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Free in, free out? Outbound transfer of user innovations in small UK firms

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ABSTRACT

Small firms develop user innovations, with some going on to become viable new industrial products - the challenge to industrial suppliers being to identify and absorb such innovations from their existing or potential customer base. In this paper we: i) analyse which small firms more likely develop user innovations; ii) investigate how the outbound knowledge transfer of user innovations is related to inbound knowledge sourcing and acquisition; and iii) explore why small firms may reveal user innovations. Drawing on a survey of 1004 small firms in the United Kingdom, of which 23 revealed their user innovations, the research confirms that the incidence of this phenomenon is related to firm size and general innovation activity. However, in direct contrast to innovating consumers or open-source contributors, the revealing of locally-created innovations was shown to be selective and motivated by optional future benefits. Further, it emerged that small firms barely freely reveal at all, suggesting that further research of this phenomena in the context of small firms is required. These in-depth insights into small firm revealing behaviour are of great value to industrial suppliers who wish to draw on innovations that emerge within their existing or potential customer base.

1. Introduction

One of the main challenges in industrial marketing is to understand customer needs so that businesses can develop better product concepts (e.g., La Rocca, Moscatelli, Perna, & Snehota, 2016; Wiersema, 2013). Beyond voicing their needs industrial customers can play an active role in the innovation process by prototyping solutions to problems they encounter in their everyday practice – a phenomenon described as user innovation (von Hippel, 2005). If other industrial customers, or users, face similar problems these solutions can become viable new products (Foxall, 1989). Empirical studies have shown that user-prototyped solutions are preferred by other potential users and have much better market prospects compared to traditionally developed products (e.g. Fuchs & Schreier, 2011). In industrial settings, supplier firms may be able to benefit from user innovations developed by their existing or potential customer base and can go beyond co-creation product development projects with customers (Hoyer, Chandy, Dorotic, Krafft, & Singh, 2010; La Rocca et al., 2016; Prahalad & Ramaswamy, 2004). User firms can develop prototypes that can go on to be successful new products once adopted by suppliers, although research suggests that tracing and absorbing user innovations is not straightforward and relatively few will successfully diffuse to commercial suppliers (de Jong, 2016; von Hippel, 2017).

This paper will investigate the conditions in which small firms are more likely to develop user innovations and to transfer these innovations to other businesses. In order to provide industrial suppliers with more detailed understanding of where and how to locate user innovations, the paper will also explore what motivates small firms to engage in outbound transfer, an important issue in the current era of rapid technological advancement and evolving supplier-buyer relationships (La Rocca et al., 2016; Wiersema, 2013).

The contributions of this paper are threefold. Firstly, we are concerned with the question of the circumstances in which small firms are more likely to engage in user innovation. It has been shown that firm size and overall innovative activity are positively related with the incidence of user innovation, although this was only demonstrated in samples of manufacturers (Kim & Kim, 2011) and high-tech small firms (de Jong & von Hippel, 2009). In this paper we explore if these findings generalize to a broad sample of firms that includes both services and primary sector businesses.

Secondly, we examine the conditions in which small firms are more likely to transfer user innovations to other organizations. Recent work has identified that firms are increasingly inclined to sell their innovations, and sometimes even reveal them for free (Dahlander & Gann, 2010; West, Salter, Vanhaverbeke, & Chesbrough, 2014). The insights offered by these studies are valuable but they recognise that the relationship between outbound knowledge transfer and inbound knowledge transfer requires further empirical exploration. According to

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Dahlander and Gann's (2010) classification, outbound knowledge transfer can take place in two ways: by selling innovations or by revealing them without compensation. Similarly, inbound knowledge transfer can take place for compensation (acquiring) or for free (sourcing). In order to explore the interactions between these inbound and outbound behaviours, we hypothesize that if free inputs are obtained in the development process user innovations are more likely to be revealed and less likely to be sold. Building on this approach we also hypothesize that if knowledge is acquired, user innovations are more likely to be sold and not revealed.

Thirdly, we explore the conditions under which small firms tend to reveal their innovations to other organizations. Although revealing without compensation may appear to be counterintuitive, the literature suggests two alternative explanations: Firstly, that firms are calculating when revealing their user innovations and may seek longer-term economic benefits that are impossible to specify or demand in advance. This 'optional benefits motive' includes revealing to existing network ties, in order to develop new relationships for future benefits, or to explain an improved version of the user innovation by transferring it to an industrial supplier (e.g., Alexy, George, & Salter, 2013; de Jong & von Hippel, 2009; Murray & O'Mahony, 2007). Revealing for possible future benefits is in line with the classical appropriation literature in which firms are expected to avoid imitation, unless there is some kind of benefit (Teece, 1986). Secondly, an alternative explanation suggests that firms may freely reveal to anyone, without expecting a return. This 'free sharing motive' includes revealing for altruism, to follow industry norms, or for a better general reputation (e.g., Allen, 1983; Henkel, Schöberl, & Alexy, 2014). In order to inform industrial suppliers looking for user innovations in their customer base and to contribute to the emerging debate on revealing innovations (e.g. West et al., 2014) we explore if small firms are driven by optional benefits and/or free sharing.

These hypotheses were tested with the results of a survey of 1004 small firms in the United Kingdom and by analysing 23 cases in which small firms revealed their user innovations. The empirical context of this study is explored in more detail below, with the next section outlining the relevant theoretical background and explaining the development of our hypotheses.

2. Theory and hypotheses

In this section we will develop our hypotheses regarding the incidence of user innovation amongst firms, the interactions between outbound and inbound knowledge transfer, and firms' motives to reveal their innovations.

2.1. Incidence of user innovation

Early studies of user innovation focused on the importance of users as a source of innovation for specific industrial product types such as printed circuit CAD software (Urban & von Hippel, 1988) or pipe hanger hardware (Herstatt & von Hippel, 1992). More recently survey methods have been developed that enable the identification of user innovations in broader samples – these methods have been successfully applied to firm (e.g., de Jong & von Hippel, 2009; Kuusisto & Kuusisto, 2013) and consumer samples (e.g., von Hippel, de Jong, & Flowers, 2012). The studies, summarized by de Jong (2016), show that user innovation is a widespread empirical phenomenon present in all parts of the economy, with estimates of user innovation frequency ranging from 18 to 54%.

Our first hypothesis explores the association between firm size and the presence of user innovation activity. Larger firms are often more process-intensive and, as a result, tend to be more commonly confronted with process challenges requiring innovative solutions, with returns to investments in this area (as compared to product-related investments) being generally better for such firms (Cohen & Klepper, 1996). It is important to recognise, however, that all user innovations will not necessarily be process innovations and all process innovations will not necessarily be user innovations. For example, when a firm innovates within its processes it may simply be adopting technologies developed by other organizations (OECD/Eurostat, 2005), while user innovations can themselves include new forms of organization and marketing (von Hippel, 2005). Industrial suppliers typically focus on markets with sufficient potential users to justify their innovation investments, with this strategy of 'few sizes fit all' leaving many users dissatisfied with the commercial products on offer (von Hippel, 2005) and providing a potential driver for innovative activity by users. Since most businesses tend to be small (e.g., in most economies firms with < 10 employees represent over 90% of the business population), it is arguable that the larger the firm, the less likely it is to find commercial suppliers who have already developed a solution to their unique internal processes.

Past studies have demonstrated that user innovation tends to be positively associated with firm size in samples of high-tech firms (de Jong & von Hippel, 2009) and manufacturers (Kim & Kim, 2011). We here seek to explore if this finding can be replicated in a broad sample of small firms that also includes the service and primary sector:

H1: The larger the firm, the more likely it is to engage in user innovation.

Developing this same theme, we would expect that a firm's general innovation ability to be associated with user innovation. The user innovation literature suggests two ingredients for user innovation: the knowledge concerning unsatisfied needs, and the knowledge required develop a solution to these needs. von Hippel (2005) explains that users have the advantage of knowing precisely what they want (perfect need-related knowledge), which is often not the case for industrial suppliers. In contrast, the knowledge bases of industrial suppliers will tend to focus on design and market innovations – they will have better solution-related knowledge to satisfy a need once it has been identified.

The association between a firm's general innovation ability and user innovation has been identified in several studies. For example, a study of Korean manufacturers reported a positive association between firms' innovative activity and user innovation (Kim & Kim, 2011) and in a study of Dutch high-tech firms a high share (54%) of user innovators was found (de Jong & von Hippel, 2009). In line with our reasoning, the authors propose that this was the result of a combination of unique internal process-related needs and the firms' high ability to develop solutions. In this study we aim to explore if this can be replicated in a broad sample of small firms:

H2: The higher a firm's general innovation ability, the more likely it is to engage in user innovation.

2.2. Outbound transfer of user innovations

The work of Dahlander and Gann (2010) proposes that firms may sell or reveal innovations, with selling implying that knowledge is transferred to other organizations for direct compensation (e.g., money, license, royalty) and revealing that firms transfer their knowledge without expecting any direct return. The latter strategy may be opportune for a range of reasons including reputational gain, development of social capital, and standard setting processes (e.g., Alexy et al., 2013; Allen, 1983; de Jong & von Hippel, 2009; West et al., 2014). In order to develop a more nuanced theoretical understanding of revealing we will examine how the selling and revealing of user innovations varies in the context of the two inbound knowledge practices identified by Dahlander and Gann (2010): acquiring knowledge (for money or other kinds of compensation, that is, pecuniary inputs) and sourcing (free external inputs to the innovation process, also known as non-pecuniary inputs).

This provides the foundation for the development of our third hypothesis that examines the relationship between free external inputs ('sourcing') and revealing behaviours. We argue that when being in

receipt of free external inputs the user firm needs to undertake outbound knowledge sharing efforts with those actors who contributed to the innovation process. Free external inputs also diminish innovation costs so that revealing may be considered less problematic (Harhoff, Henkel, & von Hippel, 2003). The decision to reveal is also likely to be positively influenced by the everyday psychological mechanisms of reciprocity and consistency (Cialdini, 2001). As a result, we argue that if a business owner/decision-maker obtains free inputs, s/he will more likely refrain from claiming ownership and engage in the same behaviour by sharing the derivatives of their free inputs, compared to someone who acquired external inputs for money. Finally, with free external inputs it is also less likely that the intellectual property rights can be claimed as other organizations will have related or overlapping knowledge, so that patents are less viable (Hall, Helmers, Rogers, & Sena, 2012). In this context outbound transfer by selling user innovations is less likely and we hypothesize:

H3: If a firm sourced non-pecuniary external inputs to develop a user innovation, it is (a) more likely to reveal, and (b) less likely to sell its innovation-related knowledge to other organizations.

Our fourth hypothesis is that in the presence of pecuniary external inputs ('acquiring'), outbound transfer by selling user innovations will increase, while revealing at no cost decreases. Paid external contributions generally imply higher innovation investments, a factor that is positively related to firms' willingness to appropriate (Cohen, Nelson, & Walsh, 2000). Further, since some form of compensation will have been paid to an external contributor, the innovating firm will be more likely to claim ownership and feel entitled to charge others who may benefit, as compared to a firm who obtained external knowledge for free. At the same time free revealing would be less likely for reasons of consistency ('We paid, so they should pay'), and the user firm is not likely to be hindered by norms of reciprocity (Cialdini, 2001). As a result we hypothesize:

H4: If a firm acquired pecuniary outside help to develop a user innovation, it is (a) more likely to sell, and (b) less likely to freely reveal its innovation-related knowledge to other organizations.

2.3. Motives to reveal

Beyond the interactions with inbound knowledge transfer, we seek to explore why small firms reveal their user innovations. Previous studies have suggested a range of motives, from which we identified two key reasons to reveal: 'optional benefits' and 'free sharing'.

'Optional benefits' revealing is in line with the classical innovation literature which suggests that firms should protect their innovations and avoid the situation in which others can take advantage of their work (Cohen et al., 2000; Teece, 1986). Thus, user innovations will be shared only if the firm is compensated – for example, a fee, license or other direct benefit. In practice, however, it is likely that in the absence of an obvious and substantial market demand direct benefits can be hard to obtain. As a result, we suggest that in such instances a small firm may decide to reveal their innovation for optional, future benefits. For example, they may share their innovation in existing networks to maintain or strengthen relationships. Social networking studies show that firms may harvest such benefits as a later date, although this is impossible to specify or require in advance (Kim & Aldrich, 2005).

The presence of optional benefits may also explain why firms may reveal user innovations to existing network ties (de Jong & von Hippel, 2009; Kuusisto & Kuusisto, 2013). Optional benefits can also include revealing to develop new relationships or to evoke new collaborations (Alexy et al., 2013), to obtain a potential better version of the user innovation from a commercial supplier (Murray & O'Mahony, 2007), or to influence standard setting processes (Alexy et al., 2013; Henkel, 2009). Optional benefits revealing will by its very nature be selective as firms would tend not to broadly reveal their user innovations.

In contrast, 'free sharing' represents a different kind of motive, not driven by direct benefits and includes revealing for altruism (Harhoff et al., 2003; Hars & Ou, 2002), to follow industry norms as observed in collective invention processes (Allen, 1983; Nuvolari, 2004), or for the good feeling obtained from reputational advancement (e.g., Henkel et al., 2014). This form of motivation is described in the user and open-source innovation literatures (e.g. von Hippel, 2005, 2017) and has been frequently documented in samples of contributors to open-source projects (e.g. Hars & Ou, 2002; Lakhani & Wolf, 2005), individual end consumers (de Jong, von Hippel, Gault, Kuusisto, & Raasch, 2015), and it has also been encountered in samples of employees in organizations (Henkel, 2009; von Hippel, 1987). In contrast to optional benefits, free revealing can occur with any external organization or other actor.

In this paper we explore what motivates small firms to reveal their innovations in order to contribute to the emerging debate on revealing by commercial organizations (e.g. West et al., 2014). This research is also intended to inform our recommendations to industrial suppliers seeking to identify and absorb user innovations and, as a result, we formulate the following research question:

RQ: Why do small firms reveal their user innovations to other organizations?

3. Data

3.1. Sample and data collection

We used a dataset that had been collected on behalf of NESTA, an innovation charity in the United Kingdom, to measure the frequency of product creation by users with the aim of developing better innovation statistics (Flowers, von Hippel, de Jong, & Sinozic, 2010). The dataset is formed of responses from 1004 firms collected using a telephone survey with the data providing the basis for the testing of the hypotheses outlined above. An initial, gross sample of 5678 firms had been drawn from the Dun & Bradstreet database and 2311 firms could not be reached for various reasons (duplicate addresses, vanished businesses, no answer after five attempts, etc.). Out of the net sample of 3367 contacted firms, 1004 participated, a response rate of 30% (or 18% of the initial gross sample). All respondents were business owners or general managers.

The sample contained firms with 10 to 250 employees in a broad sample of services and primary sector industries (Table 1). As the original survey explored the differences between user innovation and traditional innovation indicators, micro-businesses (< 10 employees) were not included, as is the case with the UK Community Innovation Survey (Robson & Achur, 2013). Firms with > 250 employees had also been excluded as there are comparatively few of them and they are relatively difficult to contact.

As the commissioner of the survey was interested in comparing various industry types and size classes, the sample had been disproportionally stratified. Firms with 50–249 employees were oversampled, as were respective industry types. Moreover, statistical χ^2-tests showed that responses had been slightly selective. Financial services firms had been less likely to participate, while hotels and restaurants and firms with 10–49 employees had responded relatively well. To obtain representative estimates for the whole population, we corrected for sampling and selection bias by computing weights for all responding firms. For this purpose UK's Office of National Statistics provided a table which broke down the population of UK firms across industry types and size classes. We present weighted results, but all findings are maintained with unweighted data (available on request).

3.2. Screening of user innovations

To identify if firms were user innovators, the survey contained a screening procedure that had previously been tested in a sample of high-tech firms (de Jong & von Hippel, 2009). This screening procedure has since become a standard approach in the measurement of user innovation in samples of firms (e.g., Kuusisto & Kuusisto, 2013) and

Table 1
Characteristics of UK small firms, sample and respondents.

Industry type	SIC 2007 codes:	Population (N = 290,396)	Net sample (n = 3367)	Respondents (n = 1004)
Manufacturing:				
Aerospace and automotive	(29 + 30.3 to 30.9 + 33.16 + 33.17)	0.6%	7.7%	6.7%
Other manufacturing	10 to 33 (but not 29 + 30.3 to 30.9 + 33.16 + 33.17) + 58 + 59	19.4%	6.1%	6.8%
Services:				
Wholesale trade	46	6.6%	5.7%	6.9%
Retail trade and personal services	47 + 95 + 96	12.0%	6.0%	6.7%
Hotels and restaurants	55 + 56	12.5%	4.2%	6.7%
Transport and communication	49 to 53 + 60 + 61	8.1%	6.8%	6.7%
Financial services	64 to 66	2.7%	9.9%	6.7%
Software and IT services	62 + 63	3.2%	6.4%	6.6%
Legal, consultancy and accounting	69 + 70	5.1%	7.3%	6.7%
Architecture and design	71 + 72	7.3%	6.4%	6.7%
Other business services	68 + 73 + 74 + 77 to 82	10.5%	6.6%	6.7%
Other:				
Mining and quarrying	05 to 09	0.3%	6.5%	6.7%
Agriculture and fishing	01 to 03	1.3%	7.2%	6.7%
Energy production	35 + 36	0.3%	5.4%	6.4%
Construction	41 to 43	10.2%	7.8%	6.7%
		100%	100%	100%
Size class:				
10–49 employees		81.5%	50.5%	61.5%
50–249 employees		18.5%	49.5%	38.5%
		100%	100%	100%

Note: Population statistics for the year 2010 obtained from the UK Office of National Statistics.

Table 2
Examples of reported innovations.

Type	Coded as a user innovation	Coded as not a user innovation
Software modification	'We added an interface to the accounting system, this interface allows us to cut down on the manual input required. Once this had been developed we transferred accounts information to the subsidiary system, for easier use and less manual work. We didn't want to repetitively enter data into the system, but rather have it put in once, and allow the accounts interface to make changes with less manual work.'	'We recently modified our systems and upgraded to the newest Microsoft Office. The management of our server system was switched to a company based in Denmark. The upgrade was done on the advice of this company and because it is a better program which best suits our business needs.'
Software creation	'We programmed an application to transfer manual drawings to a computerized system, to enable adjustments to be made in real time. We required a system that would be specific for in-house use as opposed to incumbent products.'	'We developed new computer games to maintain our position in the marketplace and to remain competitive. We are in the home entertainment industry.'
Hardware modification	'The machinery that we modified was the lathe. It is the rotary turning machinery which fabricates steel components to change the shape. We added another function in order to make blocks of steel. This new function was added so that the machinery could make different things such as steel blocks that would fabricate underwater winches.'	'We upgraded to SAGE200 as we were previously on CH50. We had to do it because we modified their stock, we relocated and had to create new areas, which had to be put on the computer for sales and administrative purposes. The previous equipment was too haphazard.'
Hardware creation	'We built small electronic modules used in the sea. There was nothing on the current market to do the job at hand and this type of equipment was specialized and tailored to suit the company's needs as and when required.'	'We developed a system to detect fingerprints for application in forensics. It was to improve our current line of products (we are a manufacturer of electronic equipment selling to police agencies).'

Source: Flowers et al. (2010): p. 35.

consumers (e.g., von Hippel et al., 2012). To trigger recall the survey offered specific cues and respondents were asked for software and hardware, the latter cue being defined further as machinery, equipment, tools or other devices. Moreover, for each cue respondents were asked for modifications or existing software/hardware, and creations from scratch. Thus, respondents had the opportunity to report up to four user innovations and were asked to indicate if, in the past three years, they had undertaken any of the four types of user innovation (software modification, software creation, hardware modification, hardware creation). If the answer was 'yes' they were asked to confirm whether they had developed the innovation for a personal, internal need, this question helping to exclude regular product development activities. Next, open-ended questions were asked to obtain a detailed description of the innovation, and to record the respondents' motivations in developing it. The answers to these questions had been validated afterwards by two independent coders in order to ensure that the reported examples were, indeed, user innovations. Respondents had initially reported 323 innovations, of which 54 were classified as false positives. Examples of reported user innovations and false positives are shown in Table 2.

This process resulted in 269 user innovations developed by 200 firms being screened out. After weighting the data, a point estimate of the frequency of user innovation in UK small firms was 15.3% (unweighted estimate 19.9%, see Flowers et al., 2010).

3.3. Variables and questions

Table 3 summarizes the variables that were analyzed, with firms who reported multiple user innovations being asked to pick their most recent one in order to obtain a random sample. To test our hypotheses

Table 3
Variables.

Variable	Description
(collected for all respondents, n = 1004)	
User innovator	Firm developed a user innovation in the past three years (reported at least one valid user innovation) (0 = no, 1 = yes)
Firm size	Number of people currently employed at the firm (including working business owners and family members)
Innovative activity	Count variable of six innovative activities conducted in the past three years (Cronbach's alpha = 0.70) (minimum score = 0, maximum score = 6): research and development acquisition of new hardware (incl. machinery/equipment) or software acquisition of external knowledge, such as patents and other types of knowledge from other business/organizations training personnel specifically to develop or introduce innovations design activities to develop or introduce innovations activities to support the market introduction of innovations
Manufacturing	Firm operated in a manufacturing industry (0 = no, 1 = yes)
Services	Firm operated in a services industry (0 = no, 1 = yes)
(collected only for user innovators, n = 194)	
Selling	Firm shared its user innovation or related knowledge with another organization, for a payment (0 = no, 1 = yes)
Revealing	Firm shared its user innovation or related knowledge with another organization, without compensation (0 = no, 1 = yes)
Acquiring	To develop the user innovation, the firm received external inputs (e.g, assistance, components, advice), for a payment (0 = no, 1 = yes)
Sourcing	To develop its user innovation, the firm received external inputs (e.g, assistance, components, advice), without compensation (0 = no, 1 = yes)
Hardware	The innovation was primarily concerned with hardware, e.g., machinery, equipment, tools (versus software) (0 = no, 1 = yes)
Creation from scratch	The innovation was created from scratch (versus a modification of existing hardware/software) (0 = no, 1 = yes)
Re-invention	The respondent knew other firms/organizations who had developed a similar innovation (0 = no, 1 = yes)
Protection	The firm had protected the innovation with formal intellectual property rights (e.g., patents, trademarks or confidentiality agreements) (0 = no, 1 = yes)
(collected for user innovators who had revealed, n = 23)	
Motive	Why did you reveal your innovation without any charge? (open-ended question)
Existing relationship	Regarding the company to whom you revealed, did you have a pre-existing relationship? (0 = no, 1 = yes)
Selectiveness	Would you be willing to reveal the innovation to anyone interested, or just this company? (1 = anyone, 2 = just this company)

H1 (firm size) and H2 (innovative activity), being a user innovator was indicated by a dummy variable based on the screening procedure elaborated above. Firm size was indicated by the number of employees including business owners and working family members (M = 32.6, SD = 36.3). Innovative activity was indicated by a measure of six items with good reliability (Cronbach's alpha = 0.70), and are traditional innovative input indicators taken from the Oslo manual (OECD/Eurostat, 2005). On average, firms had engaged in 1.51 innovative activities (SD = 1.54). We also controlled for industry types as earlier work showed that user innovation frequency can differ across industries (summarized by von Hippel, 2005).

To test our hypotheses H3 (sourcing) and H4 (acquiring) we analyzed the subset of 194 firms with user innovations (six respondents were eliminated due to missing data). Selling and revealing user innovations were measured with dummy indicators. We found that 6.5% of the user innovations had been sold (SD = 0.247), while 12.8% had been freely revealed to other organizations (SD = 0.335). As for inbound transfer, acquiring and sourcing were also measured with dummy indicators and acquisition (M = 42.9%, SD = 0.496) was found to be more common than non-pecuniary sourcing (M = 8.5%, SD = 0.280). Beyond industry types we entered four more control variables to explore different aspects of innovation diffusion. For example, if the innovation was concerned with hardware (versus software) we expected it to be more difficult to transfer. Similarly, if the innovation was created from scratch it might be more eligible to appropriate - modifications of existing software/hardware more often build or infringe on others' knowledge. In the same way, if the innovation was a 're-invention', i.e. a tailored version of an innovation that already existed elsewhere, we reasoned that inbound knowledge flows might be more likely and outbound knowledge flows less likely (as this knowledge is already publicly available) (Rogers, 2003). Finally, if the firm had protected their user innovation with formal IPRs, it was obviously eager to appropriate its broader benefits, which may be positively related to selling and negatively to revealing.

To explore the motives of small firms we analyzed an open-ended question that explored why the user innovation had been revealed. The dataset contained 23 relevant cases that were analyzed to examine if firms were willing to reveal openly to anyone (or selectively), and if they had a pre-existing relationship with the company to whom they had revealed.

4. Results

4.1. Incidence of user innovation

We tested H1 and H2 with a probit regression model of user innovation, in which we entered firm size and innovative activity as independent variables (Table 4). We included detailed industry dummies as control variables (see Table 1), treating 'other business services' as the reference group. In advance of this analysis we computed a

Table 4
Probit model of user innovation in UK small firms (n = 1004).

	dy/dx (S.E.)	
Baseline:	0.153	
Marginal effects:		
Aerospace and automotive	0.002	(0.057)
Other manufacturing	0.020	(0.054)
Wholesale trade	− 0.014	(0.058)
Retail trade and personal services	− 0.099	(0.059)
Hotels and restaurants	− 0.120	(0.071)
Transport and communication	− 0.116	(0.069)
Financial services	0.008	(0.056)
Sofware and IT services	0.128*	(0.055)
Legal, consultancy and accounting services	− 0.034	(0.059)
Architecture and design	0.027	(0.055)
Mining and quarrying	0.026	(0.053)
Agriculture and fishing	− 0.044	(0.062)
Energy production	− 0.020	(0.058)
Construction	− 0.116	(0.070)
Firm size	0.001**	(0.000)
Innovative activity	0.047**	(0.009)
Model fit:		
Log likelihood	− 360.7	
Wald χ^2(df)	83.1 (16)	
Significance	0.000	
Pseudo R^2	0.161	

Notes: Robust standard errors in parentheses. Two-tailed significance $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 5
Descriptive statistics for variables to test H3 and H4 (n = 194).

Variable	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Acquiring	0.429	0.496											
2. Sourcing	0.085	0.280	− 0.072										
3. Selling	0.065	0.247	0.025	− 0.080									
4. Revealing	0.128	0.335	0.107	0.168*	− 0.049								
5. Manufacturing	0.300	0.459	0.149	− 0.116	− 0.081	0.143							
6. Services	0.643	0.480	− 0.142	0.082	0.072	− 0.105	− 0.879**						
7. Firm size	46.9	50.3	− 0.066	− 0.027	− 0.035	− 0.026	0.118	− 0.094					
8. Innovative activity	2.59	1.79	− 0.073	0.025	− 0.043	0.122	0.109	− 0.063	− 0.029				
9. Hardware	0.304	0.461	− 0.018	0.021	− 0.138	− 0.117	0.057	− 0.044	− 0.001	− 0.004			
10. Creation from scratch	0.468	0.500	− 0.051	− 0.127	− 0.207*	− 0.065	0.188*	− 0.106	− 0.016	0.075	0.163		
11. *Re*-invention	0.277	0.449	0.111	0.278**	0.129	0.120	− 0.147	0.177*	0.048	− 0.053	0.056	0.053	
12. Protection	0.284	0.452	− 0.171*	0.159	0.054	− 0.135	− 0.241**	0.274**	− 0.033	0.268**	0.022	0.076	0.135

Notes: M = mean, SD = standard deviation. Two-tailed significance **$p < 0.01$; *$p < 0.05$.

bivariate correlation matrix in order to explore if multicollinearity could be present, with the absolute values of all coefficients were < 0.30, revealing that it was unlikely (correlation matrix available on request) with the variance inflation factors of the independent variables in the probit model not exceeding 2.3. Table 4 provides marginal effect parameters for all independent variables.

The overall model fit was good (Wald $\chi^2 = 83.1$ with df = 16, $p < 0.001$) and firm size emerged as being positively related with user innovation, with one additional employee being related to a 0.1% increase in the share of user innovators ($dy/dx = 0.001$, $p < 0.01$). Innovative activity (measured with traditional CIS indicators) was also significantly related with user innovation, with one additional innovation activity (out of six reported activities) being associated with a 4.7% increase in user innovation. In all, our replication hypotheses H1 (The larger the firm, the more likely is user innovation) and H2 (The higher a firm's general innovation ability, the more likely is user innovation) were supported by the analysis.

4.2. Transfer of user innovations

Table 5 provides descriptive statistics for all the variables utilised to analyse the determinants of selling and revealing user innovations. Revealing emerged as being a more common practice than selling and, with regard to inbound practices, acquiring was a more common practice than sourcing. Table 5 also shows that with the exception of the industry dummies, absolute values of the correlation coefficients do not exceed 0.30. The variance inflation factors in the model reported hereafter were < 4.8 (while 10.0 is the commonly accepted threshold value) indicating no multicollinearity issues.

As a firm's decision to sell a user innovation may be mutually dependent with revealing it, we estimated bivariate probit model to test H3 and H4. We entered as control variables: firm size, innovative activity, and dummies for innovations related to hardware, creations from scratch, re-inventions and protection. To avoid overfitting the dataset (n = 194) with too many parameters, we included simplified industry dummies for manufacturing and services, treating 'other industries' as the reference group. Estimated marginal effect parameters are shown in Table 6.

Model fit was good (Wald $\chi^2 = 510.3$ with df = 20, $p < 0.001$) and user innovations created from scratch were revealed as being less likely to be sold. In contrast, with re-inventions (i.e. the respondent knew other businesses who had developed a similar innovation to satisfy process-related needs) selling was more likely. We suspect that these results may indicate a lack of opportunity to appropriate the broader use value of a user innovation, implying that firms are more inclined to sell their knowledge to obtain any further benefits (on top of satisfying their internal, process-related need). We also found that user innovations protected with formal IPRs were less often revealed, although this was unsurprising as formal IPRs indicate a willingness to directly appropriate innovation benefits.

Table 6
Bivariate probit model of selling and revealing user innovations (n = 194).

	Selling		Revealing	
	dy/dx (S.E.)		dy/dx (S.E.)	
Baseline:	0.060		0.125	
Marginal effects:				
Manufacturing	− 0.034	(0.062)	0.159	(0.098)
Services	− 0.013	(0.054)	0.092	(0.077)
Firm size	− 0.000	(0.000)	− 0.000	(0.000)
Innovative activity	− 0.006	(0.010)	0.027	(0.017)
Hardware	− 0.069	(0.042)	− 0.082	(0.059)
Creation from scratch	− 0.127**	(0.048)	− 0.040	(0.063)
Reinvention	0.077*	(0.037)	0.082	(0.056)
Protection	0.052	(0.034)	− 0.134*	(0.065)
Acquiring	0.005	(0.040)	0.028	(0.052)
Sourcing	− 0.477**	(0.119)	0.167*	(0.072)
Model fit:				
Log likelihood	− 72.2			
Wald χ^2(df)	510.3 (20)			
Significance	0.000			

Notes: Robust standard errors in parentheses. Two-tailed significance **$p < 0.01$; *$p < 0.05$.

With regard to H3 we found that if the firm had sourced free external inputs, selling the user innovation was much less likely ($dy/dx = -0.477$, $p < 0.01$) and inbound sourcing was also associated with a strong increase in the frequency of revealing the user innovation ($dy/dx = 0.167$, $p < 0.05$). Both of these findings are in line with H3.

For H4 (if a firm acquired pecuniary inputs, it is more likely to sell and less likely to reveal the user innovation) we found no empirical support. The relationship between acquiring external inputs and selling the user innovation to another organization was not significant ($dy/dx = 0.005$, p = n.s.), and neither was the relationship between acquisition and revealing ($dy/dx = 0.028$, p = n.s.).

As a robustness check, we recognized that we only analyzed a subset of our data to test H3 and H4 and it might be that firms who did not engage in user innovation differ in some important (unmeasured) ways from those who did, implying a potential selection bias. To explore this matter, we estimated two Heckman selection models with maximum likelihood estimates with the selection equation (being a user innovator or not) included in the independent variables shown in Table 4. In the substantial equation (selling or revealing the user innovation, respectively) we entered the independent variables shown in Table 6. Results were nearly identical, indicating that bias was not present (tables of our robustness checks are available on request).

Table 7
Reported motives to reveal user innovations.

Case	Industry & firm size (employees)	Selectiveness	Existing relationship	Motive (coded)	Motive (open-ended)	Protected	Investment (UK Pound)
1	Aerospace/automotive; 12	Selective	Yes	Maintain relations	'In the past they have favored us and we expect them to keep doing that'	Yes	88,000
2	Software/IT; 30	Selective	Yes	Develop relations	'To improve our standing with the other party'	No	7000
3	Wholesale trade; 70	Selective	Yes	Maintain relations	'Just to help one another out as they don't know what's round the corner due to difficult changes'	No	1000
4	Other manufacturing; 60	Selective	Yes	Maintain relations	'We offer the same products but in different locations. We have the same stakeholder who expects us to share'	No	1000
5	Hotels/restaurants; 150	Selective	Yes	Maintain relations	'We are sister companies with the same owner and they needed help'	No	n.a.
6	Financial services; 65	Selective	Yes	Maintain relations	'Collaborated with them for years, always willing to help each other'	Yes	7000
7	Other manufacturing; 15	Selective	Yes	Maintain relations	'We always help each other, so that we can save time and money. There is no use in keeping the score'	No	20,000
8	Mining/quarrying; 100	Selective	Yes	Maintain relations	'From a longstanding business relationship'	Yes	9000
9	Transport; 10	Selective	Yes	Maintain relations	'Want to maintain existing relations'	No	7000
10	Retail; 195	Selective	Yes	Maintain relations	'Ongoing working partnership, happy to share with them'	No	500
11	Software/IT; 25	Selective	No	Develop relations	'We want to be part of their wider global network'	Yes	82,000
12	Transport; 50	Selective	Yes	Maintain relations	'We collaborate with them nearly continuously'	Yes	510,000
13	Other manufacturing; 40	Selective	Yes	Maintain relations	'We have worked with them before, it would be useful to them'	No	4500
14	Other services; 50	Selective	Yes	Anticipate better version	'Shared it with manufacturers as we modified their equipment. They can get us a better version'	No	2300
15	Software/IT; 13	Selective	Yes	Maintain relations	'We have complementary products, if they sell more of their hardware it will increase our software purchases'	Yes	n.a.
16	Aerospace/automotive; 50	Selective	Yes	Maintain relations	'They are often involved in our business'	No	175,000
17	Software/IT; 15	Anyone	Yes	Altruism	'As it is a product that is used every day and will be useful too many'	No	n.a.
18	Software/IT; 10	Anyone	No	Reputation	'Useful to other businesses, helps to increase their company profile'	No	n.a.
19	Agriculture; 13	Anyone	Yes	Lack of appropriation	'Shared information about the innovation because there is no intellectual property and others can invent it too'	No	1500
20	Mining/quarrying; 105	Anyone	No	Industry norms	'The quarry industry is a network industry and we help each other, new developments are commonly shared'	No	3500
21	Hotels/restaurants; 88	Anyone	Yes	Maintain relations	'They are having ongoing relations with us'	No	2500
22	Aerospace/automotive; 150	Anyone	Yes	Anticipate better version	'They are amongst our suppliers and can improve it. We are eager to share it to anyone able to make it for us'	Yes	7000
23	Transport; 67	Anyone	No	Altruism	'Not my sort of thing as the market is hard as it is. It is expensive so whoever going to make it would need help'	No	25,000

4.3. Motives to reveal

Our dataset contained 23 cases where firms had revealed their user innovations, with details being shown in Table 7. We coded the open-ended answers on why firms had revealed into seven categories: maintain relations (14 cases), develop relations (2), anticipating a better version of the user innovation (2), lack of appropriation options (1), altruism (2), reputation (1) and industry norms (1). It emerged that most of the innovations shown in Table 7 were revealed for optional future benefits (18 cases), although true free revealing emerged as being quite rare, i.e. applying to 4 out of 23 cases.

In line with what we would expect from theory in this area, Table 7 shows a correlation between the optional benefits motive and selective revealing. Selectively revealed cases were always motivated by a desire to maintain or develop relationships and in 15 out of 16 cases selective revealing was done with an existing network tie. Out of the 18 cases revealed for optional benefits (maintain relations, develop relations, anticipate better version), 16 were selectively revealed. In contrast, true free revealing was correlated with firms' willingness to share with anyone. Specifically, out of the seven cases in which the firm was willing to share with any business, four were motivated by altruism, reputation or industry norms and in these cases it was also observed that user innovations were revealed to previously unknown contacts.

To further analyse firms' motivations to reveal, we explored if firms had protected their user innovation with intellectual property. From Table 7 we infer that protecting a user innovation is related with optional benefits revealing (7 out of 18 cases) and the same for selective revealing (6 out of 16 cases). Protection does not appear to go together with free sharing-related revealing (0 cases), or for willingness to reveal to anyone (only one case protected). We had also asked respondents to provide us with a ballpark estimate of their innovation investment in UK Pounds, with selectively revealed cases having an average investment of 65,307 UK Pounds, while for openly revealed cases it was only 7900 UK Pounds. This indicates that for selectively revealed cases, motivated by optional benefits, the stakes appear to be higher – it makes sense that after a higher investment profit-seeking firms are less inclined to openly share their user innovations with anyone interested.

In summary, optional benefits revealing emerged as being the most common mechanism for sharing a locally-produced innovation and it can be argued that user innovations are typically revealed selectively to existing network ties. The frequency at which these innovations are protected, and their average investment, suggests that firms prefer to appropriate innovation benefits and true free revealing emerged from this study as being relatively rare. These findings are explored further in the discussion section below.

5. Discussion

This paper has investigated which firms are more likely to be user innovators, how they may transfer their related knowledge to other organizations, and why they are motivated to reveal their innovations. To industrial suppliers this helps to develop useful guidelines of where and how to find user innovations – an important matter to learn about what customers truly need and how viable new products can be obtained (Wiersema, 2013).

In practice, the emergence of user innovation is hard to predict as the simultaneous presence of both problem and solution knowledge can be idiosyncratic. However, our findings imply that it is possible to find small firms that possess useful innovation knowledge, or prototyped solutions that can be useful to other, similar firms. Our study supports earlier work which found that user innovation is positively related to firm size (number of employees) and general innovative activity (measured with traditional CIS innovation indicators). While these patterns have been demonstrated for high-tech firms and manufacturers, we found that firm size and general innovativeness also correlate with user innovation frequency in a broad representative sample of small firms. User innovation amongst these firms appears to be a widespread industrial phenomenon that is present in a wide range of sectors. The implications of this for industrial suppliers are that the probability of encountering customers with user innovations is likely to vary with their size and innovativeness.

Our research reveals that the outbound transfer of user innovations by small firms varies according to the way in which external inputs were obtained. If small firms employed externally-sourced, free inputs to develop the user innovation, they were more likely to reveal to other economic actors. In Dahlander and Gann's (2010) terms, firms that employed an inbound-sourcing strategy were more likely to also adopt an outbound-revealing approach. At the same time, the outbound-selling approach towards user innovation was barely observed if free inputs had been obtained. These empirical findings are in line with the observations outlined in review studies of firms' open innovation practices (e.g., West et al., 2014). With respect to Dahlander and Gann's (2010) call to study how various forms of knowledge transfer are related, non-pecuniary inbound and outbound innovation behaviours emerge from the study as being clearly connected in the case of user innovation. It seems that small firms can be inclined to be more or less 'open' (defined as sourcing and revealing knowledge without compensation) translating into knowledge transfer behaviours to both develop and diffuse innovations.

For pecuniary inbound and outbound behaviours, no empirical relationship was found (acquiring and selling knowledge was unrelated). We suspect that a firm's opportunities to sell user innovations can be restricted by their general use value – after having paid for knowledge inputs they may well prefer to sell rather than reveal, but limited general value may discourage them from doing this. Our dataset did not include any measures that enabled us to control for the extent to which innovations were potentially valuable to other organizations. We noted that only 6.5% of the innovations in our sample were sold (while 12.8% was revealed) so truly broad use value may be limited, an issue that deserves to be further investigated in future research (see below).

Concerning motives to reveal, we found that small firms seem calculative, mainly reporting motivations in line with the 'optional benefits' reasoning that was identified from the literature. This finding helps us to better interpret earlier observations that firms reveal user innovations to existing network ties (de Jong & von Hippel, 2009; Kuusisto & Kuusisto, 2013). In our sample 'optional benefits' motives are evidenced by selective revealing practices with existing network contacts, in order to maintain or develop relationships, or for anticipated better versions of the user innovation provided by an industrial supplier. Optional benefits revealing suggests that small firms seek longer-term advantages that are impossible to demand in advance.

In contrast, very few cases in our sample of user innovations were revealed freely and open to all. User and open-source innovation studies have observed specific instances in which firms reveal for altruism, reputation or industry norms, but such motivations do not appear to generalize to small firms. The majority of evidence concerning free revealing has been reported in samples of end consumers and contributors to open-source projects, and it has also been documented at the level of individual employees (e.g., Henkel, 2009; von Hippel, 1987). However, the study reveals that for decision-making business owners with a personal commercial interest, free revealing motives are very nearly absent. This finding is in line with the classical innovation appropriation literature which counsels that firms should avoid free-riding by other organizations, unless some benefit can be anticipated (Teece, 1986). This finding suggests that future studies of firms' outbound-revealing behaviour would benefit from focusing on the optional benefits that can be obtained, rather than altruism.

5.1. Implications

Drawing on our findings we suggest an alternative pathway to identify and/or co-create innovations with customers. Recognizing the

idiosyncratic presence of need and solution information, studies concerned with finding users' solution prototypes have offered various elaborative tools. Examples include the lead user method which actively involves users and related experts in an industrial firm's design efforts (e.g., Mahr & Lievens, 2012), crowdsourcing projects in which users submit solution prototypes to address a predefined need (e.g. Djelassi & Decoopman, 2013), and innovation toolkits in which users apply solution-related tools to address their personal needs (e.g. Franke & Piller, 2004). Our findings suggest an alternative strategy: deliberate search for solutions that customers initially developed for themselves is likely to be viable for many industrial suppliers serving small firms. This is likely to be of particular relevance for firms operating in a market characterised by large-scale or highly innovative customers, and especially in contexts in which innovating customers are likely to benefit from non-pecuniary external knowledge sources. In such circumstances it would be expected that developers of innovative solutions on the customer side would be willing to share their innovation knowledge and, in some cases, it could be anticipated that solution prototypes may have been created. Our research indicates that such innovative behaviours are not concentrated in one or two areas of the economy and are to be found in user firms across all sectors. Specially, in some industrial environments user innovations are likely to be self-revealing: they become visible when being used in everyday life (e.g., agricultural irrigation methods, modifications to transport equipment). If not, the deliberate search process is probably more demanding and it may be more efficient to simply focus on larger and/or highly innovative firms.

A more difficult challenge is to find those businesses that have sourced free external inputs (i.e. firms that have adopted an inbound-sourcing strategy) in order to prototype a user innovation. We suggest as starting points to identify firms that are using expired patents, or firms that are participating in open-source projects – the latter type of businesses can often be detected online. Rather than traditional marketing research, industrial suppliers might join in open-source and open design projects themselves to discover what kinds of innovations their target firms are concerned with.

Opportunities to easily benefit from the user innovations of small firms seem limited, especially when those are sought outside the existing customer base. Only a very few cases in our sample were revealed openly to all for reasons of altruism, reputation or industry norms. When searching for user innovations beyond existing network ties, industrial suppliers should ask themselves why small firms would reveal selectively to them. To previously unknown firms this would be a challenge, especially if a better version of the user innovation (embodying the supplier's superior solution knowledge) cannot be promised and or is deemed unnecessary by the user firm. Calculative small firms with selective revealing practices suggest that a truly free ride is hard to find.

5.2. Limitations and suggestions for research

Our study had various limitations, and some of them inform our recommendations for future research. Our sample included only firms with 10–250 employees in the UK. It would be interesting to replicate our findings in other countries, including micro-firms (< 10 employees) and non-profit organizations. Micro-firms, for example, have fewer opportunities to appropriate their knowledge (Cohen et al., 2000) and need to rely more on outside contributions, and this may affect observed relationships between inbound and outbound practices. Non-profit firms may be more inclined to reveal their innovations, even if pecuniary inputs (‘acquiring’) were obtained.

Another limitation to our analysis was that in everyday life only a subset of user innovations will be eligible for adoption by industrial suppliers (de Jong et al., 2015). Some user prototypes will address general problems that other organizations face, but others do not. As we speculated in the discussion, this may be the reason that we did not observe a relationship between inbound-acquisition and outbound-selling and in future studies of outbound transfer the general use value of user innovations should be investigated as a potential moderating variable.

Regarding the outbound-revealing of user innovations, we found that optional future benefits was the prevailing motive – much more than free revealing for altruistic or reputation motives suggested by the user and open-source innovation literature. Nevertheless, earlier studies found that free revealing is sometimes practiced at the level of individual employees. We suggest it would be interesting to investigate if and how the discrepancy between revealing employees and unwilling-to-reveal business owners can co-exist. To industrial suppliers it may imply that searching at the employee level may be beneficial and, although challenging, it may be a promising pathway for future investigation. Finally, a potential limitation in this study arises from the small number of firms who were prepared to freely reveal their innovations. This issue could be further examined in future studies (possibly exploring different national contexts and territories) although care would need to be taken concerning the influence of context in the interpretation of results.

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