The Empirical Scope of User Innovation

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The Empirical Scope of User Innovation

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Abstract
Until seven years ago, user innovation studies focused on specific cases or industries, leaving room for criticism that the phenomenon is marginal. This chapter summarizes and discusses the empirical work concerned with the scope of user innovation in broader samples. A first finding is that user innovation is widespread. The share of firms developing and/or modifying processes for in-house use is generally about 15 to 20 percent, while amongst consumers four to six percent innovated to satisfy personal needs in the past three years. This corresponds with millions of innovating businesses and consumers across the globe. For firms, user innovation indicators measure process-related innovation activities which remain partly invisible in official surveys, while user innovation by individual consumers is not at all present in the official statistics. A second finding is that user innovation is more open than traditional, producer-oriented innovation. Especially innovating consumers do not patent their knowledge, and 10 to 30 percent of them even shares their knowledge freely with other users and/or adopting businesses. Finally, it appears that users' innovations can be useful to other economic actors. Diffusion mechanisms include free revealing to other users, new venture creation, and adoption by commercial producers. Overall, the empirical studies suggest that user innovation indicators should be part of the official innovation metrics.

1. Introduction

User innovation refers to innovations developed by end users, rather than by producers. User-innovators can be either firms or individual consumers. They are distinguished from producer-innovators by the fact that they expect to benefit from their innovation efforts by using a product or a service. All others, lumped together under the term 'producers' only benefit from innovation by selling their output by licensing or product commercialization (von Hippel, 2005). Any firm or individual can be a producer of user innovator in specific situations. For example, Sony is a manufacturer of electronic equipment, but it is also a user of machine tools. With respect to the innovations that it develops for its electronic products, Sony is considered a producer-innovator, but if we would investigate innovations in its machinery or production processes, the company may qualify as a user-innovator. Likewise, an individual inventor developing a new transport device for manually disabled people would be a producer-innovator, but if he would develop the device primarily for personal use (being manually impaired), he would be a user-innovator.

Empirical user innovation studies have concluded that the most significant innovations in many fields were originally developed by users. It has also been shown that substantial shares of users engage in innovation, that their innovations are generally

unconstrained by intellectual property, and that their innovations serve a general interest i.e. diffuse to other economic actors, which increases social welfare (von Hippel, 2005). Although these results are compelling, empirical evidence has usually been collected for very specific cases. Von Hippel's earlier work demonstrating the significance of users as a source of functionally novel innovations was concerned with scientific instruments, automated clinical chemistry analyzers and pultrusion processes (see for example von Hippel, 1976). Likewise, when summarizing empirical evidence on the share of user innovators, von Hippel (2005) cited studies of printed circuit CAD software, pipe hanger hardware, library information systems, surgical equipment, outdoor consumer products and mountain biking equipment. A general criticism is that this work may not generalize to larger populations. As von Hippel (2005) noticed:

> "each of the studies looked at innovation rates affecting a particular product type among users who care a great deal about that product type (…) university surgeons care a great deal about having just-right surgical equipment, just as serious mountain bikers care a great deal about having just-right equipment for their sport. As the intensity of interest goes down, it is likely that rates of user innovation drop too" (p. 20).

A hostile critic might conclude that, given the specific samples, user innovation is actually rather marginal. This is one of the reasons that researchers recently started to explore the incidence and diffusion of user innovation in broad samples, including businesses and individual end consumers. In this chapter I review and discuss this emerging literature.

The proposed contribution is threefold. First, I summarize empirical evidence on the share of user innovators in broad samples of firms and consumers (section 2). A general finding is that 15 to 20 percent of all firms are user innovators, while in samples of consumers this range is 4 to 6 percent. For samples of firms, I will also discuss to what extent user innovation overlaps with process innovation, as this is already present in the official statistics. Second, findings regarding the protection of user innovations with intellectual property rights are discussed (section 3). In consumer populations very few innovators apply for these – they rather share their work for free or don't bother about diffusion at all. In businesses the application of intellectual property rights is more substantial, but rarely exceeds 50 percent. Third, I review to what extend and how user innovations diffuse to other economic actors (section 4). Part of their innovations appear to be useful to others, i.e. depending on the sample 5 to 25 percent is adopted by others users or by commercial producers for further development and commercial sale. Finally, I reflect on the implications for measurement and policy.

2. Incidence of user innovation

In the case of innovating firms, a legitimate question is to what extent user innovation resembles with process innovation. Why would we need separate indicators? Innovating user firms modify existing techniques, equipment or software for in-house use, or create those entirely from scratch for internal purposes (von Hippel, 2005). Conceptually, user innovation can be expected to overlap with traditional process innovation indicators. More specifically, user innovation should be a subset of process innovation. The Oslo Manual - which guides statistical offices in collecting and interpreting innovation data with CIS surveys - defines process innovation as "the implementation of a new or

significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software" (OECD/Eurostat, 2005: paragraph 163). Importantly, the manual sets a low threshold for what qualifies as an innovation: "the minimum requirement (…) is that the (…) process (…) must be new or significantly improved to the firm. This includes (…) processes and methods (…) that have been adopted from other firms or organizations" (paragraph 148). Accordingly, to qualify as a process innovator it is sufficient to adopt a piece of technique, equipment or software, while user innovation excludes adoption, and requires some kind of development effort and functional novelty.

I suggest that from a conceptual point of view, it is important to distinguish user innovation from broader process innovation indicators. Past studies have shown that user innovations are marked by functional novelty (e.g., Riggs & von Hippel, 1994), provide an important feedstock for commercial producers' new product development efforts (Lilien et al., 2002; de Jong & von Hippel, 2009), can lead to new venture creation and the emergence of new industries (Shah & Tripsas, 2007), are more likely to be commercially attractive and serve the needs of other users (Franke & von Hippel, 2003) and enhance social welfare (Henkel & von Hippel, 2005). In contrast, when process innovations are adoptions, these benefits would barely or not apply.

For individual end consumers, the situation is different. User innovation by consumers is not-at-all recorded in official surveys, and until recently it could be considered dark matter – unmeasured, and so impossible to include in economic or policymaking analyses. Table 1 lists the survey studies that researchers have done in the past seven years to identify user innovators in broad samples.

Table 1. Share of user innovators in broad samples of firms and consumers

Source	*Country*	*Year*	*Sample*	*Estimate*
Firm surveys:				
Arundel & Sonntag (1999)	Canada	1998	3,702 manufacturing plants with > 10 employees	41.0%
Schaan & Uhrbach (2009)	Canada	2007	6,478 manufacturing plants with > 20 employees and $ 250K revenues	39.8%
de Jong & von Hippel (2009)	Netherlands	2007	498 high-tech SMEs with < 100 employees	54.0%
de Jong & von Hippel (2008)	Netherlands	2008	2,416 small firms (< 100 employees)	21.0%
Flowers et al. (2010)	United Kingdom	2009	1,004 SMEs with 10-250 employees	15.3%
Kim & Kim (2011)	South-Korea	2009	3,081 manufacturers with > 10 employees	17.7%
Consumer surveys:				
von Hippel et al. (2012)	United Kingdom	2009	1,173 individual end consumers ≥ 18 years	6.1%
de Jong (2011)	Netherlands	2010	533 consumers ≥ 18 years	6.2%
Ogawa & Pongtalanert (2011)	USA	2010	1,992 consumers ≥ 18 years	5.2%
Ogawa & Pongtalanert (2011)	Japan	2011	2,000 consumers ≥ 18 years	3.7%
Kuusisto et al. (2013)	Finland	2012	993 consumers of 18-65 years	5.4%
de Jong (2013)	Canada	2013	2,021 consumers ⩾ 18 years	5.6%

Samples of firms

An early study identifying user innovation in a sample of firms was done by Arundel and Sonntag (1999). Back in 1998, as part of their survey of Advanced Manufacturing Technologies, Statistics Canada sampled manufacturing plants with at least 10 employees. Amongst other questions, data were collected on the adoption, modification and development of specific technologies. From their findings it can be inferred that 41.0 percent of the Canadian manufacturing plants went beyond the adoption of technologies 'off-the-shelf', but modified existing technologies to better fit their internal needs, or developed their own technologies from scratch for application in their operations[1]. In 2007, the AMT survey was updated by Schaan and Uhrbach (2009). From their findings it can be estimated that 39.8 percent of the Canadian manufacturing plants with > 20 employees and > $ 250K revenues were user innovators – close to Arundel and Sonntag's original finding.

Another project to measure user innovation was done in the Netherlands, drawing on computer-assisted telephone interviewing. In 2007, de Jong and von Hippel (2009) piloted questions in a panel of high-tech SMEs. They utilized two indicators of the presence of user innovation: (1) had the firm developed new process equipment or software for its own use; (2) had the firm modified existing process equipment or software for its own use within the past three years. Next, respondents were asked to select their most recent innovation and report what it was about (open-ended question). After cleaning the data for falsely identified cases, 54.0 percent of the sample appeared to be user innovators.

This survey method gave rise to a second type of user innovation indicators in which respondents are first asked whether they innovated in software or physical products, and if they created their innovation from scratch or by modifying an existing product. Survey scripts would follow up with open-ended questions to obtain a detailed description of what the firm have done, and why. These descriptions were then screened to eliminate "false positives" – reported examples which are in fact not innovations. Finally, additional false positives were eliminated via additional questions, i.e., if respondents know of equivalent products already available on the market, and if they developed their innovations for customers (which would make the example a product innovation). De Jong and von Hippel's (2008) study of 2,416 small- and medium-sized enterprises was a next application of this method. In this sample (covering all commercial industries including agriculture, manufacturing, construction, retail, trade, financial services, business services, personal services and hotels and restaurants) 21.0 percent of all Dutch SMEs was estimated to be a user innovator.

Next, in the United Kingdom, Flowers and colleagues (2010) applied the same method to document user innovation by SMEs with 10 to 250 employees. They found that in the past three years, 15.3 percent of the businesses developed or modified hardware or software for their own process-related needs, without similar offerings being available on the market. This was the equivalent of 30,500 companies. Even more interesting is that Flowers et al. followed up on respondents' most recent innovations to record their time and money expenditures. They found that for every user innovation, companies spent on average 107 person-days and £ 44,500 in out-of-pocket costs. When

[1] More specifically, Arundel and Sonntag (1999) found that 76 percent of their respondents were adopting at least one advanced manufacturing technology. Within this group, 53.9 percent did so by modifying existing technologies or by creating them from scratch.

evaluated at the average salary for UK workers, this represented an annual spending on user innovation of £ 1.7 billion. It was also estimated that the annual R&D-spending by similar firms was £ 2.6 billion, indicating that investments in user innovation are not marginal.

An alternative method was applied by Kim and Kim (2011) in a sample of manufacturing firms with > 10 employees in South-Korea. Their study represents a third type of survey method which first uses the national Community Innovation Survey (CIS) to identify potential user innovators. The CIS identifies process innovators, and also if process innovations were developed in-house (OECD/Eurostat, 2005). These process innovators can be contacted for a follow-up survey to see if they are truly user innovators, and to collect data on their innovation processes. Applying this method Kim and Kim found that 17.7 percent had engaged in user innovation in the past three years.

The aforementioned surveys share some common findings. First and foremost, the frequency of user innovation in firm surveys is substantial, even in broad samples of small firms. Second, user innovation appears to be contingent on firm size, industry types and technical capabilities. Larger organizations are more process-intensive which calls for in-house innovation, and indeed, studies report that the frequency of user innovation increases with size (e.g., de Jong & von Hippel, 2008; Flowers et al., 2010). For industry types, generally manufacturers are more process intensive and likely to innovate for their own process-related needs (e.g., de Jong & von Hippel, 2009). For technical capability, it has been found that high-tech firms are more likely to innovate (e.g., de Jong & von Hippel, 2009). In general, these explanations are well in line with the broader literature on firms' process innovation (e.g., Cohen & Klepper, 1996; Levin et al., 1987).

A third finding is that, although user innovation is conceptually a subset of process innovation, this does not show up in empirical analyses. De Jong and von Hippel (2008) found that 10 percent of the firms in their sample were user innovators, but had responded negatively to the CIS process innovation indicator. They concluded that "user innovation apparently measures (…) innovation that remains hidden" (p. 16-17). In more recent surveys similar findings were obtained (Schaan & Urbach, 2009; Flowers et al., 2010). This underscores the importance to collect separate indicators for user innovation, and also to initiate follow-up studies on the ability of official surveys to capture all (process) innovation activities by firms.

Samples of consumers

Most recently, researchers have started to explore user innovation in samples of individual end consumers. Consumers may innovate in their leisure time by creating and/or modifying everyday items for their own benefit.

The first survey to empirically estimate the frequency of user innovation in a broad sample of consumers was done by von Hippel et al. (2012). While collecting data from 1,173 UK consumers aged 18 and over, their methodology was inspired by the UK survey of SMEs mentioned in Table 1. The survey was done by computer-assisted telephone interviewing. It started by asking consumers whether they had created and/or modified software in the past three years, then ditto for the creation and/or modification of hardware. For each of these options open-ended questions were asked to exclude false positives (e.g., "I bought a piece of Ikea furniture and put it together myself.") Additional false positives were eliminated via analysis of responses to two screening questions. If respondents knew of equivalent products already available on the market, or

if they had developed the innovation as part of their jobs, their claimed innovations were excluded. In effect, the survey was designed to identify only innovations with some kind of functional novelty that consumers had developed in their leisure time.

Von Hippel and colleagues (2012) estimated that 6.1 percent of the UK consumer population had engaged in user innovation in the past three years. This is the equivalent of 2.9 million individuals aged 18 and over. Next, the researchers had asked respondents to identify their most recent innovation example and to report how much time and money they had spent on it. Innovating consumers on average spent 7.1 days and £ 1,098 out-of-pocket costs per year. At the macro-level and when evaluating person-days at average UK workforce salaries, total annual spending by consumers on innovation was estimated to £ 3.2 billion. In comparison, estimated annual R&D expenditures by companies on consumer products were £ 2.2 billion. Although R&D does not represent all producers' innovation expenditures, these findings suggest that user innovation cannot be neglected.

Other consumer surveys have come to similar conclusions. De Jong (2011) organized a survey of Dutch consumers aged 18 and over. Applying a next generation of indicators (in which respondents were offered a list of nine specific cues to improve recall, but still including open-ended and other screening questions to filter out false positives) I found that 6.2 percent of the Dutch consumer population had engaged in user innovation in the past three years. Next, Ogawa and Pongtalanert (2011) organized replication studies in the US and Japan, and found user innovation frequencies of 5.2 percent and 3.7 percent, respectively. They also included time and money questions in their surveys, and estimated that in both countries consumers are spending billions of dollars on innovation. Moreover, in recent studies in Finland (Kuusisto et al., 2013) and Canada (de Jong, 2013), a more or less standardized methodology emerged to adequately measure user innovation in broad samples of consumers. The method first offers a list of specific cues, including computer software, household fixtures and furnishing, tools and equipment, and more. For each the respondent indicates if s/he has created an innovation in the past three years to satisfy his/her personal needs, then a list of questions is asked to eliminate false positives (for details, see Kuusisto et al., 2013). Applying this method the share of innovating consumers were 5.4% in Finland and 5.6% in Canada, respectively.

Consumer surveys shows that in absolute numbers, many consumers develop or modify products for personal use, and spend considerable time and money on it. It has also been found that user innovation frequency varies with gender, education attainment, and technical training. Males are generally more likely to be innovating consumers, and the same applies to those with higher education and technical training (von Hippel et al., 2011; de Jong, 2013). Obviously, education and training reflect personal capability for innovation: highly educated engineers are most likely capable of developing fixes for their personal problems.

3. Openness of user innovation

In the traditional, linear model of innovation, it is assumed that innovations originate from producers and are supplied to consumers via goods that are for sale, so that eventually economic growth and social welfare are enhanced. A potential problem, however, is that private investments in innovation may end up being too low due to knowledge spillovers and the ability of other economic agents to 'free ride' on others' investments (Arrow, 1962). As a consequence policy makers offer intellectual property rights (IPRs) so that producer-innovators can secure temporary monopolies to benefit

from their efforts (Levin et al., 1987). This creates a situation that we here label as 'closed innovation', i.e. innovating actors who are potentially restricting further application of their innovation-related knowledge via IPRs.

Compared to innovating producers, user innovators are generally less concerned with IPRs, or in the case of innovating consumers, not at all. They innovate primarily for personal need or in-house use benefits, and do not need to conquer a market to recoup their innovation investments. Moreover, user innovation does not automatically imply the presence of a big market of other users facing sufficiently similar needs. Producers generally employ product development strategies to meet the needs of homogenous market segments. This strategy of 'few sizes fit all' leaves many user firms and end consumers dissatisfied with commercial products on offer so that they are triggered to innovate for themselves (von Hippel, 2005), but then user needs can be pretty diverse so that applying for IPRs is less useful.

We define 'open innovation' as innovation without intellectual property. It might be preferable from a social welfare perspective, as the application of IPRs does not seem to result in net economic value in many fields (Bessen & Meurer, 2008). To explore the openness of user innovation, most of the surveys that we discussed earlier on asked respondents if they had protected their innovations with IPRs – including patents, copyrights, trade marks and the application of confidentiality agreements. Results for both firm and consumer samples are shown in Table 2.

Table 2. Protection of user innovations with IPRs by firms and consumers

Source	*Country*	*Year*	*Sample*	*Protection with IPRs*
Firm surveys:				
de Jong & von Hippel (2009)	Netherlands	2007	364 user innovations developed by high-tech SMEs (< 100 employees)	12.5%
Schaan & Uhrbach (2009)	Canada	2008	1,277 user innovations developed by manufacturing plants with > 20 employees and $ 250K revenues	53.3%
Flowers et al. (2010)	United Kingdom	2009	200 user innovations developed by SMEs with 10-250 employees	35.5%
Kim & Kim (2011)	South-Korea	2009	370 user innovations developed by manufacturers with > 10 employees	43.8%
de Jong (2010)	Netherlands	2010	81 user innovations developed by high-tech SMEs (< 100 employees)	13.6%
Consumer surveys:				
von Hippel et al. (in press)	United Kingdom	2009	104 user innovations developed by consumers ≥ 18 years	1.9%
Ogawa & Pongtalanert (2011)	USA	2010	114 user innovations developed by consumers ≥ 18 years	8.8%
Ogawa & Pongtalanert (2011)	Japan	2011	83 user innovations developed by consumers ≥ 18 years	0.0%
Kuusisto et al. (2013)	Finland	2012	176 user innovations developed by consumers of 18-65 years	4.7%
de Jong (2013)	Canada	2013	539 user innovations developed by consumers ≥ 18 years	2.8%

In their survey of high-tech SMEs, de Jong and von Hippel (2009) identified 364 user innovation cases for which they asked respondents (business owners or managers) if they had protected their innovation-related knowledge with IPRs. This applied to only 12.5 percent of the cases. In contradiction, other firm surveys reported higher percentages.

Schaan and Urbach (2009), in a subsequent study of manufacturing plants who had reported to be technology modifiers or technology creators, found that 53.3 percent of their sample protected their knowledge with IPRs. This percentage, however, also included 'secrecy' as a protection method. Flowers et al. (2010), analying 200 user innovation cases, found that 35.5 percent was protected, while Kim and Kim (2010) found 43.8 percent for South-Korean manufacturing firms. In general the odds of protection seem to increase with firm size, a finding that is further discussed below.

A direct investigation of openness was presented by de Jong (2010). Drawing on a database of high-tech small firms in the Netherlands who had previously developed user innovations, I organized a new survey in which respondents were asked to identify and report on their most recent producer and user innovations. I analyzed only those 81 respondents who had recently engaged in both types of innovations, so that a direct comparison was possible. A first finding was that while high-tech firms were inclined to protect the intellectual property of their new products (60.3 percent), the same firms did not bother about protecting their user innovations (only 13.6 percent protected). Next, in a binary logistic regression model, I controlled for some of the usual determinants of the propensity to protect, including time and money expenditures and innovation collaboration. After adding these controls the distinction between producer and user innovations was still significant at $p < .001$. Moreover, I found that high-tech small firms were more willing to share their user innovations than their product innovations. Drawing on a multiple-item scale measuring firms' willingness to freely reveal (e.g., 'We are willing to share this innovation for free') the average score for product innovations was 1.2, while for user innovations it was 2.3 (minimum = 1.0, maximum = 5.0). These results suggest that user innovation is indeed more open than producer innovation.

In samples of consumers the incidence of protection has been found to be much lower. Von Hippel et al. (2012) reported that only two out of 104 consumer innovations were patented. Similar findings were obtained for user innovations by American and Japanese consumers (Ogawa & Pongtalanert, 2011), and more recently, in Finland (Kuusisto et al., 2013) and Canada (de Jong, 2013).

Some conclusions can be drawn based on these surveys. First, user innovation seems more open than producer innovation. This seems most true for consumers, but also for high-tech small firms who are competing with differentiated products rather than unique production processes. A disclaimer, however, is that many of these firms will still not be inclined to freely share their knowledge. Rather than IPRs, they may prefer secrecy as a more effective protection method to exclude rivals from imitation – a similar preference has been documented for the broader category of process innovation (Levin et al., 1987). For larger organizations, findings certainly differ from consumers. In the Canadian, British and South-Korean samples quite a few firms were eager to protect their knowledge. We speculate that especially large manufacturers are more likely to operate in oligopolistic markets where competitive advantage revolves around unique production processes, and then it makes sense to exclude rivals from copying innovative processes.

4. Diffusion of user innovation

Previous studies have shown that some user innovations can be very valuable to other users. Users and producers generally know different things and accordingly employ different types of knowledge in the innovation process. Users tend to develop innovations that are functionally novel, as they are most aware of where and how commercially

available products fail to meet their specific needs. In contrast, producers tend to develop innovations that are improvements on well-known needs, but in which they can apply their superior engineering and design skills to increase robustness, sustainability and technical quality (Riggs & von Hippel, 1994).

From a social point of view, it is important that innovations diffuse across society. When innovations are developed by producers, the pathway to diffusion is well known, as producers have a strong incentive to sell what they have developed to all interested consumers and/or firms. Besides, their knowledge will involuntarily spill over to other innovating actors as a consequence of labor mobility, site visits of external actors, and more. Ideally, user innovations should diffuse too, or multiple users with similar needs would need to invest in similar innovations. This would lead to considerable duplication and be inefficient from a social welfare point of view (Kuusisto et al., 2013).

In general, three mechanisms have been identified for the diffusion of user innovations (Kuusisto et al., 2013). First, users may reveal their innovations to others for inspection, copying and adoption without charge. Second, users may start a new business to introduce a commercial version of their innovation to the market. Third, commercial producers may adopt users' innovations to further improve and sell them as commercial products. Survey evidence for these mechanisms is discussed next.

Free revealing

Users are less likely to apply for IPRs than producers, but some go even further by actively revealing their innovations for free, so that their innovation-related knowledge becomes a public good. They may do so hoping that commercial producers will adopt and improve their innovations so that more robust and reliable solutions become available. Alternatively, free revealing can be driven by expected recognition of peers and reputation gains, communal norms of reciprocity (i.e. benefit from other users' contributions like in open-source software) and the desire to set informal standards (Harhoff et al., 2003).

After early studies demonstrated that users may freely share their innovations in specific industries, for example in medical equipment, open source software, semiconductor process equipment and mine pumping engines (von Hippel, 2005), recent studies find similar results for broad samples. Seven of the previously discussed surveys asked if innovators had revealed the details of their innovations to others for free. See Table 3.

Table 3. Free revealing by firms and consumers, and adoption by other actors (firms or consumers)

Source	*Country*	*Year*	*Sample*	*Free revealing*	*Adoption*
Firm surveys:					
de Jong & von Hippel (2009)	Netherlands	2007	364 user innovations developed by high-tech SMEs (< 100 employees)	12.0%	24.7%[b]
Schaan & Uhrbach (2009)	Canada	2007	1,277 user innovations developed by manufacturing plants with > 20 employees and $ 250K revenues	10.9%	26.3%[b]; 25.3%[c]
Flowers et al. (2010)	United Kingdom	2009	200 user innovations developed by SMEs with 10-250 employees	12.5%	19.5%
Kim & Kim (2011)	South-Korea	2009	370 user innovations developed by manufacturers with > 10 employees	9.5%[a]	3.2%
Consumer surveys:					
von Hippel et al. (in press)	United Kingdom	2009	104 user innovations developed by consumers ≥ 18 years	28.9%	17.1%
Ogawa & Pongtalanert (2011)	USA	2010	114 user innovations developed by consumers ≥ 18 years	18.4%	6.1%
Ogawa & Pongtalanert (2011)	Japan	2011	83 user innovations developed by consumers ≥ 18 years	10.8%	5.0%
Kuusisto et al. (2013)	Finland	2012	176 consumer innovations developed by consumers of 18-65 years	26.7%	18.8%
Dupuis et al. (2014)	Canada	2013	539 consumer innovations developed by consumers ≥ 18 years	33.6%	21.2%

[a] This percentage reflects companies'/individuals' willingness to freely reveal, [b] Adoption by commercial producers only, [c] Adoption by other users only.

These empirical findings show that many of the innovations developed by users are meaningful to others. Beyond this, there is a subset of user firms (not listed in Table 3) revealing selectively, for example to close social ties, and/or for non-monetary compensations like discounts on future orders and other favors. For example, in a sample of innovating high-tech small firms selective revealing was practiced by 13 percent (de Jong & von Hippel, 2009).

In consumer samples the share of freely revealed innovations is higher: in the 10 to 30 percent range. This reflects that innovating consumers generally have no direct commercial interests, and do not bother to bargain for compensation or any favors. In fact, many innovating consumers tend to be excited if other people show interest in their solutions and adopt those for personal use (von Hippel et al., in press). Apparently, recognition by others constitutes a benefit to these innovators.

However, it must be noted that the overall economic impact of user innovation hinges to a large extent on the value that others also gain from adopting those user-developed innovations. While 10 to 30 percent of the users reveal their innovations to others, 70 to 90 percent does not – implying that other firms/individuals who may benefit from the same innovation, would need to develop it by themselves again. Kuusisto et al. (2013) argued that the diffusion of user-developed innovations will be negatively affected by a novel type of market failure: value that others may gain from a user-developed product will often be an externality from the viewpoint of innovating users, who therefore may not invest effort in supporting diffusion to the extent that would be socially optimal. Evidence compatible with this view is found in recent studies in Finland (Kuusisto et al., 2013) and replicated in Canada (de Jong, 2013). In Finland, for example, 84% of the innovating consumers were willing to diffuse information about their innovations to all or

selected others for free – but only 26% had made any efforts at all to do so. Further, diffusion effort was found to be significantly associated with diffusion attained (Kuusisto et al., 2013).

New venture creation

If users have developed an innovation that other people like, they generally receive requests from others to build them a copy. Users then sometimes decide to start their own business to commercialize their innovations, and accordingly become producers – despite that they were initially driven by personal need. Examples of entirely new industries which emerged via such a process are juvenile products, rodeo kayaking equipment and dishwasher machines (Shah & Tripsas, 2007).

Systematic empirical studies demonstrating the relationship between user innovation and new venture creation have yet to be undertaken. A first attempt was reported by de Jong (2011). After an extensive screening procedure, I obtained a sample of 33 Dutch consumers who had developed a user innovation in the past three years. Next, I analyzed how these innovators performed on various indicators adopted from the Global Entrepreneurship Monitor (GEM) (Hartog et al., 2010). Table 4 offers descriptive statistics for user innovators and all Dutch consumers aged 18 to 64.

Table 4. Entrepreneurship indicators for user innovators and broad consumer population

GEM indicator	*User innovators (n=33)*	*Dutch consumers aged 18-64 (n=2,133)*
Entrepreneurial intentions	15.2%	7.4%
Nascent entrepreneurship	9.1%	3.1%
Start-up entrepreneurship	3.0%	4.1%
Established entrepreneurship	3.0%	8.0%

Source: de Jong (2011: p.56)

I found that user innovators were more likely to have entrepreneurial intentions and to engage in nascent entrepreneurship. Thus, 15.2 percent expected to start a new business within the next three years, and 9.1 percent was actively involved in the process of business creation but had not yet received any income. Within the broad consumer population these percentages were 7.4 and 3.1, respectively. Next, I found that user innovators were less likely to be established entrepreneurs, i.e. being an owner/manager of a registered business with salaries or wages being generated for more than 42 months already. Although the sample size is very modest, Table 4 gives a first hint that user innovation and entrepreneurship are correlated – but obviously these findings do not prove causality. It may be that innovating consumers are more likely to recognize opportunities to build a business and then do so. Alternatively, user innovation and early-stage entrepreneurship may reflect people's general pro-activity to take charge and pick up challenges and opportunities in life.

Adoption by commercial producers

The third diffusion mechanism is that commercial producers can take up users' innovations, develop them further, and then introduce them to the market for sale. In the process of an emerging industry user innovators tend to be most significant and active in the early stages when a homogeneous market need has yet to be identified. Producers typically enter only later when sufficient numbers of users can be identified with homogenous needs (von Hippel et al., 2011).

Survey results regarding frequency of adoption are shown in the right-hand column of Table 3. Note that most studies did not distinguish between adoption by producers and other users, but asked for adoption in a broad sense. In the samples of Dutch high-tech SMEs and Canadian manufacturing plants adoption by commercial producers was around 25 percent of all reported innovations. Moreover, Schaan and Urbach (2009) found that another 25.3 percent was adopted by other users. For consumers these general adoption rates are lower, i.e. 5 to 20 percent, but across the globe this would still represent a large number of innovations which are apparently useful to others. The only 'outlier' is the South-Korean sample in which few manufacturers reported that other business had picked up their inventions. Kim and Kim (2011) argued that this may due to cultural reasons and the presence of hierarchically organized industry structures ('chaebols').

In summary, although most user innovations seem of interest to the innovator alone, it is generally found that 5 to 25 percent are useful to other agents and get adopted either in part or as a whole. Adoption of user innovations is definitely also done by commercial producers.

5. Concluding remarks

We discussed evidence collected in broad surveys of firms and consumers in multiple countries. User innovation is present in large parts of the economy and practiced by many businesses and individual consumers. Substantial money and time investments are annually made by these innovators to satisfy their own process-related or personal needs, and this effort is probably at best partially recorded in official statistics (firms) or still invisible (consumers). Moreover, we found that in consumer samples user innovation is relatively open (unconstrained by intellectual property), while firm studies suggest that user innovation is at least more open than traditional producer innovation. Finally, user innovations appear to be useful to other economic actors. Diffusion mechanisms include free revealing (about 10 percent of the innovations developed by firms, and 10 to 30 percent of the innovations developed by consumers), new venture creation (user innovators are more likely to be occupied with early-stage entrepreneurship) and adoption by incumbent producers for further development and commercial sale. In parallel, however, emerging empirical evidence shows a new type of market failure with regard to diffusion. Diffusion is basically an externality to the innovating user, so s/he will not invest as much effort in diffusion as would be desirable from a social welfare point of view.

In the near future user innovation is likely to become even more important. Empowered by the internet specific types of user innovation, including open-source projects and other distributed forms of innovation, will become increasingly important. Moreover, easy-to-use design tools such as CAD software and 3D printers are becoming more widely available. As the average world education level is improving, an increasing share of world citizens will be able to innovate for themselves (Baldwin & von Hippel, 2011). It is therefore of considerable importance to start exploring the implications of user innovation for current innovation metrics and policies, respectively.

To those involved in innovation metrics, we recommend further work to more explicitly capture user innovation and how it diffuses to society. Given that a significant amount of firms engages in user innovation, continued work should be done to explore to what extent official surveys like the CIS empirically capture process innovation, so that

any follow-up survey can effectively go into the details of user innovation. Alternatively, we recommend experimenting with new survey designs to measure the phenomenon more directly. Until the actual levels of user innovation and expenditures are made clear, it will be difficult to get governments to take the policymaking needs of user innovators serious. In this vein, current measurement practices are among the major reasons that policy makers still favor the sequence of R&D and subsequent commercialization. Several scholars have already pointed out that current innovation metrics are in need of modification (e.g., Jensen et al., 2007; Godin, 2006). Moreover, as far as we know there are no official surveys which attempt to measure user innovation by consumers. The challenge would be to incorporate indicators in any of the social surveys which statistical offices implement throughout the world.

For policy makers, the implications of the emerging user innovation phenomenon are yet to be explored in detail. Since user innovations are marked by functional novelty, contribute to the emergence of new industries, are a useful feedstock of innovation for producers, and contribute to social welfare, it is important to study how and what hampers user innovation, and how policy makers can intervene. Although too early for specific recommendations, we offer two design principles in advance. First, it is important that policymakers see through their current logic of what effective innovation policies look like. User innovation is dissimilar from 'user-driven' forms of innovation in which producers pay close attention to user needs while developing new products for them. It is important that any policy would actually target users themselves, rather than the traditional producer focus based on (assumed) market failures. Second, as user innovation is not confined to businesses, policies should also become eligible for individuals. We are aware that this would be giant step from an incumbent policy point of view. It may however be urgent because the anticipated and ongoing shift of product development activities to users can potentially wipe out incumbent producers (Baldwin & von Hippel, 2011). In the next few years we hope to witness interesting new measurement practices and policy insights from the work that is currently in progress.

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