: (1) They expect attractive innovation-related profits from a solution to their needs and so, as just noted, are likely to innovate; and (2) they experience needs prior to the majority of a target market (von Hippel 1986). The first characteristic selects for users with a higher likelihood of innovating, because there is a positive association between profit expectations and innovative activity (Schmookler 1966, 1972). The second characteristic is a type of filter that preferentially identifies user innovations that manufacturing firms would be likely to find commercially attractive: viz., those that foreshadowed general demand in a target marketplace. (In

[2] With respect to the impact of appropriability of innovation-related benefit, empirical studies of industrial product and process innovation have long shown that innovation is an economically motivated activity (Schmookler 1966, 1972). The greater the benefit an innovator expects to obtain from a needed novel product or process, the greater will be his investment in obtaining a solution (Mansfield 1968, von Hippel 1988, Riggs and von Hippel 1994).

With respect to the impact of information stickiness on the locus of innovation, consider that information regarding user needs for innovations is generated at user sites. Often, it is very costly to transfer that information to manufacturers completely and with good fidelity—the information is "sticky." When this is so, it has been shown that it can pay to do problem solving at the user site rather than attempting to transfer sticky user information to a manufacturer for manufacturer-based innovation activities (von Hippel 1994, 1998; Ogawa 1998). (The logic here is the same as that used by mining firms when deciding where to locate their ore-refining facilities: In cases where ore is very bulky and costly to transport, it often makes sense to locate that processing facility right at the mine.) In our particular application the physical, contextual, and cultural distance of the local market from the center of global lead user innovation is likely to bring this factor into play, increasing the likelihood of local user innovation.

addition, as was noted earlier, there are some data[3] plus an economic rationale for expecting that innovations developed by users will be found concentrated among lead users.)

Morrison (1995) developed LES first to ensure the construct validity of the two items in the lead user definition, and second to avoid the need to dichotomize the population into lead users and others. LES is a continuous analog to the essentially binary characterization of lead users described above. The LES construct contains four types of measures. The first two, benefits recognized early and high benefits expected, represent the two elements of the original lead user definition. The third represents direct elicitation of the overall construct (both self-reports and from third parties). The fourth set represents measures of innovative activities that have been hypothesized to be associated with benefits recognized early and high benefits expected. In a separate study Morrison tested the LES construct on a sample of 464 users of library information technology systems, and found it to have both high reliability and high validity. She found that the shape of the distribution of leading edge status in the population studied was unimodal, arguing for the continuous measure. Finally, the four component measures were highly correlated, and it was therefore meaningful to view them as part of the same LES construct.

The next set of variables hypothesized as likely to distinguish innovating from noninnovating users all relate to possible barriers to innovation (or the converse, drivers of innovation). The first of these was existing in-house technical capability to innovate. In the instance of OPACs, we collect data on this variable by asking users in our sample whether or not they have the in-house capability to (1) do major reprogramming to their OPAC, and (2) create minor add-on programs. (The first-named activity is more technically demanding than the second.) We have two reasons for expecting that in-house technical capability will discriminate between innovating and noninnovating users. First, we reason that users that are at the leading edge with respect to needs for innovations, and that also have relatively high expectations for gaining a benefit from such innovations—that is, lead users—are likely to have an incentive to innovate repeatedly. Users in this position might well find it reasonable to invest in acquiring in-house capability to develop the type of innovations they repeatedly need. Second, users having an existing in-house technical capability to execute an innovation are likely to have some "slack" with respect to those resources. Cyert and March (1963) defined *slack* as the difference between the available resources and those necessary for production. We argue that users with available slack with respect to resources required to carry out an innovation are likely to find lower administrative barriers with respect to developing it—and so will be more likely to innovate. (Projects undertaken via slack do cost "real money." However, there is typically no need to justify additional budgetary expenditures such as the hiring of additional personnel in order to undertake projects that can be carried out utilizing slack resources. Interviewees in our sample confirmed that it was much easier to "just do" a project utilizing slack than it was to seek and obtain approval for a project that required assignment of incremental, specific resources).

A variable we hypothesized would distinguish between innovating and noninnovating users was users' perceptions of the technical difficulty of making modifications to the particular product or service in their possession ("Our OPAC is technically difficult to modify"). Different brands of many products and services differ in their design or in the level of design information given to the user. These differences can mean that some are significantly easier for users to modify than others. For example, in the case of software systems (of which OPACs are an example) access to the source code can make it considerably less costly for users

[3] Urban and von Hippel (1988) studied a sample of 136 users of a type of software product, called PC-CAD, used to design the circuit boards of electronic equipment. Analysis of the responses of these users showed two clusters of respondents: 38 fell into a "lead user" cluster having relatively high values on both lead user characteristics. The second cluster had lower values on both of these characteristics. Users in the lead user cluster were found to have much richer solution information than the nonlead users. Fully 87% of the lead users had developed their own PC-CAD software to address their own advanced in-house needs, while 99% of the nonlead users purchased and used commercially available PC-CAD systems.

or other programmers to make modifications. Because innovation is an economically motivated activity, it is likely that users will be less likely to modify systems that they see as difficult to modify, other things being equal. This effect has been documented in a study of clinical chemistry analyzer innovations (von Hippel and Finkelstein 1979).

We also needed measures of external resources. Therefore, we asked users whether they felt that their OPAC supplier "is receptive to user modification requests," reasoning that users who think their product supplier is generally willing to make modifications on request would be less likely to make modifications on their own. As a related question, we asked users whether they felt that their supplier was "motivated to make *free* changes." Clearly, if a supplier is willing to modify a system at no charge, users are even less likely to undertake their own modifications.

Users who do want to undertake a modification project have the choice of doing it themselves or hiring an external contractor ("consultant") to do it for them. We reason that users who want to carry out an innovation project and feel they cannot find a suitably qualified one are more likely to innovate themselves. In the case of OPACs, this situation is likely to pertain frequently. OPACs are relatively specialized systems used by relatively few organizations in any local area. The result is that users may well find few or no locally accessible contract programmers that are familiar with their particular system type. Accordingly, we asked users whether they felt that there was a "lack of suitably qualified external consultants" capable of making modifications to their OPAC. We also asked respondents the extent to which they agreed that "our library has no money to pay for modifications," reasoning that libraries are more likely to innovate for themselves if they don't have the funds to pay external organizations for the required modifications.

The above questions investigate capabilities available, both internally and externally, as well as capabilities required. The final capability issue for a user with a strong incentive to innovate (a lead user) and the resources to do so is whether an internal culture exists that encourages the resources to be harnessed to reap the reward. Some user organizations—in the case of the present study, library administrations—have policies against allowing any in-house modifications to purchased products. Among the reasons for this are concerns that "something will be damaged" in the course of these modifications, that manufacturer warranties will be voided as a result of in-house tinkering, or that desirable commonality among sites will be compromised. Whatever the reason for installing such a policy, it seems reasonable that a user policy against making modifications would tend to reduce their likelihood. Accordingly, we asked users to agree or disagree with the statement that "our library policy does not encourage changes."

A final measure hypothesized to affect the likelihood of innovation by users is the level of need they experience for such innovations. As noted earlier, it has been shown that users innovate if and as they expect that activity to pay. We used "need" as a proxy for expectations of innovation-related benefit, and asked our respondents to agree or disagree with the statement that "we have no real need to modify our OPAC."

4.2. Findings Regarding Characteristics of Users That Modify OPACs

We next test the ability of each of the factors described in §4.1 to discriminate between users that do and do not modify their OPACs. First, with respect to leading edge status, we follow Morrison (1995), and use a seven-item scale to measure the construct of leading edge status. The measures used are contained in the appendix and the results of the factor analytic measurement model are provided in Table 4. (A standard statistical test suggests one factor, and the Cronbach alpha is 0.77 suggesting good construct validity.)

Our findings with respect to the capability factors hypothesized to discriminate between users that do and do not modify OPACs follow next. Data were collected for each of the nine items shown by eliciting responses on a seven-point Likert scale. A principal components factor analysis of responses to these nine items yielded three factors explaining 62% of the attribute variance, as illustrated in Table 5. After varimax rotation we labeled these three factors "lack of in-house technical skills" (related to no technical skills, no technical capability, and the inability to penetrate a closed manufacturer system); "lack of

Table 4 Factor Analysis of Leading Edge Status

Facet of LES Construct	Item	Factor Loading
Benefits recognized early	We are ahead of other libraries in recognizing new solutions	0.750
High level of benefits expected	We have benefited from the early adoption of OPACs	0.499
Perceived LES		
(by self)	We are leading edge (definition provided)	0.671
(by others)	Mentions by others as leading edge	0.454
Applications innovativeness	We have pioneered some applications	0.749
	We suggest new applications to developers	0.738
	We have been used as a test site for prototypes	0.648

Table 5 Factor Analysis of Barriers to Innovation

Item	Factor 1: Lack of in-house technical skills	Factor 2: Lack of external resources	Factor 3: Lack of incentive to modify
No technical capability for major reprogramming	**0.916**	0.062	−0.066
No technical skills for small add-on programs	**0.907**	0.103	−0.035
Our OPAC is technically difficult to modify	**0.599**	−0.057	0.166
Library has no money to pay for modifications	0.231	**0.731**	0.340
Supplier is receptive to user modification requests	0.261	**−0.661**	0.438
Supplier is not motivated to make free changes	−0.089	**0.647**	−0.025
Lack of suitably qualified external consultants	0.296	**0.492**	−0.057
Our library policy does not encourage changes	−0.051	0.312	**0.810**
No felt need to modify OPAC	0.058	−0.332	**0.702**

external resources" (no money to pay vendors, unwillingness of suppliers to make modifications for users, and lack of suitable external consultants); and "lack of incentive" (no need for changes, and user organization policies discouraging in-house modifications). These three factors represent different facets of barriers to innovation and its converse, corporate capability.

If we assume that the decision to innovate or not innovate, and share or not share, are utility-based and that the error in estimating the utility of these decisions in i.i.d. Weibull distributed we can use a logit model to understand the decisions' determinants. When we assess the relationship between our hypothesized factors and innovative behavior, we find that leading-edge status is highly statistically significant and important, followed by whether the firm has in-house technical skills. The third barrier to adoption (having to do with the incentive to modify) is also statistically significant, whereas the second barrier ("lack of external resources") is marginally not significant (Table 6).

Table 6 Logit Model of Innovative Behavior

	Coefficient	Standard Error
Leading edge status	1.862	0.601
Lack of in-house technical skills	−1.069	0.412
Lack of external resources	0.695	0.456
Lack of incentive to modify	−0.845	0.436
Constant	−2.593	0.556

$\chi^2_4 = 33.85$ $\rho^2 = 0.40$ Classification rate = 87.78%

5. User Sharing of Innovations

Although much work has been undertaken on the development of user innovations, little research has been done on whether user innovations tend to be held secret by the innovating users or whether they are somehow made available to other users. This is an interesting question for at least two reasons. First, the economic welfare generated by a user innovation is substantially greater if that innovation is made available to all users either by direct user-to-user sharing or by revealing of the innovation to a manufacturer. After all, if a generally useful user-developed innovation is not shared, others must go to the expense of independently inventing something similar. Second, it only benefits manufacturers to seek out modifications and innovations by users if user-innovators are willing to reveal what they have done.

5.1. Factors Likely to Be Associated with Innovation Sharing by Users

Research into "informal information trading" has shown that users do sometimes informally trade and share innovation-related information with others. It has also been shown that reciprocal trading will pay

even among direct rivals if the loss of profit associated with revealing an exclusively held innovation to a rival is more than offset by the gain in profit associated with the information received in trade. In brief, the logic is as follows: Suppose that two rivals are considering trading innovations that they each currently hold exclusively, and that each has equal competitive value. Also suppose that the profit each receives from its exclusively held innovation can be represented by $R + \Delta R$, where ΔR is the incremental profit each obtains because it holds its innovation exclusively. After trading, each side will have both innovations and will gain benefit from them of $2R$ because exclusivity on both has been given up by both traders. This means that trading will pay whenever $R > \Delta R$ (von Hippel 1987, Schrader 1991).

Libraries are not direct rivals in the marketplace because they tend to specialize with respect to both geographic coverage and subject matter. In fields where users are not commercial rivals ΔR is zero, and information trading will always pay—as long as the cost of actually transferring the information is offset by perceived benefit of some kind.

Costs associated with transferring innovation-related information on OPAC modifications are relatively minor—at most involving providing a copy of user-developed software code plus some informal consulting by library staff. As a result, we hypothesize that small transfer costs, such as when an innovating user already has established links in place to other users and manufacturers (for example, via membership in manufacturer-sponsored user groups), will increase the likelihood that a user making a modification will share it with others. Rogers (1983) has identified the importance of preexisting communication networks in the diffusion of innovation, while Midgley et al. (1992) demonstrated the effect of different network structures in determining the shape of the diffusion curve of an innovation. In addition, we would expect users to be more likely to undertake the effort to inform other users and/or manufacturers of an innovation they had developed if they thought that those others would find it of value. We use membership of a manufacturer-sponsored OPAC user group as a surrogate for network connectedness of the user. We have direct measures of the manufacturer's valuation of the innovation based on a description from the user. Finally, we measure whether the innovating user thought that its innovations were of general value by its level of agreement with the statement, "The needs of this library are unique."

Table 7 Logit Model of Innovation Sharing

	Coefficient	Standard Error
User belongs to OPAC user group	2.443	1.148
Manufacturer's evaluation of the commercial Value of user's modifications	0.032	0.018
User's perception its needs are unique	−0.572	0.304
Constant	−0.780	1.283

$\chi^2_3 = 11.03$ $\rho^2 = 0.28$ Classification rate = 78.57%

5.2. Findings Regarding Characteristics of Users Who Share

In our sample, we found a fairly high level of information sharing by users who have modified their OPACs. Of the 26 users who developed modifications, 20 answered the question on who they shared with. Of these, 4 reported fully explaining these to their OPAC supplier only, 6 reported sharing their information with users only, and 5 reported sharing with both users and manufacturers. Only 5 users did not share any information regarding their modifications with others. If we focus on modifications rather than users, we find that 56% (22 of the 39) of the modifications studied were shared with manufacturers or users, while 17 were not. (See Table 1—modifications that were shared with users and/or manufacturers are indicated by (S).) The results of fitting these data by the logit model of sharing behavior are described in Table 7. All of the variables are statistically significant, and the model has very strong discriminating ability. It forecasts that 10 users would not share their innovations who did not, 12 users who did share their innovations would, and misforecast only 4 cases of sharing where it did not occur and 2 cases of not sharing where it did occur. That is, the overall classification accuracy was 79%, which is extremely high.

As a matter of interest, we also asked respondents whether they were the recipients of the innovations of others. Sixteen respondents said that they had received innovations from other users, whereas 86 said

that they had not. This is reasonably consistent with the number of innovations that were claimed by innovators to be shared. We undertook a chi-square statistical test to determine whether there was a positive association between the sharing of innovations and the receiving of them. Such a positive association would lend support to the argument that one of the major reasons to share user innovation is for information trading. The test did not have a lot of statistical power because of the relatively small number of innovations received and shared (16 and 20, respectively). The results were in the hypothesized direction (sharers were more likely to receive), but not statistically significant.

6. Discussion

In this research we have provided a first comprehensive view of user product modification activities within a user population, including sharing behavior. Further, we have focused our inquiries on a "local" user population that is not the world leader with respect to technical change of the type studied. In this discussion, we explore some implications of our findings for innovation research and for idea generation processes used by manufacturing firms.

In the introduction to this paper, we noted that there was some evidence and logic to suggest that innovation by users might be found concentrated among lead users. In this study we found innovating users had high leading-edge status relative to other Australian OPAC users, with the impact of LES being moderated by the capability of users to harness their resources and those of the external environment. On the face of it, this adds support to the hypothesis that innovation will be found concentrated among lead users.

Libraries in our sample found to have high leading-edge status when judged relative to other Australian libraries would surely have lower leading-edge status if a worldwide ranking were used. At the start of this study we reasoned that users at the leading edge of a local population would have an incentive to innovate when either or both of two conditions hold. First, when a local community has unique needs, local lead users really are world lead users with respect to those needs, and would be expected to innovate given expectations of an attractive cost-benefit ratio from so doing. Second, local lead users would have reason to develop innovations for which their local community has follower status if they think that it will be cheaper to innovate anew than to search for and acquire a needed innovation that may exist elsewhere.

In our sample, it is likely that both of these conditions hold for some innovations. With respect to the first condition, recall that several of the user-developed innovations in our sample were judged by their developers to serve the unique needs of their library. With respect to the second condition, recall that costs of many of the OPAC modifications developed by users in our sample was quite low. We also saw that the cost of local sharing—among users in the Australian OPAC user community—was low, with sharing users tending to participate in local, Australian users' groups and so forth. It is quite likely—but not certain—that the cost of global sharing (learning about innovations carried out by users outside the local OPAC community) would be at least somewhat higher—justifying independent development of low-cost innovations by users in the local OPAC community. Further research is needed to test the possibility that more costly innovations are developed by suppliers and/or libraries that qualify as lead users in worldwide terms. The choice regarding local customization here for the innovating user is analogous to the choice for manufacturers in international marketing when they have to choose where to sit on the customization versus globalization spectrum (see Quelch and Hoff 1986).

On a second matter, recall that while 72% of respondents agreed that they were "satisfied with the performance of their OPAC," 54% also agreed with the statement that "we would like to make additional improvements to our OPAC functionality that can't be made by simply adjusting the standard, customer-accessible parameters provided by the supplier." Recall that OPACs are quite user-adjustable as products go, and are often even further customized to meet the needs of individual users by suppliers at initial installation. Taken together, these findings suggest that some amount of OPAC-related user needs—needs where users can say exactly what additional functionality they want—are not presently being satisfied by commercial offerings. It would be useful to carry out

further research to explore whether a significant level of such unsatisfied needs is characteristic of many markets, and if so, it would be useful to think about how these needs might be better satisfied.

Lack of knowledge or misapprehension of stable needs uniformly held by many users in a marketplace can be addressed by better marketing research, followed by the development of more appropriately designed products. On the other hand, if the root of the problem turns out to be high heterogeneity of needs in a given marketplace, the problem is more difficult. A traditional solution would be to develop differing product types and features for different segments of the market. However, this approach cannot address within-segment heterogeneity, which may also prove to be considerable, and it cannot address any evolution in user need that occurs after purchase. A second, less-conventional solution would be to enhance the ability of users to make modifications to products on their own post-purchase. In our sample, 26% of the users invested money and time to modify their OPACs to more closely meet their needs. It is likely that a greater fraction of the users expressing dissatisfaction would find it worthwhile to also make post-purchase modifications if this solution were somehow made cheaper or faster or easier. More research along these lines would be useful to explore how this might be better done (von Hippel 1999).

On a third matter, we note that innovations by users are a more efficient use of resources from a systemwide perspective if and as innovating users are willing to share information on their innovations with others. (Absent such sharing, an innovation developed by a user would have to be developed anew at an additional cost to the system by each user until a user or a manufacturer innovated that was willing to diffuse the innovation-related information to others, either gratis or at a charge.) Our study supports the idea that innovation by users can at least sometimes be efficient in this sense, because we did see widespread innovation sharing at no cost to recipients by innovating users of OPACs. However, as was discussed earlier, sharing typically makes economic sense in an industry where users are not direct rivals in the marketplace—as is the case for the libraries in our sample. Therefore, this finding cannot be generalized beyond marketplaces with this characteristic. In marketplaces where users are direct rivals, hiding rather than sharing of innovations by user-innovators may be the norm.

What are the general implications of our findings for the idea generation practices of manufacturers? Our study has shown OPAC users in a local market frequently modify products in ways that OPAC manufacturers find to be of potential commercial interest. We also found that users making modifications are typically willing to share them. Taken together, these facts suggest that manufacturers might find it useful to develop systematic ways to acquire information on user innovations and modifications as an input to their idea generation processes—even if they only collect information from lead users in their local marketplace.

Several of the factors we have tested in this study have proven useful for distinguishing innovating from noninnovating and sharing from nonsharing users. In principle, therefore, they could be useful in manufacturer efforts to screen user populations in order to identify innovating users. However, full screenings of user populations can be a costly approach to identifying innovating lead users—especially in cases involving large user populations and relatively rare instances of innovation by users. In such cases a networking process might be more practical.

Networking is possible if likely innovators in a population are known to many others in that population via reputation. When this is so, interviewers are able to identify many likely innovators by asking a relatively small number of users to nominate likely candidates (von Hippel et al. 1999), a technique increasingly practiced under the label of viral marketing. Data we collected on one of the items incorporated into Morrison's LES construct—"mentions by others as leading edge"—support the likely effectiveness of a networking approach. We found that the correlation between the number of mentions a user received by others as leading edge and the LES score of that user was significant. (Spearman rho for "number of mentions" and "LES" score $= 0.389$ ($p < 0.01$), Pearson correlation $= 0.454$ $p < 0.01$). We also found a significant correlation between the number of mentions of a given user by others as leading edge and that user having reported making innovations (Spearman rho for "number of mentions" by others as leading

edge and reported "modifications" of OPAC = 0.181 ($p < 0.10$), Pearson correlation = 0.276 $p < 0.01$). Further research on the reputations of innovators and the efficiency of identifying them via networking would be useful.

Our study has added to the literature on innovation documenting extensive innovation by lead users in a local market. We have been able to characterize users likely to innovate and users likely to share information regarding their innovations with other users and with manufacturers. We think that these findings strengthen the case for systematic inclusion of lead user ideas in manufacturer idea generation processes. We look forward to additional research that will explore still more pieces of the puzzle related to this very interesting topic.

[4] The authors would like to thank the department editor, Ralph Katz, and two anonymous reviewers for their assistance with this manuscript.

Appendix. Variable Operationalizations

Measures for the variables were either adapted from the previous literature or developed specifically for this study, based on qualitative research.

Dependent Variables: Modification and Share. To address the primary research question of how many users innovated we asked the question, "Has your library recently developed modifications to the function of the OPAC?" with a binary yes/no response.

For the second research question regarding the extent of innovation sharing and its causes we asked, "Did you share your modification with (a) other users or (b) a supplier?" again with a binary yes/no response. Additionally, open-ended descriptions of innovations developed and shared were elicited, together with the specific skills that users thought made it useful for them to undertake the innovations themselves.

Independent Variable Measures. The majority of independent variables were measured by multiple items that were reduced to single constructs using principal components factor analysis with varimax rotation. In estimating the probability of "innovation activity" there were two hypothesized independent constructs, namely "leading edge status" (LES) and "capability." The LES construct measures how leading edge the organization is, and consists of seven items. Five of these were measured on five-point Likert scales anchored at *strongly agree* and *strongly disagree* (applications pioneering, suggesting new applications, use as a test site, early in recognizing solutions, and benefited from early adoption, see Table 4). The sixth of these was a self-stated measure on a seven-point scale, while the last was a count of how often other libraries referred to this one as leading edge. The second independent construct, "capability," measures the user's perceptions of the organization's financial, technical, and policy capabilities and barriers related to undertaking innovation. Nine items were elicited on a seven-point Likert scale: policy, finances, supplier reluctance, technical skills, technical capacity, closed systems, supplier communications, lack of third parties, and low level of need (see Table 5).

Modification sharing was explored via three independent constructs: network connectedness, uniqueness of needs, and "value" (were the shared modifications valued by other users/manufacturers). The first construct here, network connectedness, was measured by a surrogate, whether the library belonged to a user group. "User group" was a single binary (yes/no) measure. Uniqueness of needs was elicited on a seven-point Likert scale. "Value" was measured as follows. After the survey data were received from the library respondents, a list containing a description of each modification was prepared and independently evaluated by two manufacturers. These independent judges were asked to rate each of the user modifications, using a 100-point scale, on questions relating to "novelty of information contained in the user innovation" and "how much value does the user innovation bring to the system."

The survey also collected information on the size of the organization, time of adoption of the OPAC system, customization by self and supplier during installation, receipt of others' innovations, and experience with other technologies. These were used as covariates.

References

Cyert, R. M., J. G. March. 1963. *A Behavioral Theory of the Firm*. Prentice Hall, Englewood Cliffs, NJ.

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

Freeman, C. 1968. Chemical process plant: Innovation and the world market. *National Inst. Econom. Rev.* **45** (August) 29–57.

Gans, J. S., S. Stern. 1999. The economics of user-based innovation. Working paper, MIT Sloan School of Management, Cambridge, MA.

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

Lionetta, W. G., Jr. 1977. Sources of innovation within the pultrusion industry. Unpublished S.M. thesis, MIT Sloan School of Management, Cambridge, MA.

Mansfield, E. 1968. *The Economics of Technological Change*. W. W. Norton & Company, New York.

Matthews, J. 1985. *Public Access to Online Catalogs*, 2nd Ed. Neal-Schuman, New York.

Midgley, D. F., G. R. Dowling. 1978. Innovativeness: The concept and its measurement. *J. Consumer Res.* **4** (March) 229–242.

——, P. D. Morrison, J. H. Roberts. 1992. The effect of network structure in industrial diffusion processes. *Res. Policy* **21** (6) 533–552.

Morrison, P. D. 1995. A framework for studying the adoption of technological innovations by organizations and the role of leading edge users in the process. Unpublished doctoral dissertation, Australian Graduate School of Management, UNSW, Sydney, Australia.

Ogawa, S. 1998. Does sticky information affect the locus of innovation? Evidence from the Japanese convenience-store industry. *Res. Policy* **26** 777–790.

Quelch, J. A., E. J. Hoff. 1986. Customizing global marketing. *Harvard Bus. Rev.* **64** (May–June) 59–68.

Riggs, W., E. von Hippel. 1994. The impact of scientific and commercial values on the sources of scientific instrument innovation. *Res. Policy* **23** (July) 459–469.

Rogers, E. M. 1983. *Diffusion of Innovations*, 3rd Ed. The Free Press, New York.

Schmookler, J. 1966. *Invention and Economic Growth.* Harvard University Press, Cambridge, MA.

——. 1972. *Patents, Invention, and Economic Change.* Harvard University Press, Cambridge, MA.

Schrader, S. 1991. Informal technology transfer between firms: Cooperation through information trading. *Res. Policy* **20** 153–169.

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

Tedd, L. A. 1994. OPACs through the ages. *Library Rev.* **43** (4) 27–37.

Urban, G. L., E. von Hippel. 1988. Lead user analyses for the development of new industrial products. *Management Sci.* **34** (May) 569–582.

VanderWerf, P. 1990. Product tying and innovation in U.S. wire preparation equipment. *Res. Policy* **19** 83–96.

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

——. 1977. The dominant role of users in the semiconductor and electronic subassembly process innovation. *IEEE Trans. on Eng. Management* **24** (May) 60–71.

——. 1986. Lead users: A source of novel product concepts. *Management Sci.* **32** 791–805.

——. 1987. Cooperation between rivals: Informal know-how trading. *Res. Policy* **16** 291–302.

——. 1988. *The Sources of Innovation*. Oxford University Press, New York.

——. 1994. Sticky information and the locus of problem solving: Implications for innovation. *Management Sci.* **40** (4) 429–439.

——. 1998. Economics of product development by users: The impact of `sticky' local information. *Management Sci.* **44** (5) 629–644.

——. 1999. Toolkits for user innovation. Working paper # 4058, MIT Sloan School of Management, Cambridge, MA.

——, J. Churchill, M. Sonnack. 1999. *Breakthrough Products with Lead User Research.* Lead User Concepts Inc., leaduser.com.

——, Stan N. Finkelstein. 1979. Analysis of innovation in automated clinical chemistry analyzers. *Sci. Publ. Policy* **6** (1) 24–37.

Accepted by Ralph Katz; received October, 1999. This paper was with the authors 4 months for 2 revisions.

CORRECTION

In this article, "Determinants of User Innovation and Innovation Sharing in a Local Market" by Pamela D. Morrison, John H. Roberts, and Eric von Hippel (first published in *Management Science*, 2000, vol. 46, no. 12, DOI:10.1287/mnsc.46.12.1513.12076), the authors have now made this article Open Access under CC BY-ND License below: