Arvanitis, Spyros; Fuchs, Barbara; Woerter, Martin

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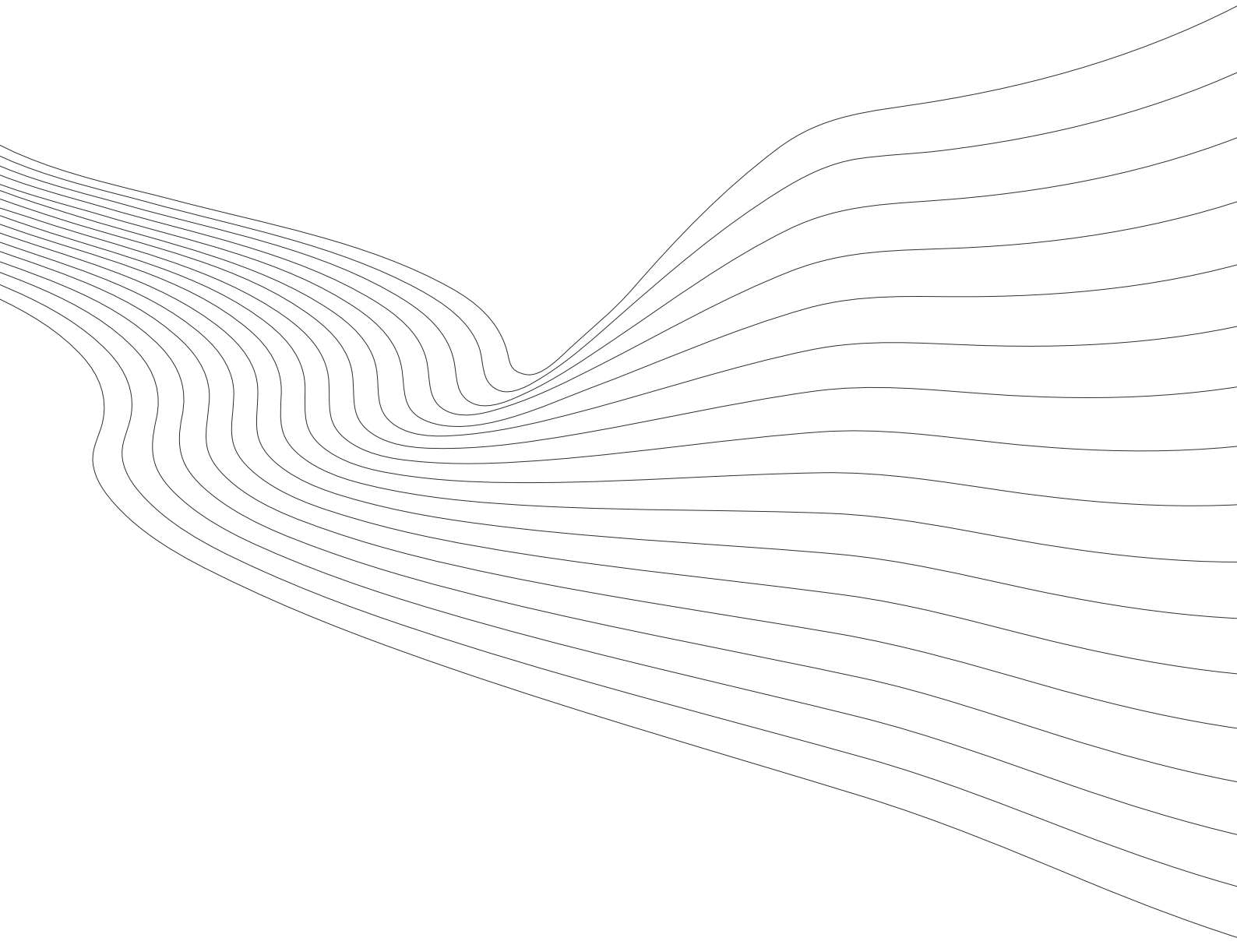

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ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

KOF

ETH Zurich
KOF Swiss Economic Institute
WEH D 4
Weinbergstrasse 35
8092 Zurich
Switzerland

Phone +41 44 632 42 39
Fax +41 44 632 12 18
www.kof.ethz.ch
kof@kof.ethz.ch

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Spyros Arvanitis

ETH Zurich, KOF Swiss Economic Institute
Weinbergstrasse 35
8092 Zurich, Switzerland
Phone: +41 44 632 51 68
Fax: +41 44 632 12 34
E-mail: arvanitis@kof.ethz.ch

Barbara Fuchs

University of Liechtenstein
Institute for Entrepreneurship
Fürst-Franz-Josef-Strasse
9490 Vaduz, Liechtenstein

Martin Woerter

ETH Zurich, KOF Swiss Economic Institute
Weinbergstrasse 35
8092 Zurich, Switzerland
Phone: +41 44 632 51 51
Fax: +41 44 632 12 34
E-mail: woerter@kof.ethz.ch

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Abstract

Research about users as a source of innovation has been largely restricted to case studies exploring specific innovation projects at the firm level. This study assesses empirically the relationship between external end users' knowledge as an input factor to innovation and firms' innovation success. The results strongly support the hypotheses: (i) that external end users have the potential to essentially improve the innovative performance of firms; (ii) that the technique of interaction during the innovation process and the characteristics of involved external users matter as well. The more firms make use of emphatic design and select specific users to acquire hard-to-articulate customer needs, the stronger is the relationship between access to external end users' knowledge and firm innovation success measured in sales of innovative products.

Keywords: user innovation, user interaction, lead user, innovation performance

JEL-Code: O31

1. Introduction

There is broad consensus that knowledge possessed by users is a fundamental source for generating original ideas and successful innovation.[1] However, most of the research on user innovation has been conducted on the basis of case and small-sample studies exploring specific product and process innovations as the main unit of analysis (Bogers et. al. 2010). These studies are very perceptive but it is difficult to esteem how representative they are. Very little attention has been given to investigating the impact of cooperating with users on the overall innovative output of firms. However, firms are seeking more information on the potential benefits of user innovation to justify the often costly search for external users and the disclosure of strategically sensitive data. Thus, the purpose of this study is to provide broader empirical evidence on the relationship between interacting with users during the innovation process and firm innovation performance.

In our research we seek to develop an empirical model to explain how pervasive and economically important external end users' knowledge is as an input to firm innovation. We investigated users who are external to the firm, i.e. they are neither employed by the firm nor do they work as a freelancer or consultant on a regular basis with this firm. In addition, external users had to have personal hands-on experience with the respective firms' final goods and services. With respect to these two criteria we further distinguished between external end users coming from other firms or other institutions and private external end users.

Based on our econometric analysis combining survey data on cooperation with users and on firm innovation output, we find that integration of external end users is positively related with the sales share of innovative products. We also detect positive relationships between the specific interaction methods of emphatic design and the lead user method and the sales share of innovative products. We propose that our findings should help managers and policy makers to better assess and manage the input of external end users to innovation success.

Our contribution to the literature is threefold. First, to our best knowledge, this is the first study to econometrically model and test the relationship between external end user's knowledge as an input factor to firm innovation and firm innovation success. Second, we contribute to a better understanding of how firms can capture external end users' knowledge by applying different methods of interaction. Third, we add to the accumulation of empirical evidence on some of the central tenants of user innovation research, and more specifically of lead-user theory.

The remainder of this paper is organized as follows. We first review the related literature to demonstrate the importance of users as innovators. We shed light on their motivations and outline the relevance of user characteristics and different users' knowledge in order to predict

[1] For a comprehensive overview and discussion of the empirical evidence on user innovation see: von Hippel (1988), p. 19ff., von Hippel (2005), p.22ff., Lüthje and Herstatt (2004), p. 556 and Franke et. al. (2006), p. 303f.

their innovative output. Then, drawing on the work of scholars from user innovation, the resource-based view of the firm and new product development, we develop our research hypotheses. In the following, we describe the research design and report our empirical findings. Finally, we present our conclusions and outline important limitations as well as directions for further research.

2. Literature Review

There is considerable empirical evidence on the importance of users in the innovation process. Enos (1962) pointed out that most of the important innovations in oil refining were not developed by the equipment manufacturers but by the refineries using their machines and material. Freeman (1968) showed that about 70% of major process innovations in the chemical industry stem from firms not producing but using the tools and machinery. Rosenberg (1976) and von Hippel (1976, 1977) presented further evidence that in some industries industrial products are usually invented, prototyped and first applied by users and not by the firms manufacturing such goods for commercial sale.

By further examining users as a source of innovation, considerable progress has been made in understanding their motivations and impact on innovation projects. Users can generally be defined as individuals making use of a specific object for their professional or private use. In more detail, users fall into different categories. On the one hand, they work inside of firms and institutions making use of tools, materials and equipment for the purpose of delivering their own firm's goods and services, e.g., assembly line workers, engineers, scientists, doctors and administrative staff. Their innovative activities can be directed either at the resources of their own firm or of other firms, e.g., their suppliers. On the other hand, users can be individuals who are using final products and services for their own private endeavors. In any case, users seem to innovate primarily if they derive a net benefit. Users directly benefit from their innovative activities by modifying existing products or creating an original solution that better satisfies their individual needs than any offering readily available on the market (Lerner and Tirole 2002, von Hippel 1988, 2005). The mere joys of carrying out innovative tasks, the opportunity to signal special skills to peer groups and potential employers and financial rewards have been identified as further incentives for users to innovate (Lerner and Tirole 2002, Lakhani and von Hippel 2003, Lüthje 2004). Users indirectly benefit from later payoffs as they sell their ideas, products and services to others or start their own business (Foxall and Tierney 1984, Lee 1996, Sha and Tripsas 2007). Lower innovation-related costs in combination with sticky information and tacit knowledge have also been offered as plausible explanation for why users rather than manufacturers innovate (von Hippel 1994, Lüthje et. al. 2005). In general, findings from empirical studies on user innovation suggest that the higher the expected benefits from innovation, the more likely users are to engage in innovation.

Whereas most user innovators seem to be motivated by similar factors, they vary in personal traits and innovation success: The more users meet the characteristics of advanced or lead users, the more substantial seems to be their innovative output (Urban and von Hippel 1988, Franke and Shah 2003, Morrison et. al. 2004, Lühtje 2004, Franke et. al. 2006, Lettl et. al. 2006). Advanced or expert users are facing needs that are quite common among all users, but are experiencing high problem pressure urging them to look for new solutions (Lettl et. al. 2006). In addition, they possess both high experience in using a product and product related expert knowledge, e.g., about materials and technologies used that allows them to systematically analyse and redesign the integrated product experience. They also exhibit tolerance for ambiguity, are able to translate their needs into concrete specifications and usually have access to a larger network of experts in their specific user domain (von Hippel and Katz 2002, Lüthje 2004, Lettl et. al. 2006). Lead users show similar characteristics as advanced users, but differ from them in trend leadership. Lead users are defined by facing needs "that will be general in a market place – but face them months or years before the bulk of that marketplace encounters them, *and* lead users are positioned to benefit significantly by obtaining a solution to those needs" (von Hippel 1988, p. 107). Typically, lead users possess knowledge with very distinctive properties. They have built knowledge around their own user experience and individual problem solving capabilities. Their knowledge is highly concentrated and contextualized as they understand their own needs and have a perspective in which context and how a new product will be used (Sha and Tripsas 2007). Being ahead of a major market trend, they are familiar with existing artifacts and systems of usage as well as with emerging possibilities for reframing or recombining resources by the use of new technologies. Moreover, lead users tend to develop and test their own prototypes, and to gather feedback from experts and friends on design, functionality and usage (Franke et. al. 2006). As a result, they gain deep insight into market demand and develop a good understanding of dynamics possibly determining industry evolution. Hence empirical studies strongly suggest that lead user innovations results in commercially attractive new products and services (Urban and von Hippel 1988, Morrison et. al. 2000, Lüthje et. al. 2003). In particular, empirical studies have demonstrated that product concepts developed by advanced and lead users are strongly preferred by ordinary users over any other solution (Urban and von Hippel 1988, Herstatt and von Hippel 1992). When compared to projects developed on more conventional market research methods projects involving lead users also tend to exhibit lower development cost (Herstatt and von Hippel 1992) and shorter development time (Langerak and Hultink 2008). Finally, findings emphasize that advanced and lead users have the potential to generate ideas for more radical and break-through innovations (Lilien et al. 2002, Lühtje and Herstatt 2004, Lettl et al. 2006, Lettl 2007). Based on these original findings, it is by now incontrovertible that users play an important role in the innovation of products and processes and that established firms can potentially benefit from cooperating with users during the process of innovation.

3. Research hypotheses

In the following two sub-sections, we develop our research hypotheses regarding the relationships between cooperating with external end users for the purpose of innovation and firm innovation performance. First, we delve into the portrayed positive relationship between external end user innovation and firm innovation performance, and put forth supporting arguments from evolutionary economics and the resource-based view of the firm. Second, we seize the suggestion that important user innovations will be found concentrated in the segment of advanced and lead users (Franke and von Hippel 2003). Therefore, we propose that systematically interacting with certain types of external end users can be also positively related to firm innovation performance.

3.1. Distinctive properties of external users' knowledge

Scholars from different fields have increasingly expressed their doubts that the traditional innovation paradigm according to which corporations manage innovation primarily or even exclusively from their own strictly protected R&D to production and marketing was a good representation of reality. Generally accepting the idea that firms do not innovate in isolation, Nelson and Winter (1977), Dosi (1982), Freeman (1987), Patel and Pavitt (1994) and Edquist (1997), among many others, have investigated how firms interact with other institutions to generate new ideas and propel technological change. They highlighted the interactive nature of innovation and the importance of absorbing external knowledge to succeed in innovation. To evaluate the relationship between external end users as an important source for external knowledge and firm innovation performance, we have to consider two different aspects. On the one hand, external knowledge can contribute to further specialization of a firm, which in turn makes an above average innovation success more likely (Hagedoorn 1993, Woerter 2010). As pointed out earlier in this paper, external end users, especially advanced and lead users, are in the possession of highly specialized and solution oriented knowledge stemming from their own user experience. Whereas they usually have a good understanding of the overall situational use context, many firms are adding only one part to the final product and therefore lack such understanding. Advanced and lead users´ knowledge can be characterized by high degrees of scarcity, inimitability and non-substitutability as well as by high complementarity to a firm's knowledge. There might also be a high overlap of their knowledge with strategic industry factors. In fact, these criteria were outlined by scholars from the resource-based view of the firm as some of the major determinants to explain differentiations in the resource endowments and strategic behaviour of firms. Penrose (1995), Wernerfelt (1984), Barney (1991), Grant (1991, 1996), Amit and Schoemaker (1993) applied these criteria to show why some firms are able to establish positions of sustainable competitive advantage and earn superior returns over a prolonged period of time. Therefore the specific characteristics of external end users´ knowledge hold the promise of fostering

further specialization of the firm's knowledge base with positive effects on innovation success.

On the other hand, firms tend to develop routines (Nelson and Winter 1982) resulting in persistent firm behaviour that poses a threat to endure competitive advantages under changing market conditions (Teece et al. 1997, Wernerfelt 1984). In addition, highly specialized firms bear the risk of running in a competence trap (technology lock-in) and to become technologically outdated (Woerter 2010). Cohen and Levinthal (1990) therefore defined absorptive capacity as the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends. External end users develop quite individual routines of using goods and services. They supposedly act on different sets of cognitive limitations than users inside the boundaries of firms and they are following a different rationale in their own usage behavior. From this perspective, access to external end users' individual bodies of knowledge might prove to be a profitable strategy for established firms for monitoring alternative usage scenarios and emerging technologies in order to counter the risks of high specialization. Furthermore, advanced and lead users are mostly willing to share their knowledge at comparatively low cost with firms that are potentially in the position to deliver new solutions based on their preconceived ideas and prototypes

In sum, cooperation with external end users can be positively related with firm innovation success because of an increased specialization in the knowledge base, and at the same time lowering the risk of an outdated knowledge base through access to external users' knowledge. Hence we formulate the following hypothesis:

Hypothesis H1: There is a positive relationship between cooperating with external end users for the purpose of innovation and firm innovation success.

3.2. Methods of interaction and characteristics of users

The identification of customer and user requirements in the early stages of innovation has been recognized as one of the most important factors for developing commercially attractive new products and services (De Brentani 1995, De Brentani and Cooper 1992, Cooper and Kleinschmidt 1997, Griffin and Hauser 1993, Gruner and Homburg 2000, Alam 2005, Verwoorn et al. 2008). The need for identifying user requirements can be further accentuated in early phases of new technological cycles when uncertainty about how these technologies will eventually materialize in new products and services is extremely high (Engelbrektsson and Söderman 2004).

However, capturing new customer and user requirements is not achieved easily. Some of the difficulties directly stem from the limitations of conventional market research. Customer surveys, consumer inquiries and desk top based approaches to market analysis typically gather information from customers representing the mass market or well defined target segments. When being asked about their future needs, most of them can only speculate and tend to

request rather general and more obvious improvements in existing market offers. Simonson (1993) and Hamel and Prahalad (1994) have argued that customer's direct input to new product and service requirements should therefore be more or less ignored. Literature of social networks pointed out that although close and commercially important customers have a greater motivation to cooperate, they cannot provide access to potentially rich and diverse information (Granovetter 1982). In order to overcome these shortcomings, advocates of user innovation stress the importance of more unconventional interaction methods to discover subtle, latent and equivocal customer needs and solutions already developed by users (Lüthje 2004, von Hippel 2005). Firms are supposed to implement methods of interaction that allow them to transfer and absorb customers´ and users´ tacit, implicit and explicit knowledge.[2] Although concepts of knowledge are rather dispersed, there is a common agreement that the acquisition of knowledge and the generation of new knowledge is the product of experience grown over time, and in a specific social context (Nelson and Winter 1982, Patel and Pavitt 1984, Lundvall and Borras 1997, Hodgson 1999). Learning can only take place through the attempt to solve a problem and therefore it only takes place during activity and cumulative learning experience (Arrow 1962). Alternative market research methodologies therefore create learning situations that involve both external end users and those who are developing and commercializing new products and services, e.g., engineers, designers and marketers. Contextual inquiry (Beyer and Holtzblatt 1998) and emphatic design (Leonard and Rayport 1997) methodologies emphasize observing users in their most natural use environment, for example their workplace, to reveal latent needs and real usage scenarios. Other methods, such as the lead user method (Churchill et al. 2009), interact with users in a controlled laboratory situation and in workshops. Another common denominator of all of these methods is the use of physical or non-physical product representations to support non-verbal communication with customers and users, and the effort to cooperate with users taking into account the locus of innovation (Engelbrektsson and Söderman 2004).

In addition to the method of interaction, user innovation scholars emphasize the process of systematically selecting and identifying customers or other external end users with advanced and lead user profiles. Contextual and emphatic design methods comprise a well described phase to profile users and to consecutively observe them in their original user environment. Though often carried out with advanced users, these methods are not explicitly linked to advanced and lead users. Their focus rests on observing users in their original use environment. The lead user method encompasses a stringent process of identifying, selecting and cooperating with lead users to access their rich need information and valuable design data (Churchill et. al. 2009).

In sum, studies have shown that customer interaction during the early phases of the innovation process can separate "winners from losers" (Cooper and Kleinschmidt 1987) and that a

[2] For the definition of theses different types of knowledge see Polanyi (1966) and Nonaka (1994).

systematic approach to directly interact with certain types of external end users in their use environment might well increase the chances to discover latent needs and commercially attractive new product and service concepts. Therefore we hypothesize:

Hypothesis H2: The more firms directly and systematically interact with advanced and lead users, the more likely is a positive relationship between external end user cooperation for the purpose of innovation and firm innovation success.

4. Data and Empirical Issues

4.1. Sample

Past evaluations of user involvement analysed single innovation projects or a subset of innovation projects across firms with comparable settings and goals. To allow more general statements on the empirical relationship between cooperation with external end users' and firm innovation performance, we drew a sample of companies from the Liechtenstein company census maintained by the Institute for Entrepreneurship at the University of Liechtenstein. The small country of Liechtenstein is characterized by a highly diversified economic structure encompassing a broad range of industries and services (Hasenmaile and Golay 2004). While most firms in crafts and traditional services are competing locally over quality and price, firms in the modern industrial industries have a long standing tradition in positioning themselves as global niche players (Fuchs and Durst 2007). Innovation has been strategically most important for them. For example, Hilti, a leading provider of high-technology solutions to the global construction industry, invested at least 5% of revenue in innovation over the past decade[3]. Hilti has also been at the forefront of cooperating with lead users in product innovation processes (Herstatt and von Hippel 1992). Further anecdotal evidence by the Liechtenstein Institute for Small and Medium Enterprises suggests that also small and medium sized enterprises (SME) in Liechtenstein cooperate with external end users for the purpose of product development.

At the end of 2008, the Liechtenstein National Yearbook of Statistics showed a total number of 3648 companies. The company census of the Institute for Entrepreneurship comprised a total number of 2207 companies in manufacturing and services, representing about 61% of the total firm population.[4] For the purpose of our study we excluded private medical practices, lawyers, hotels and restaurants, unless they were also providers of catering services. In May 2009, we then drew a sample of 893 companies from the remaining census that met the criteria of having more than 1 employee and a total estimated revenue of more than 35000 Swiss Francs (see Table A.1 in the appendix, column 1 for the composition of the sample of firms that were addressed to).

[3] See Hilti Factbox (2009).
[4] Because of the Institutes' research focus on industry, the census is biased towards manufacturing (68%).

4.2. The questionnaire

To test our hypotheses the questionnaire was developed in the following procedure. To capture data on market environment and firm innovation performance, we opted for standard innovation indicators and questions taken from standard innovation surveys such as the Community Innovation Survey (CIS) of the European Union. In the questionnaire respondents were asked to give information about their market environment, competitive situation and to indicate number of employees, total revenue, etc. In the following part, we aimed at gathering data on standard innovation input and output indicators to assess the innovation performance of the firm.

Whereas for non-innovating firms, the questionnaire ended after capturing more standardized information on competition and innovation, innovating firms were asked further about whether and how they interacted with external end-users (firms, institutions, private end users). The dependent variable, which measured innovation success as sales from innovative products new to the firm, can be positive only if the firm is an innovator. We therefore restrict our analysis to these innovating firms in Liechtenstein.

Those parts of the questionnaire that had to be filled out only by firms cooperating with external end users were initially developed based on findings from the user innovation literature. Early versions of the questionnaire were then pre-tested with about 12 practitioners from Swiss and German firms with high expertise in user cooperation. Findings from these pre-tests indicated that precise definition of users, awareness of different user characteristics and knowledge about search procedures and accurately described interaction methods were among the most critical aspects to assess the innovative input of external users. Subsequently, we further developed the questionnaire to gain insights into whether and how firms selected certain types of users, their motives for and expectations about user involvement as well as techniques for and barriers to external end user interaction.

4.3. Data collection

A written questionnaire was used for data collection which started on June 27, 2009. In the first step personalized electronic mails were sent out to appropriate informants, mostly new product developers, R&D managers and firm owners of the 893 companies. When personal contacts, especially in the case of smaller firms, were missing, phone calls were made to verify the contact information. The first electronic mailing packet included a short note that informed about the research project and asked for personal support by filling out the questionnaire. Each mail contained a clickable link to the online version of the questionnaire. Mail recipients were also offered the possibility to fill out the written questionnaire attached as a .pdf-file and to return it via mail. Finally, mail recipients were informed that project members would be happy to step by for a personal interview to jointly complete the questionnaire. The first follow-up mail was sent out one month later to those respondents who

had yet to reply; further follow-up mails were sent out on October 6, October 23 and November 19, 2009. To increase the response rate, 6 project members carried out about 300 hundred extensive personal calls in parallel to the mailings to remind respondents of the research project and to arrange for personal interviews. After completion of the data collection in early December 2009, a total number of 173 questionnaires were filled out; 90 were completed through personal interviews and 83 filled out online. Each of the personal interviews took about one hour. The response rate of 19.3% can be regarded as fairly high considering the high sensitivity of firm data requested (see Table A.1 in the appendix, columns 2 and 3). However, due to item non-response not all of the 173 observations could be used for the econometric estimations.

5. Specification of the empirical model

We formulate three types of empirical models in order to test our hypotheses:

a) An innovation model, b) an end-user model and c) a lead-user model.

$$LINNS = \beta_0 + \beta_1 R\&D\_PD + \beta_2 DEMAND + \beta_3 N\_COMPET + \beta_4 EXPORT + \beta_5 INTERNAT\_COMPET + \beta_6 L\_AGE + \beta_7 LEMPL + \beta_8 HT + \beta_9 LT + \beta_{10} M\_SERV1 + \beta_{11} M\_SERV2 + \beta_{12} T\_SERV \quad \text{(a)}$$

Model (a) describes the relationship between the sales share of innovative products (LINNS) and important determinants of innovative behaviour (see Table 1 for the variable description)[5]. R&D expenditures are an important input factor for innovation activities; also the current demand is expected to be positively related with innovation performance. We further control for the number of principal competitors (N_COMPET), the export activities of firms (EXPORT), the exposure of firms to international competition (INTERNAT_COMPET), the firm age (L_AGE), the firm size (number of employees), and industry affiliation (HT, LT, M_SERV1, M_SERV2, T_SERV; construction is the reference sector).

$$LINNS = \beta_0 + \beta_1 INNUSER\_X + \beta_2 R\&D\_PD + \beta_3 DEMAND + \beta_4 N\_COMPET + \beta_5 EXPORT + \beta_6 INTERNAT\_COMPET + \beta_7 L\_AGE + \beta_8 LEMPL + \beta_9 HT + \beta_{10} LT + \beta_{11} M\_SERV1 + \beta_{12} M\_SERV2 + \beta_{13} T\_SERV \quad \text{(b)}$$

where $INNUSER\_X \in (INNUSER\_TOT, INNUSER\_FIRM, INNUSER\_INST, INNUSER\_PRIV)$

[5] Table 2 shows the data composition by sub-sector and firm size for the external end user variables.

Model (b) looks at the relationship between innovation performance and firm's cooperation with external end users. We distinguish between three types of external end users: other firms as end users, institutions as end user, or private persons as end users. We also built the variable INNUSER_TOT that tells us whether a firm has cooperation with external end users at all (independent of the type of external end user). The rest of the explanatory variables are identical with model (a).

$$LINNS = \beta_0 + \beta_1 LEAD\_PHAT\_1 + \beta_2 LEAD\_PHAT\_0 + \beta_3 R\&D\_PD + \beta_4 DEMAND + \beta_5 N\_COMPET + \beta_6 EXPORT + \beta_7 INTERNAT\_COMPET + \beta_8 L\_AGE + \beta_9 LEMPL + \beta_{10} HT + \beta_{11} LT + \beta_{12} M\_SERV1 + \beta_{13} M\_SERV2 + \beta_{14} T\_SERV \quad (c)$$

$$where\ LEAD\_PHAT\_1\ \varepsilon\ (INNUSER\_LEAD\_USER\_1, INNUSER\_EMPHAT\_DESIGN\_1, INNUSER\_COMPLAINT\_1)$$

$$while\ LEAD\_PHAT\_0\ \varepsilon\ (INNUSER\_LEAD\_USER\_0, INNUSER\_EMPHAT\_DESIGN\_0, INNUSER\_COMPLAINT\_0)$$

In model (c) we distinguish between firms that contact external end users through the "lead user method", through the "emphatic design" method, or the "customer complaint management" method. Following Arvanitis (1997) we model the combined effect of cooperation with external end user and the application of one of the identified methods in the following way: If firms have cooperation with external end users and apply the "lead user method" than INNUSER_LEAD_USER_1 receives the value 1 and 0 otherwise. The same procedures apply to INNUSER_EMPHAT_1 and INNUSSER_COMPLAINT_1 if firms apply the "emphatic design method" or "customer complaint management", respectively. In case firms have contacts to external end user but do not apply one of the mentioned "methods", the variables INNUSER_LEAD_USER_0, INNUSER_EMPHAT_DESIGN_0, and INNUSER_COMPLAINT_0 receives the value 1, respectively and 0 otherwise. This way we try to figure out if one of the mentioned methods provides an additional value to the innovation performance of firms.

6. Results

In order to estimate the models (a), (b), and (c) we use a tobit estimator since our dependent variable shows a great number of zeros (firms without any innovation activities). Furthermore, our proxy for cooperation with external end users (INNUSER_TOT) is expected to be endogenous. Hence, we use an instrumental variable estimator in order to address endogeneity (Table A.2 in the appendix shows the test for endogeneity and the validity of the instrument).

Table 3 shows the results for model (a) and model (b). Model (a) is a simple innovation equation (first time estimated for Liechtenstein) and we can see than R&D active firms, firms with export activities and firms with a regional (Switzerland, western Austria, southern

Germany) focus show a greater innovation performance on the average than other firms. The variables for number of competition, demand, age, size, and the industry controls are not significant.

In model (b) we investigate the relationship between external end user cooperation and firm innovation success. In Table 3, column 3 we see that firms with external end user cooperation (INNUSER_TOT) have a significant greater innovation success compared to firms without such cooperation. Moreover, we see that this result remains stable if we instrumentalise the external end user variable (INNUSER_TOT_HAT) (see Table 3; column 4). If we distinguish between the type of external end user, i.e. other firms, private users or institutions, we clearly see that cooperation with private users and with firms is significantly positive related to the innovation performance of a firm, while the variable for cooperation with institutions does not show any significance (see Table 3, column 5, 6, and 7). This result allows us to confirm hypothesis H1. It is true that there is a positive relationship between cooperating with external end users for the purpose of innovation and firm innovation success. We want to add that this is the case for cooperation with firms and private users, but it is not the case for cooperation with institutional users.

In model (c) we look at the relevance of different "end user contact methods", i.e. "lead user method", "emphatic design", and "complaint management", for the innovation performance of firms. The estimation results show that a systematic method to consider external end user knowledge for innovation activities is related with greater innovation performance. All variables for systematic methods (LEAD_USE_METHOD, EMPHAT_DESIGN_METHOD, COMPLAINT_MANAGEMENT), show a significant positive sign. However, if we distinguish among firms that collaborate with external end users and apply one of the mentioned methods and firms that collaborate with external end users and do not apply one of the mentioned methods we get a more differentiated result. We see that firms with external end user cooperations and "lead user method" or "emphatic design method" show a greater coefficient compared to firms with end user cooperations and without such systematic methods. However, the differences are only significant in the case of "emphatic design" (see Table 4; column 5 (F-test)).

Hence, we can partly confirm our hypothesis H2. Firms with a systematic external end user approach tend to have a greater innovation performance compared to firms without such approaches. However, the differences between firms with systematic approaches and without systematic approaches are only significant in the case of "emphatic designs". Firms applying the "lead-user method" show also a greater coefficient compared to firms without "lead user method". However the difference is only significant on a 15% level. In case the "emphatic design method" implies contacts with lead users or advanced users, we can also confirm H2, in the sense that direct and systematic interaction between firms and advanced and lead users

is significantly positively correlated with the innovation performance of firms compared to firms with systematic approach but without involving advanced and lead users.

7. Conclusions

Our research was motivated by the apparent discrepancy between the overwhelming positive results from user innovation literature concerning users´ innovative contributions and the comparatively small number of studies that have investigated the effect of this form of cooperation on firm innovation success. Certainly, the technological and economic output is of utmost importance to firms to justify such cooperative agreements. We therefore developed three econometric models. First, we estimated an innovation performance function in order to confirm earlier results on the main determinants of innovation activities. Secondly, we estimated the relationship between innovation performance and cooperation with external end users distinguishing between private users, firms as end users and institutions. Thirdly, we estimated a model that looks at different systematic methods of external end user contacts: "lead-user method", "emphatic design", and "complaint management". This way we can see if systematic contact methods and cooperation with users of a specific profile are significantly related with innovation performance and if there are differences among the systematic approaches.

First, our empirical test confirmed, that firms cooperating with external end users for the purpose of innovation perform better in terms of innovative sales than do other firms. This is in line with the findings from user innovation research pointing out that gathering information from sources outside the company is an important element to enhance innovation output (von Hippel 1988, Lilien et al. 2002). Past research suggests that firms can benefit from cooperating with external end users within the framework of single innovation and new product development projects. In our study we assessed the extent to which firms profit from engaging users as external partners and found a clear, positive relationship between cooperating with external end users and firms´ overall innovation success. We suggest that this result stems from the parallel effects of external end users´ knowledge adding both to specialization and enhanced absorptive capacity. Second, taking a look at how firms interact with customers and users, we see that different methods influence our success measures differently. The finding that the use of the emphatic design method goes hand in hand with a higher share in innovative sales is in line with our second hypothesis. This finding suggests that more conventional forms of market research based on verbal and written forms of communication are hardly apt to deliver insights into latent needs, new ways of framing a problem or solutions to existing problems. As pointed out by many scholars (e.g., Polanyi 1966, Arrow 1962, Grant 1991, Kogut and Zander 1992) before, knowledge must be regarded as the product of experience. In order to learn from external end users and to absorb their knowledge, firms need to engage personally and in a well described manner with users. The

pursuit of a clear strategy towards user interaction might also have a positive effect on the absorptive capacity as firms have to nurture individual skills and organizational learning routines that allow them to systematically search and evaluate external end users knowledge Considering user characteristics our findings are more ambiguous. In contrast to our expectations, we observed a greater significance with firms deploying the emphatic design method than those carrying out the lead user method. Firms implementing emphatic design also indicated that their cooperative users can be characterized by high levels of use experience and expert knowledge. We conjecture that firms deploying emphatic design have access to advanced users´ complementary knowledge that represents the needs of most users at the time of innovation. Thus, they can profit from their knowledge at any time of the product or industry life cycle. In contrast, firms cooperating with lead users might achieve superior returns in times when a new technological paradigm is emerging. Exploring the role of different users in technology and industry dynamics further might well be a fruitful direction for future research (Bogers 2010).

From a management point of view, our findings indicate that external end user cooperation is a crucial point for succeeding in innovation. There might be a role for policy makers to design policy measures targeting the knowledge absorption emanating from external advanced and lead users.

As with any exploratory empirical study this one also has some limitations. A cross-sectional approach to data collection was adopted to allow for the econometric modeling of some basic hypotheses addressing key tenants of user innovation and innovation success. A possible avenue for further research would be to investigate the impact and effect of this form of cooperation on diverse innovation output measures through a longitudinal research. More studies on the time horizon might also shed light on the specific contributions of advanced and lead users on the technological and growth trajectories of firms. In addition, similar to most econometric studies, we have treated the relationships between innovation input factors and innovation output as a black box limiting the richness of the constructs. We can only speculate about the internal mechanisms ensuring the successful transformation of newly acquired knowledge into new products and processes. Further research on variables controlling for organizational variables would be needed. For example, a firm’s absorptive capacity is also dependent on its employees’ absorptive capacity. Further studies could include the share of qualified employees in our empirical model. The higher is the share, the higher should be the ability to absorb and exploit external end users´ knowledge. To conclude, we hope that our econometric modeling and first test of data will help lay the foundation upon which later empirical research on outcome measures of cooperation with external end users can be built.

References

Alam, I. (2006), Removing the Fuzziness from the Fuzzy Front-end of Service Innovations through Customer Interactions. Industrial Marketing Management, 35(4), 468-480.

Amit R., Schoemaker P. (1993), Strategic Assets and Organisational Rent. Strategic Management Journal, 14, 33-46.

Arrow, K. (1962), The Economic Implications of Learning by Doing. The Review of Economic Studies, 29(3), 155-173.

Arvanitis, S. (1997), The Impact of Firm Size on Innovative Activity – An Empirical Analysis Based on Swiss Firm Data. Small Business Economics, 9(6), 473-490.

Barney J. (1991), Firm Resources and Sustained Competitive Advantage. Journal of Management, 17, 99-120.

Beyer, H., Holtzblatt, K. (1998), Contextual Design: Defining Customer-Centered Systems. San Francisco: Morgan Kaufmann.

Bogers, M., Afuah, A. and Bastian, B. (2010), Users as Innovators: A Review, Critique, and Future Research Directions. Journal of Management, 36(4), 857-875.

Churchill, J., von Hippel, E. and Sonnack, M. (2009), Lead User Project Handbook – A Practical Guide for Lead User Project Teams. Cambridge, Mass.: MIT Press.

Cohen W., Levinthal D. (1990), Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly, 35, (1), 128-152.

Cooper R., Kleinschmidt E. (1987), New Products: What Separates Winners from Losers? Journal of Product Innovation Management, 4(3), 169–184.

De Brentani, U. (1995), New Industrial Service Development: Scenarios for Success and Failure. Journal of Business Research, 32, 93–103.

De Brentani, U., Cooper, R. (1992), Developing Successful New Financial Services for Business. Industrial Marketing Management, 21, 231–241.

Dosi G. (1982), Technological Paradigms and Technological Trajectories. Research Policy, 11(3), 146-162.

Edquist C. (1997), Systems of Innovation: Technologies, Institutions, and Organizations. London: Pinter.

Engelbrektsson, P., Soderman, M. (2004), The Use and Perception of Methods and Product Representations in Product Development: A Survey of Swedish Industry. Journal of Engineering Design, 15(2), 141-154.

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

Foxall, G., Tierney, J. (1984), From CAP1 to CAP2: User-initiated Innovation from the User's Point of View. Management Decision, 22(5), 3-15.

Franke, N., Shah, S. (2003), How Communities Support Innovative Activities: An Exploration of Assistance and Sharing among End-users. Research Policy, 32, 157-178.

Franke N., von Hippel E. (2003), Satisfying Heterogenous User Needs via Innovation Toolkits: The Case of Apache Security Software. Research Policy, 32, (7), 1199–1215.

Franke, N., von Hippel, E. and Schreier, M. (2006), Finding Commercially Attractive User Innovations: A Test of Lead User Theory. Journal of Product Innovation Management, 23(4), 301–315.

Freeman, C. (1968), Chemical Process Plant: Innovation and the World Market. National Institute Economic Review, 45, 29-57.

Freeman, C. (1987), Technology Policy and Economic Performance: Lessons from Japan. London: Pinter.

Fuchs, B., Durst, S. (2007), Technologische Innovation in Liechtenstein: Ergebnisse der empirischen Erhebung 2006. Projektbericht. Vaduz: Institut für Entrepreneurship.

Granovetter, M. (1982), The Strength of Weak Ties: A Network Theory Revisited. In P. Marsden and N. Lin (Eds.), Social Structure and Network Analysis. Beverly Hills: Sage.

Griffin, A., Hauser, J. (1993), The Voice of the Customer. Marketing Science, 12(1), 1–27.

Grant R. (1991), The Resource-based Theory of Competitive Advantage: Implications for Strategy Formulation. California Management Review, 33 (Spring), 114-135.

Grant, R. M. (1996), Towards a Knowledge-based Theory of the Firm. Strategic Management Journal, 17, 109-122.

Gruner, K., Homburg, C. (2000), Does Customer Interaction Enhance New Product Success?, Journal of Business Research, 49(1), 1–14.

Hagedoorn, J. (1993), Understanding the Rationale of Strategic Technology Partnering: Interorganisational Modes of Cooperation and Sectoral Differences. Strategic Management Journal, 14(5), 371–385.

Hamel, G., Prahalad, C. (1994), Competing for the Future. Boston: Harvard Business School Press.

Hasenmaile, F., Golay, S. (2004), Regionalstudie der Credit Suisse "Fürstentum Liechtenstein - Struktur und Perspektiven", Zürich.

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. Journal of Product Innovation Management, 9, 213-221.

Hilti Factbox (2009): http://www.hilti.com/fstore/holcom/LinkFiles/Factbox_Hilti_de_11.pdf.

Hodgson, G. (1999), Economics and Utopia: Why the Learning Economy Is not the End of History. London and New York: Routledge.

Kogut, B., Zander U. (1992), Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. Organization Science, 3(3), 383-397.

Lakhani, K., von Hippel, E. (2003), How Open Source Software Works: “Free” User-to-user Assistance. Research Policy, 32(6), 923-943.

Langerak, F., Hultink E. (2008), The Effect of New Product Development Acceleration Approaches on Development Speed: A Case Study. Journal of Engineering and Technology Management, 25(3), 157-167.

Lee, K.R. (1996), The Role of User Firms in the Innovation of Machine Tools: The Japanese Case. Research Policy, 25(4), 491-507.

Leonard, D., Rayport, J.F. (1997), Spark Innovation through Empathic Design. Harvard Business Review, 75(6), 102-113.

Lerner, J., Tirole, J. (2002), Some Simple Economics of Open Source. Journal of Industrial Economics, 50(2), 197-234.

Lettl C. (2007), User Involvement Competence for Radical Innovation. Journal of Engineering and Technology Management, 24 (1, 2), 53-75.

Lettl, C., Herstatt, C. and Gemuenden, H. (2006), Users' Contributions to Radical Innovation: Evidence from Four Cases in the Field of Medical Equipment Technology. R&D Management, 36(3), 251-272.

Lilien G., Morrison P., Searls K., Sonnack M. and von Hippel E. (2002), Performance Assessment of the Lead User Idea-generation Process for New Product Development. Management Science, 32(7), 791-805.

Lüthje, C. (2004). Characteristics of Innovating Users in a Consumer Goods Field. An Empirical Study of Sport-related Product Consumers. Technovation, 24(9), 683–695.

Lüthje, C., Herstatt, C. (2004), The Lead User Method: An Outline of Empirical Findings and Issues for Future Research. R&D Management, 34(5), 553–568.

Lüthje, C., Herstatt, C. and von Hippel E. (2003), Patterns in the Development of Minor Innovations by Users: Bricolage in Mountain Biking. MIT Sloan School of Management Working Paper, Cambridge Mass.

Lüthje, C., Herstatt, C., and von Hippel, E. (2005), User-Innovators and ‘‘Local’’ Information: The Case of Mountain Biking. Research Policy, 34(6), 951–965.

Lundvall, B-Å., Borrás, S. (1997). The Globalisation-Learning Economy: Implication for Innovation Policy, TSER Programme, DG XII, Commission of the European Union.

Morrison, P., Roberts, J. and Midgley, D. (2004), The Nature of Lead Users and Measurement of Leading Edge Status. Research Policy, 33(2), 351–362.

Morrison, P., Roberts, J., and von Hippel E. (2000), Determinants of User Innovation and Innovation Sharing in a Local Market. Management Science, 46(12), 1513-1527.

Nelson, R., Winter, S. (1977), In Search of a Useful Theory of Innovation. Research Policy, 6(1), 36-76.

Nelson, R., Winter, S. (1982), An Evolutionary Theory of Economic Change. Belknap Press of Harvard University Press: Cambridge, Mass.

Nonaka, I. (1994), A Dynamic Theory of Organizational Knowledge Creation. Organization Science, 5(1), 14-37.

Patel P., Pavitt K. (1994), The Nature and Economic Importance of National Innovation Systems. STI Review, No. 14, OECD, Paris.

Penrose E. (1995), The Theory of the Growth of the Firm, Third Edition, Oxford, New York/Oxford: Oxford University Press.

Polanyi, M. (1966), The Tacit Dimension. New York: Doubleday & Company.

Rosenberg, N. (1976), Perspectives on Technology, New York: Cambridge University Press.

Shah, S., Tripsas, M. (2007), The Accidental Entrepreneur: The Emergent and Collective Process of User Entrepreneurship. Strategic Entrepreneurship Journal, 1, 123-140.

Simonson, I. (1993) Get Closer to Your Customers by Understanding How They Make Choices. California Management Review, 35(4), 68-84.

Teece D.J., Pisano G. and Shuen, A. (1997), Dynamic Capabilities and Strategic Management. Strategic Management Journal, 18(7), 507-53.

Urban G., von Hippel, E. (1988), Lead User Analysis for the Development of New Industrial Products. Management Science, 34(5), 569 – 581.

Von Hippel (1976), The Dominant Role of Users in the Scientific Instrument Innovation Process. Research Policy, 5(3), 212-239

Von Hippel, E. (1977), Transferring Process Equipment Innovations from User-innovators to Equipment Manufacturing Firms. R&D Management, 8, 13–22.

Von Hippel, E. (1988), The Sources of Innovation. New York, Oxford University Press.

Von Hippel, E. (1994), “Sticky Information" and the Locus of Problem Solving: Implications for Innovation. Management Science, 40(4), 429-439

Von Hippel E. (2005), Democratizing Innovation. Cambridge, Mass.: MIT Press.

Von Hippel, E., Katz, R. (2002). Shifting Innovation to Users via Toolkits. Management Science, 48(7), 821-833.

Verwoorn B., Herstatt C., Nagahira A. (2008), The Fuzzy Front End of Japanese New Product Development Projects: Impact on Success and Differences between Incremental and Radical Projects. R&D Management, 38(1), 1-19.

Wernerfelt B. (1984), A Resource-based View of the Firm, Strategic Management Journal, 5, 171-180.

Woerter, M. (2010), Technology Diversification, Product Innovations and Technology Transfer, KOF Working Paper No. 221, Zurich.

Tables:

Table 1: Definition of the variables

Variable	Definition
LINNS	Natural logarithm of the sum of the sales shares of new products and significantly modified new products
INNUSER_TOT	Cooperation in innovation with *external end users* yes/no
INNUSER_FIRM	Cooperation in innovation with *external end users* that are *firms* yes/no
INNUSER_INSTIT	Cooperation in innovation with *external end users* that are *institutions* yes/no
INNUSER_PRIV	Cooperation in innovation with *external end users* that are *private persons* yes/no
DEMAND	Average score on a five-point Likert scale of the assessment of (a) the current demand development 2006-2008 and (b) of the expected demand development 2009-2011 on the main product market
R&D_PD	Values 4 or 5 of the assessment of R&D expenditures for *product innovations* 2006-2008 on a five-point Likert scale (1: “no expenditures”; 5: “very high expenditures”
N_COMPET	Number of main competitors on the (worldwide) main product market (ordinal variable: value 1: more than 50 competitors; 2: 16 to 50; 3: 11 to 15; 4: 6 to 10; 5: up to 5 competitors
EXPORT	Exports of goods and/or services 2008 yes/no
INTERNAT_COMPET	International competition: dummy variable (1: regional competition (Switzerland; western Austria; southern Germany); 2: all other regions/countries
LAGE	Natural logarithm of the firm age (2008 minus foundation year)
LEMPL	Natural logarithm of the number of employees (in full-time equivalents) 2008
PROD_INTRA	*Intra*-firm high division of work in the production process; ordinal variable measured on a six-point Likert scale(1: “non-relevant”; 6: “very relevant”)
PROD_INTER	*Inter*-firm high division of work in the production structure; ordinal variable measured on a six-point Likert scale(1: “non-relevant”; 6: “very relevant”)
PROD_MOD	Modular structure of the production process; ordinal variable measured on a six-point Likert scale(1: “non-relevant”; 6: “very relevant”)
LEAD_USER_METHOD	Contact to external end users through the *Lead User Method;* originally ordinal variable measured on a five-point Likert scale(1: “non-relevant”; 5: “very relevant”) was transformed to a dummy variable (1: for values 4 and 5 of the original

	variable; 0: for values 1, 2 and 3 of the original variable
INNUSER_LEAD_USER_1	Dummy variable; value 1: if INNUSER_TOT = 1 *and* LEAD_USER_METHOD = 1); otherwise value 0
INNUSER_LEAD_USER_0	Dummy variable: value 1: if INNUSER_TOT = 1 LEAD_USER_METHOD = 0); otherwise value 0
EMPHAT_DESIGN_METHOD	Contact to external end users through *Emphatic Design;* originally ordinal variable measured on a five-point Likert scale(1: "non-relevant"; 5: "very relevant") was transformed to a dummy variable (1: for values 4 and 5 of the original variable; 0: for values 1, 2 and 3 of the original variable
INNUSER_EMPHAT_DESIGN_1	Dummy variable: value 1: if INNUSER_TOT = 1 *and* EMPHAT_DESIGN_METHOD = 1); otherwise value 0
INNUSER_EMPHAT_DESIGN_0	Dummy variable: value 1: if INNUSER_TOT = 1 *and* EMPHAT_DESIGN_METHOD = 0); otherwise value 0
COMPLAINT_MANAGEMENT	Contact to external end users through *Customer Complaint Management;* originally ordinal variable measured on a five-point Likert scale(1: "non-relevant"; 5: "very relevant") was transformed to a dummy variable (1: for values 4 and 5 of the original variable; 0: for values 1, 2 and 3 of the original variable
INNUSER_COMPLAINT_1	Dummy variable: value 1: if INNUSER_TOT = 1 *and* COMPLAINT_MANAGEMENT = 1); otherwise value 0
INNUSER_COMPLAINT_0	Dummy variable: value 1: if INNUSER_TOT = 1 *and* COMPLAINT_MANAGEMENT = 0); otherwise value 0
HT	*High-tech manufacturing:* Manufacture of chemical, pharmaceutical, plastic, glass and ceramic products; manufacture of electrical, electronic, and optical equipment; manufacture of machinery, motor vehicles, and equipment.
LT	*Low-tech manufacturing:* manufacture of food products, beverages, tobacco products; manufacture of textiles, wearing apparel, footwear; Manufacture of products of wood, paper, printing products; manufacture of metals and metal products; Other manufacturing; repair and installation of machinery and equipment; electricity, gas, water, steam and air conditioning supply, sewerage, waste management.
M_SERV1	*Modern services 1:* financial and insurance activities; other modern business services (legal advice, trustee services)
M_SERV2	*Modern services 2:* other modern business services (advertising, business consulting, human resource consulting).
T_SERV	*Traditional services:* wholesale and retail trade; repair of motor vehicles and motorcycles; transport and telecommunications; real estate activities; education; accommodation and food service activities; health and social services; other services.

Table 2: Some innovation variables by sub-sector and firm size; number of firms

Subsector	INNUSER_ TOT	INNUSER_ FIRM	INNUSER_ INSTIT	INNUSER_ PRIV
High-tech manufacturing	9	9	6	3
Low-tech manufacturing	11	10	2	5
Modern services I	8	8	3	4
Modern services II	9	7	5	5
Traditional services	9	9	2	3
Construction	4	3	3	3
Total	*50*	*46*	*21*	*23*
Firm size				
Up to 4 employees	17	15	5	9
5-19 employees	20	18	10	8
20 employees and more	15	15	7	8
Total	*52*	*48*	*22*	*25*

Table 3: Estimates of innovation equations: LINNS; INNUSER-variables

	LINNS Tobit	LINNS Tobit	LINNS IV Tobit; (bootstrapped 200 repl.)	LINNS Tobit	LINNS Tobit	LINNS Tobit
INNUSER_TOT		3.009***				
		(0.643)				
INNUSER_TOT_HAT			1.616***			
			(0.386)			
INNUSER_FIRM				2.830***		
				(0.639)		
INNUSER_INSTIT					1.162	
					(0.823)	
INNUSER_PRIV						1.601**
						(0.747)
R&D_PD	2.522***	0.852	-1.244	1.207*	2.149***	2.408***
	(0.674)	(0.675)	(1.010)	(0.661)	(0.750)	(0.687)
DEMAND	0.270	-0.139	-0.837	-0.068	0.064	0.010
	(0.382)	(0.338)	(0.523)	(0.342)	(0.396)	(0.388)
N_COMPET	-0.139	-0.302	-0.416*	-0.301	-0.203	-0.195
	(0.226)	(0.204)	(0.216)	(0.208)	(0.238)	(0.226)
EXPORT	1.968***	1.516***	1.308*	1.408**	2.138***	2.227***
	(0.644)	(0.565)	(0.679)	(0.579)	(0.651)	(0.647)
INTERNAT_COMPET	-1.657*	-1.909**	-2.022*	-2.039**	-1.612	-1.973*
	(0.992)	(0.863)	(1.088)	(0.886)	(0.985)	(0.995)
L_AGE	0.131	0.356	0.408	0.360	0.142	0.241
	(0.390)	(0.339)	(0.429)	(0.345)	(0.387)	(0.386)
LEMPL	0.052	-0.194	-0.643*	-0.171	-0.132	-0.099
	(0.297)	(0.267)	(0.371)	(0.271)	(0.314)	(0.302)
HT	0.992	0.653	1.632	0.723	0.390	0.857
	(1.342)	(1.145)	(1.405)	(1.168)	(1.368)	(1.321)
LT	1.430	-0.214	0.136	0.196	0.959	1.084
	(1.008)	(0.918)	(1.100)	(0.915)	(1.039)	(1.017)
M_SERV1	-1.223	-3.035***	-2.971***	-2.931***	-1.718	-1.805
	(1.095)	(1.035)	(1.108)	(1.051)	(1.131)	(1.105)
M_SERV2	0.534	-1.458	-3.022*	-1.217	-0.312	-0.121
	(1.119)	(1.032)	(1.320)	(1.037)	(1.219)	(1.127)
T_SERV	0.859	-0.946	-0.811	-0.810	0.418	0.355
	(1.041)	(0.952)	(1.022)	(0.964)	(1.061)	(1.036)
Const.	0.851	3.687*	9.809***	3.460	2.187	2.200
	(2.426)	(2.123)	(3.228)	(2.158)	(2.532)	(2.429)
N	68	68	65	68	68	68
Left-censored	22	22	22	22	22	22
Pseudo R2	0.105	0.186	0.211	0.178	0.114	0.124
LR chi2	28.3***	49.2***	53.8***	47.3***	30.3***	32.9***

Note: ***, ** and * denote statistical significance at the 1%-, 5%- and 10%-level respectively; reference sector: construction.

Table 4: Estimates of innovation equations: LINNS; methods of finding external end users

	LINNS Tobit	LINNS Tobit	LINNS Tobit	LINNS Tobit	LINNS Tobit	LINNS Tobit
LEAD_USER_METHOD	2.451**					
	(1.205)					
INNUSER_LEAD_USER_1		3.333***				
		(1.145)				
INNUSER_LEAD_USER_0		1.876**				
		(0.789)				
EMPHAT_DESIGN_METHOD			4.491***			
			(1.507)			
INNUSER_EMPHAT_DESIGN_1				4.894***		
				(1.382)		
INNUSER_EMPHAT_DESIGN_0				1.362*		
				(0.747)		
COMPLAINT_MANAGEMENT					2.288*	
					(1.155)	
INNUSER_COMPLAINT_1						2.008*
						(1.101)
INNUSER_COMPLAINT_0						2.070***
						(0.772)
R&D_PD	1.713*	1.058	3.628***	2.136***	2.392**	1.584**
	(0.969)	(0.821)	(0.967)	(0.793)	(0.969)	(0.771)
DEMAND	0.082	-0.029	0.258	0.104	0.450	0.101
	(0.487)	(0.389)	(0.441)	(0.363)	(0.456)	(0.379)
N_COMPET	-0.050	-0.387	0.028	-0.327	0.326	-0.271
	(0.310)	(0.235)	(0.285)	(0.220)	(0.290)	(0.229)
EXPORT	3.358***	1.371**	3.091***	1.498**	3.415***	1.349**
	(0.906)	(0.640)	(0.878)	(0.613)	(0.928)	(0.646)
INTERNAT_COMPET	-1.718	-2.052**	-2.396*	-2.025**	-0.726	-1.715*
	(1.335)	(0.982)	(1.368)	(0.939)	(1.213)	(0.959)
L_AGE	0.216	0.421	0.304	0.437	0.215	0.368
	(0.448)	(0.385)	(0.447)	(0.373)	(0.465)	(0.390)
LEMPL	-0.099	-0.074	0.101	0.052	-0.238	0.005
	(0.350)	(0.288)	(0.346)	(0.277)	(0.361)	(0.298)
HT	1.785	1.397	1.111	1.161	1.118	0.993
	(1.887)	(1.299)	(1.823)	(1.247)	(1.193)	(1.298)
LT	2.420	1.455	1.952	1.681*	2.751*	1.227
	(1.518)	(0.980)	(1.538)	(0.942)	(1.563)	(0.996)
M_SERV1	-0.433	-2.539**	-0.271	-2.178**	0.799	-2.018*
	(1.772)	(1.168)	(1.631)	(1.081)	(1.677)	(1.118)
M_SERV2	1.307	-0.572	1.372	-0.457	2.429	-0.215
	(1.658)	(1.128)	(1.594)	(1.083)	(1.690)	(1.121)
T_SERV	2.333	-0.031	2.858*	0.430	3.554**	0.302
	(1.617)	(1.934)	(1.570)	(0.982)	(1.691)	(1.029)
Const.	-1.457	3.104	-2.323	1.870	-5.708	1.761
	(3.951)	(2.516)	(3.627)	(2.297)	(3.743)	(2.408)
N	52	69	50	69	52	69
Left-censored	21	22	21	22	21	22
Pseudo R2	0.171	0.133	0.196	0.145	0.171	0.126
LR chi2	33.3***	35.7***	36.2***	39.1***	33.2***	34.1***
F-test [coeff.(3.333) – coeff.(1.876)]		2.04				
		Prob>F=0.159				
F-test [coeff.(4.894) – coeff.(1.362)]				6.45**		
				Prob>F=0.014		

F-test [coeff.(2.008) – coeff.(2.070)]	0.00 Prob>F=0.955

Note: ***, ** and * denote statistical significance at the 1%-, 5%- and 10%-level respectively; reference sector: construction.

APPENDIX:

Table A.1: Composition of the data set and response rate by industry

Economic sector	Number of firms addressed to	Respon-ding firms	Response rate %
A,B Agriculture, forestry, mining and quarrying	3	0	0
C Manufacturing			
CA Manufacture of food products, beverages, tobacco products	14	6	43
CB Manufacture of textiles, wearing apparel, footwear	5	2	40
CC Manufacture of products of wood, paper, printing products	47	8	17
CD -CG Manufacture of chemical, pharmaceutical, plastic, glass and ceramic products	18	1	6
CH Manufacture of metals and metal products	31	5	16
CI-CJ Manufacture of electrical, electronic, and optical equipment	23	5	22
CL-CM Manufacture of machinery, motor vehicles and equipment	33	13	39
CM Other manufacturing; repair and installation of machinery and equipment	24	5	21
D Electricity, gas, water, steam and air conditioning supply, sewerage, waste management	8	2	25
F Construction	116	12	10
G Wholesale and retail trade; repair of motor vehicles and motorcycles	124	18	15
J - H Transport and telecommunications*	96	24	25
L Real estate activities	9	1	11
P Education	3	1	33
I Accommodation and food service activities	23	6	26
K Financial and insurance activities	27	7	26
M, N Other modern business services	201	41	20
Q, R Health and social services	23	4	17
S Other services	65	12	18
Total	*893*	*173*	*19*

Table A.2: Endogeneity test for INNUSER_TOT

	INNUSER_TOT Probit (instrument equation)	LINNS Tobit; boostrapped (200 replications)
INNUSER_TOT		2.891***
		(0.766)
RES		*1.129***
		(0.332)
R&D_PD	1.737***	-1.067
	(0.400)	(0.916)
DEMAND	0.542**	-0.755
	(0.236)	(0.502)
PROD_INTER	0.413***	
	(0.130)	
INNO_TEAM	0.232**	
	(0.112)	
INNO_TIME	0.061**	
	(0.031)	
N_COMPET		-0.405
		(0.256)
EXPORT	-0.102	1.267*
	(0.359)	(0.654)
INTERNAT_COMPET		-2.064*
		(1.182)
L_AGE		0.438
		(0.428)
LEMPL		-0.588
		(0.395)
HT	-0.750	1.173
	(0.642)	(1.329)
LT	-0.522	-0.574
	(0.620)	(1.377)
M_SERV1	0.794	-3.538***
	(0.681)	(1.162)
M_SERV2	1.447**	-3.158**
	(0.619)	(1.435)
T_SERV	0.348	-1.446
	(0.563)	(1.215)
Const.	-4.621***	8.810***
	(1.098)	(3.163)
N	106	65
Left-censored		22
Pseudo R2	0.452	0.236
Wald chi2	43.2***	59.0***

Note: ***, ** and * denote statistical significance at the 1%-, 5%- and 10%-level respectively; reference sector: construction; instrument variable: DEMAND.