Utrecht University

School of Economics

User Innovation and Business Incubation

Carolin Eckinger
Mark Sanders

U.S.E. Working Paper Series nr: 19-16

School of Economics

Utrecht University School of Economics (U.S.E.) is part of the faculty of Law, Economics and Governance at Utrecht University. The U.S.E. Research Institute focuses on high quality research in economics and business, with special attention to a multidisciplinary approach. In the working papers series the U.S.E. Research Institute publishes preliminary results of ongoing research for early dissemination, to enhance discussion with the academic community and with society at large.

The research findings reported in this paper are the result of the independent research of the author(s) and do not necessarily reflect the position of U.S.E. or Utrecht University in general.

U.S.E. Research Institute
Kriekenpitplein 21-22, 3584 EC Utrecht, The Netherlands Tel: +31 30 253 9800, e-mail: use.ri@uu.nl www.uu.nl/use/research

Utrecht University School of Economics

U.S.E. Research Institute
Working Paper Series 19-16

User Innovation and Business Incubation

Carolin Eckinger*
Mark Sanders*~
*Utrecht School of Economics
Utrecht University
~ Sustainable Finance Lab
Utrecht University

August 2019

Abstract

This paper investigates user innovations in business incubation programs. User innovations are defined as innovations by users rather than suppliers of products, processes or services and have been identified as a potentially rich source of innovative ideas. Business incubators aim to help entrepreneurs find and develop ideas into viable businesses and have been shown to contribute to the success rate of start-ups. Current incubator acquisition strategies, however, are rather passive (founders need to apply) and selection into the incubation programs is geared towards attracting potentially profitable start-ups. User innovations often lack a dedicated founder team and the innovator typically has a lower ambition to build a venture and achieve profitability. In this paper we construct a measure based on existing literature to classify user innovations in a dataset of 296 start-ups that applied to one of two incubation programs between 2014 and 2017 in the Netherlands. Analysing this dataset, we found only 19 and find that incubator programs benefit user innovations as much as they do other ventures. Our data also suggests a negative self-selection bias of user innovations, shown by very few user innovations applying to incubation programs. At the same time only a few of the user innovations found have been selected for incubation, revealing an additional selection bias of incubator acquisition strategies towards user innovations.

Keywords: User Innovation, Business Incubation, Startups, Entrepreneurship

JEL classification: O31, O32, L26

Acknowledgements: The authors gratefully acknowledge financial support of the European Union's Horizon 2020 research and innovation programme under grant agreement No 774199 (IRIS project)

Comments welcomed to: m.w.j.l.sanders@uu.nl

Introduction

Users can be an important source of innovation (Urban & von Hippel, 1988). User innovations are developed for personal use and as such satisfy needs not yet detected by manufacturers. The innovations developed can thus be used to detect latent consumer demand (von Hippel et al. 2011). Additionally, user innovations help to resolve inefficiencies in the market such as reducing information asymmetry, reducing business stealing and filling high-need niche markets (Henkel & von Hippel, 2005). We find successful user innovations in form of modifications or improvements of equipment for kayaking, mountain biking, kite surfing or canoeing (Franke & Schah, 2002; Lüthje, Herstatt, & von Hippel, 2002; Franke, von Hippel, & Schreier, 2006; Hienerth, 2006; Baldwin, Hienerth, & von Hippel, 2008). Other examples are found in open software development (i.e. Linux), scientific instruments, improvements to librarian information systems or computer assistance systems (Urban & von Hippel, 1988; Morrison, Roberts, & von Hippel, 2000). Eventually incumbent manufacturing firms pick up many of these innovations, but several modern household names like Dyson and Dropbox can indeed be traced to user innovations. User innovations sometimes linger in obscurity for quite some time. Only a few user innovators built successful firms and became famous with their innovations. Many more user innovators can simply not be traced. These inventors lacked the skill, capacity or incentives to develop their innovations into a business themselves and others have picked up their ideas.

While researchers and industrialists are starting to recognize the importance of user innovation, users as a source of innovation are still being underestimated by policy makers (Brandonjic, Franke, & Lüthje, 2019). The cases described in the literature all show that user innovations justify further attention and could be promoted more openly to encourage users to innovate and increase the number of user innovations. Incumbent firms are increasingly interested in mining this hidden treasure (e.g. Kraft 2012) and developed design thinking and open innovation to tap into the user resource for their own benefit. But these processes are designed to promote the interests of the company, not society at large. Therefore, truly transformative ideas that could disrupt, cannibalize or creatively destroy exiting activities, will receive insufficient support from incumbent firms and in fact may be actively discouraged. The same market failures that justify public support for new ventures can also justify the support for the disclosure and incubation of user innovations. Business incubation programs could play an important role as providers of skills, facilities and finance, as they are for would-be entrepreneurs.

To target public support for user innovation, however, it is essential that decision makers can identify them unambiguously and early on. The academic literature on user innovations to date is very case-based and academics and innovation managers still use their own definitions. There is some theory development, but rigorous empirical testing is limited by a lack of data and an established, unambiguous definition of the concept is missing to date. In this paper we develop a user innovation index (UI-index) which

can be used as a measure to identify user innovations in data sets. With its development we aim to close a gap in the literature and provide a measure for identifying user innovations more easily for future research. Additionally, the performance link between user innovation and business incubation programs has not yet been investigated. We therefore test the usefulness of our UI-index in a set of start-ups that have applied to two incubation programs in the Netherlands and try to answer the following research question with our analysis: '*What is the effect of incubation on user-innovation-based start-ups' performance?'*

In section 2, we first provide an overview of the most relevant definitions of user innovation based on existing literature. This overview is the foundation for developing our index and shows how the concept has been adjusted and complemented by different researchers. As our baseline we used 20 articles from the years 1988 to 2018, empirical as well as theoretical. These have been collected and summarized in a table that provides an overview of existing definitions and operationalization criteria of user innovations. By means of the literature and definitions provided, we then introduce our User Innovation Index (UI-Index). Then section 2 reviews the literature on incubation programs, concluding they are found to be a useful instrument to increase start-up performance and deriving the hypotheses we aim to test. In section 3 we present our data and empirical strategy. First we introduce our data set of 269 start-ups that have applied to two incubation programs in the Netherlands. Scoring these startups on our UI-Index we find that only 19 classify as user innovations. Additionally,

this section provides an overview of our dependent, independent and control variables as well as the models used for our analysis. In section 4 we present our results and discuss our findings, followed by concluding remarks in section 5.

2 Theoretical Background and Hypotheses

2.1 User innovation characteristics

Eric von Hippel is one of the pioneers in researching user innovation and has defined user innovation as ‘firms or individual consumers that benefit from using a product or a service they develop’ (von Hippel, 1988; 2005). Key elements in this early definition are therefore: (1) firms or individual consumers, (2) development of a service or product, (3) personal usage, and a (4) received benefit. This definition has been used (papers cited 1459 and 9228 times respectively) and extended by many other researchers. For instance, Baldwin and von Hippel (2011) further specified the type of user innovators into single user innovators as either a single firm or individual, or collaborative user innovations. Collaborative user innovations or communities of users have been additionally identified by Baldwin et al. (..) by introducing a model that illustrates the transformation of a user innovation through a user community into a commercialised product. This concept was validated in case studies of the rodeo and kayak industry (Hienerth, 2006). Hence, ‘user community’ can be added as an element to the user innovation definition.

A user innovation is first and foremost, an innovation. That is, it is classified as a ‘modification’ or ‘new creation’. This criterion can be

especially found in empirical research, identifying user innovations within broad samples. De Jong and von Hippel (2008) distinguished ‘user creation’ and ‘user modification’ and defined firm user creation ‘as developing an entirely new technique, equipment or software’ whereas firm user modifications are ‘any modification the firm may do to an existing technique, software or equipment’. Other empirical studies have applied the same criteria to identify firm user innovators within samples of UK firms, high-tech SME’s in the Netherlands and Canadian manufacturing plants (Flowers, von Hippel, de Jong, & Sinozik, 2010; de Jong & von Hippel, 2009; Gault & von Hippel, 2009).

Next to firm user innovations, the elements ‘user creation’ and ‘user modification’ have also been applied to distinguish among consumer innovators. For instance, Flower et al. (2010) adjusted the definition of these two elements for individual consumers to ‘modification or creation from scratch of an existing product or service’ and used these as selection criteria within a sample of UK consumers.

A final element of user innovation is the development of an innovation for ‘personal use’ by individual consumers or ‘in-house use’ by firms. De Jong and von Hippel (2009) added this element to their criteria of user innovations in a sample of Dutch high-tech SME’s, as did Flower et al. (2010) in their sample of firms and consumers based in the UK and De Jong et al. (2015) in a random sample of the Finnish population.

This gives us three elements of user innovations identified within the literature build the key characteristics of a user innovation: (1) firm user,

individual consumer user or user community, (2) modification or new creation of products, processes, techniques or software, and (3) development for personal or in-house use.

Other elements were mentioned rather briefly or only mentioned by a limited number of researchers. Nevertheless, these elements still need to be taken into consideration in order to create a specific understanding of innovations that qualify as a user innovation. As Von Hippel stated in his first papers, user innovations create a benefit for the user (Von Hippel, 1988; 2005). This realization has been supported by other researchers as well (e.g. Morrison, Roberts, & von Hippel, 2000; Franke, von Hippel, & Schreier, 2006; Henkel & von Hippel, 2005). Further characteristics identified are (1) new to market and novelty, (2) satisfaction and better suit of own needs, and the (3) development of tailor-made and customized innovations (e.g. Morrison, Roberts, & von Hippel, 2000; Hienerth, 2006; Baldwin, Hienerth, & von Hippel, 2006; Gault& von Hippel, 2009).

We will not use characteristics such as “high product-related knowledge” and “high-use experience” (Lühtje, Herstatt, & von Hippel, 2002; Luhtje, 2004; von Hippel, 2005), “low production cost” (Luthje, Herstatt, & von Hippel, 2002; Morrison, Roberts, & von Hippel, 2000) and “low market demand for the innovation” (Henkel & von Hippel, 2005) in our definition as they do not appear consistently in the literature. Table 1 provides an overview of all user innovation characteristics identified in the literature base (see Appendix) and ranks these according to the number of times they have appeared.

Table 1 User innovation characteristics and their numerical appearance

Rank	UI characteristic	Numerical appearance
1	Individual consumer innovator	18
2	Firm user innovator	17
3	User community innovator	17
4	Modification / improvement / elements added	15
5	New creation	11
6	For personal / in-house use	11
7	High expected benefit / value	9
8	New to market (novelty)	8
9	Satisfies / better suits own needs	5
10	Tailor-made / customized	5
11	High product-related knowledge	3
12	High use experience	3
13	Low cost	2
14	Low market demand	1

In *Table 2* we group the individual user innovation characteristics into different categories and assigning them a position based on their importance. The first three most highly ranked characteristics fall in the category ‘user type’. Additional categories are: innovation type, innovation characteristic, type of motivation, market characteristic, user characteristic, and production characteristic. We used now construct our definition by using the most relevant characteristics with a minimum numerical

appearance of 5 (see *Table 1*) and limited the number of characteristics to be included in the measure to a number of 10.

Table 2 Categorical grouping of user innovation characteristics

Rank	Category	UI characteristic	Position N°
	Type of user		
1		Individual consumer	1
2		innovator	2
3		Firm user innovator	3
		User community innovator	
	Type of innovation		
4		Modification	4
5		New creation	5
	Type of innovation		
6	characteristic	For personal / in-house use	6
10		Tailor-made / customized	7
	Type of motivation		
7		High expected benefit / value	8
9		Satisfies / better suits own needs	9
	Type of market characteristic		
8		New to market (novelty)	10
14		Low market demand	(11)
	Type of user characteristic		
11		High-product-related	(12)
12		knowledge	(13)
		High use experience	
	Type of production		
13	characteristic	Low cost	(14)

It is of course possible to score actual ventures, firms, innovations and ideas on the criteria identified above. Each characteristic (item) can then take on a value of zero (false) or one (true). But for a meaningful and consistent measure of the degree to which a specific activity classifies as a user innovation, we need to develop an index. The index we are looking for must

exclude those activities that are not innovations and those that do not come from users, while it should give higher values to activities that tick more of the boxes. We, admittedly somewhat arbitrarily, used the innovation characteristics with position number 1 to 10 (see *Table 2*). The first three characteristics (with position number 1 to 3 and a numerical appearance higher than 10) were used as “user innovation identifying” characteristics. The remaining four characteristics were added as “supplementary criteria”, that intensify an identified user innovation. The results are shown in *Table 3.*

Table 3 Value assignment to user innovation characteristics

Item	**Value**
User innovation identification	
1. Individual consumer / firm / community user innovator	0 **|** 1
2. Modification / new creation	0 **|** 1
3. For personal / in-house use	0 **|** 1
User innovation intensification	
a. Tailor-made / customized	0 **|** 1
b. High expected benefit / value	0 **|** 1
c. Satisfies / better suits own needs	0 **|** 1
d. New to market (novelty)	0 **|** 1

Note: 0 = false **|** 1 = true

We then apply *equation 1* in order to calculate an ordinal index measure ranging from 1 to 5 that captures the degree to which a venture conforms with the criteria used most often in the literature.

$$UI\ Index = (\text{Item } 1 * \text{Item } 2 * \text{Item } 3) * (1 + \text{Item } a + \text{Item } b + \text{Item } c + \text{Item } d) \quad (1)$$

If the first three items of the user innovation identification outlined in *Table 3* are not satisfied and, hence, take on a value of zero, the outcome of the formula will be zero and the innovation is not a user innovation. If the value is 1 for the first three criteria, the user innovation can be classified as a very weak (1) up to a very strong (5) user innovation based on its index number (see *Graphic 1*).

Graphic 1: User Innovation-Index

0	1	2	3	4	5
Non-UI	*Very weak*	*Weak*	*Moderate*	*Strong*	*Very strong*

With this index in hand we can now turn to the discussion of the literature on business incubation in general and the role of business incubation for user innovations in particular to derive our hypotheses.

2.2 Business incubation & acquisition strategies

Business incubation as a concept has been introduced for the first time in the US in 1959 and has been developed and expanded upon internationally from thereon (Shepard, 2013). The main role of business incubators is to support innovative and entrepreneurial start-ups and new ventures with services geared towards their performance and success. Adegbite has created an overview of these services which include incubator space, professional management, strict admission and exit rules. Furthermore, common services such as counselling, training, secretarial support, start-up financing, as well as assistance with product development and marketing, support ventures in their growth process (Adegbite, 2001, p. 157). In broader terms, services of business incubators address needs regarding the overall infrastructure of the start-up, coaching and networking (Peters, Rice, & Sundararajan, 2004, p. 86). Entrepreneurs and starting enterprises benefit from incubation programs since these often lack these specific success factors. Limited access to funding is one of the main challenges start-ups face due to high risk evaluations by financial institutions based on their failure rate (Kirsty, 2010, p. 3). Additionally, start-ups are lacking skills regarding market opportunity recognition and industry expertise, have limited access to technologies needed and have only limited social and business network connections for further expansion (Kirsty, 2010, p. 3-5). Due to these limitations, start-ups are motivated to apply to business incubation programs which provide the services required in order to grow and succeed (Lose & Tengeh, 2016). The performance of

start-ups can be observed by certain indicators such as survival, growth or increased R&D activity (Barbero, Casillas, Ramos, Guitar, 2012). A lot of empirical research has tested the effect of incubation on start-up performance which has led to the identification of a positive relationship between incubation programs and the success rate of start-ups and their innovations (Arlotto, Sahut, & Teulon, 2011; Patton, 2014; Sedita, Apa, Bassetti, & Grandinetti, 2017; Eveleens, van Rijnsoever, & Hekkert, 2019). In order to validate our data we will retest this effect and compare our findings to the positive relationship found in the literature. Based on this we can formulate our first hypothesis:

H1: Business incubation positively influences the performance of start-ups.

If we are able to support hypothesis 1, we can show that incubation positively affects the performance of start-ups, implying that start-ups benefit from incubation. If the effect is positive and significant, we have found the same outcome as previous research and can use this as a validation of our data in order to test our following hypotheses.

Start-ups and new ventures develop innovations for different reasons. These can be profit-related, aimed at increasing social welfare or developed for the own personal benefit. If the latter applies, the innovation developed could classify as a user innovation. User innovations differ from non-user innovations, also called producer or manufacturing innovations, in the sense that the latter are developed in order to create a financial profit from selling

it (von Hippel, 2005; de Jong & von Hippel, 2009; Gambardella, Raasch, & von Hippel, 2016). This stands in contrast to user innovations. Another distinguishing feature is that producer innovations are specifically developed in order to satisfy consumer needs and to attract a large share of the market (Henkel & von Hippel, 2005) instead of being developed for personal use or value (Gambardella, Raasch, & von Hippel, 2016). But even though differences regarding the motivation of the innovations' development exist, similarities can still be observed. Firstly, some user innovations are developed due to recognition of new market opportunities as well (Baldwin, Hienerth, & von Hippel, 2006; Franke & Shah, 2002), though not necessarily for a large share of the market. Secondly, both lead to a benefit for the developer, either in terms of financial profitability or personal use, though with regard to user innovation this is not the initial motivation. Third, user innovations as well as non-user innovations imply the development of new products or addition to existing products or services (Hienerth, 2006; Gault & von Hippel, 2009), though new product development derives from an individual need, looking at user innovations. Since both innovation types show underlying similarities and since business incubators can be considered profitable for start-ups by providing the necessary skills, we hypothesize that business incubators can be beneficial also for user innovations:

H2: Business incubation positively influences the performance of user innovation based startups.

If we are able to support hypothesis 2, we can show that incubation positively affects the performance of user innovations, implying that user innovations benefit from incubation as well.

Regarding the acquisition process of start-ups, business incubators use specific selection criteria in order to evaluate start-ups and to estimate its incubation success. Common screening factors include characteristics of the management team, financial ratios and market factors (Aerts, Matthyssens, & Vandenbempt, 2007). Since the success of an incubator depends on the performance of the start-up that has been accepted to the program, incubators try to select only the most suitable candidates with lowest potential failure rates (Aerts, Matthyssens, & Vandenbempt, 2005). As a result, strict screening practices are applied by the business incubators. We hypothesized that business incubators can be beneficial for the performance of user innovations. However, when it comes to the selection of suitable start-ups for the incubation program, user innovations might have a disadvantage compared to other candidates. Since user innovations are developed for personal use due to the detection of a problem or need, the founding team of user innovations usually consists of the user himself (Shah & Tripsas, 2007) and therefore, tends to be small in size. Even a user innovation community or group doesn't match the selection criteria because most user innovators are specialized in their field and have strong experience with the product or service they develop (Lühtje, Herstatt, & von Hippel, 2002; Lühtje, 2004), hence the overall diversity as well as technical, management, financial and marketing skills of the innovation team (Aerts,

Matthyssens, & Vandenbempt, 2007) being rather low. In terms of their financial strength user innovations might also experience barriers regarding their selection to incubation programs. Most user innovations are developed at low cost and therefore do not require much capital and investment from the user side (Lühtje, Herstatt, & von Hippel, 2002; Morrison, Roberts, & von Hippel, 2000). Taking this into consideration, financial ratios regarding the start-ups liquidity, profitability or debt are likely to have a negative effect on the selection of the user innovations to incubation programs (Aerts, Matthyssens, & Vandenbempt, 2007). From this, we hypothesize that a selection bias of business incubator selection criteria towards user innovations exists, meaning that incubators are not likely to select many user innovations to their programs based on the selection criteria applied.

Moreover, user innovations are not primarily developed to achieve financial profitability and to become commercially successful, but rather to satisfy the users own personal needs (Shah & Tripsas, 2007). We therefore further hypothesize that user innovations show a negative self-selection bias towards business incubators themselves. This would imply that not many user innovations are attracted by incubation programs nor apply for their support in the first place.

Even though we hypothesise the existence of selection biases of incubators as well as user innovations, incubation programs could strongly benefit user innovations because of their small size and lack of financial profitability. Therefore we would like to test whether the benefit of incubation, if hypothesis 2 can be supported, differs for user innovations

and non-user innovations. By looking for a moderation effect of user innovations on incubation in comparison to other start-ups, we can formulate our third hypothesis:

> *H3: User innovation positively moderates the influence of incubation on performance.*

If we are able to support hypothesis 3, we can show that incubation indeed more positively influences the performance of user innovations compared to non-user innovations.

3 Data and Empirical Strategy

3.1 Sample and data collection

Our data set is a collection of 269 start-ups that have applied to two incubation programs in the Netherlands from 2014 to 2017, including subgroups with start-ups that have been accepted and rejected to the program. This data has already been used for previous research (Eveleens, van Rijnsoever, & Hekkert, 2019) and was collected by the researchers based on archival data of the incubation programs. The archives provided information about the interview process, the start-ups characteristics and the quality of the start-up applications. In addition, information about the start-ups' performance was collected via an online investigation and the data verified and clarified by talking to the incubator managers in person.

Our first step was to code the ventures in this data set using the UI-Index in order to differentiate user innovations from non-user innovations and to classify the ones detected as weak or strong. We first read the start-

up descriptions provided in the data set and scan for the three main identifying characteristics: (1) Is the user innovator an individual consumer, a firm user or a community of users, (2) is the innovation a modification of an existing product or service or a new creation, and (3) was the innovation developed for personal or in-house use (see *Table 3*). If the descriptions were not sufficient to distinguish between a user innovation and non-user innovation, additional information was gathered from the start-up's website, LinkedIn, other information found online or by calling the start-ups in person. Once a user innovation was identified, it was further classified by using the UI-Index by coding on the number of intensifying criteria satisfied (see *Table 3*). In order to validate our findings, we applied two cross-check procedures throughout the data analysis.[4] Based on this coding method we could identify 19 user innovations out of the 269 start-ups, about 7%. An overview of the user innovations we identified in the dataset is provided in *Table 4*. A more detailed overview of these start-ups can be found in *Table 9* of Appendix B. From the table it can be seen that our data set contains user innovations that were coded as strong (3 start-ups), moderate (13 start-ups) and weak (3 start-ups). Only 7% of all 269 start-ups in our dataset were coded as user innovations. Compared to percentages of user innovations in broader datasets (e.g. De Jong, von Hippel, Gault, Kuusisto and Raasch find 176 verified user innovations out of 624 innovations (28%) reported by of 2048 respondents in Finland), we therefore find an indication

[4] The cross-check procedure consisted of five steps: 1) send 20 non-coded start-ups to control person 2) receive start-ups back coded from control person 3) meet with control person to compare results 4) Discuss findings and coding approach 5) Repeat process if not 90% overlap found (repeated two times).

for a negative self-selection bias of user innovations towards incubation programs. Only 6 out of the 19 user innovations, so about 32%, have experienced incubation. This is 58% in the total dataset and the relatively low acceptance rate for user innovations could indicate a further selection bias of business incubators against user innovations.

Figure 2 Categorical Representation of User Innovation Variable (in percentages)

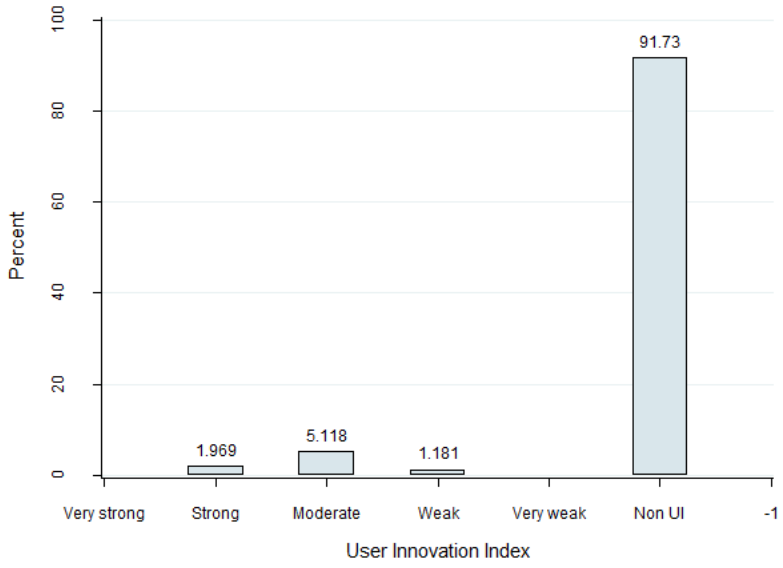

Table 4 Descriptive overview of user innovations identified

Start-up	Description	Found. Y.	Incub	UI-Index
Plane and Train	International travel planner worldwide with detailed description of how to travel from and to the airport or railway station by using public transport. *Reason:* too much time spent on finding the next destination while traveling the world after studies.	2012	Yes	4 (strong)
Ukky	Printed memory book for children including the use of photos, videos, stories, songs. *Reason:* problems of too many photos of son that were not touched again and difficulty of cretaing online photo books.	2013	Yes	4 (strong)
Goodie-store	An interactive, dynamic vending machine that gives people inspiration and lets them be introduced by others through products with a meaning and on social, environmental basis. *Reason:* personal need for more personalised vending machines for lunch at the workplace.	2014	No	4 (strong)
Stoov	Sustainable people warming solution for churches, terraces of bars, restaurants and hotels and offices. We warm sitting people direct from their seats. *Reason:* wanted to reduce the seat heating from his car to be more	2014	Yes	3 (moderate)
Sustainyl-Analyze	Provides a R&D decision making tool (Sustanalyzer) which helps incorporate multiple sustainability criteria at a very early stage in chemical process development. *Reason:* to improve research process within own CatchBio project.	2014	Yes	3 (moderate)
VetVat	Collect baking residues from households to reduce CO2 contribution. *Reason:* to answer the question what to do with gravy.	2016	Yes	3 (moderate)
2 Build	Crowdfunding application that oversees where the money goes. *Reason:* Sponsor as a child from Basil not knwoing where the money goes.	2016	Yes	3 (moderate)
4Kelvin	Digital environment for teachers in secondary education, in which they gradually build up lessons that are structured in such a way that the pupils can practice their 21EV daily within the requirements of the existing curriculum. *Reason:* Started by teachers and used in schools.	2014	No	3 (moderate)
Move to Run	Application for running therapy that focuses on the changes in mood, energy and relaxation before and after running with interventions aimed at motivation and persevering exercise behavior. *Reason:* used by herself for patients as a psychomotoric therapist.	2013	No	3 (moderate)
Part of Science	Capturing science in print. *Reason:* Technique develoepd and then made public.	2016	No	3 (moderate)
Devlin	Device which takes a computed tomography scan of a fractured bone, uses CAD style engineering software to design a surgically implantable fixation and mechanical support device unique to the effected patient and bone. *Reason:* Collegiate Athlete and coach who does not think the procedures used are the best.	2012	No	3 (moderate)
Boekzorg	Make the healthcare easier to find, accessible and bookable for everyone in the Netherlands. *Reason:* due to personal experience with care seeking and searching online.	2016	No	3 (moderate)
BuzNezz-Card	Mobile business card and contact management service. *Reason:* personal experience of contact administration efforts.	2016	No	3 (moderate)
Goede Voorw-aarden	Online reviews of different businesses. *Reason:* personal experience in finding the right offices.	2013	No	3 (moderate)
OnePenny	Online community and collaboration space for entrepreneurs and startups to develop and validate early-stage business ideas. *Reason:* perosnal experience and participation in start-up contests and profitability from idea sharing.	2013	No	3 (moderate)
Highbrow	E-mail based learning platform that brings bitesized courses straight to readers in their inboxes every morning. *Reason:* experience in not finishing online courses.	2014	No	3 (moderate)
Nebulair	Small scale fully automated aquaponics and aeroponics systems within aesthetically beautiful furniture pieces. This allows people to grow food within their house without compromising on their interior design. *Reason:* Originally a hobby project	2016	No	2 (weak)
Dialog Trainer	Online, game-based e-learning environment in which students and professionals can practice with conversation skills. *Reason:* developed and used for in-house by UU.	2015	No	2 (weak)
Crony	First real social APP that ensures that scheduling an appointment for all parties involved is a piece of cake without long consultation. *Reason:* Experiencing problems in making appointments with family or friends during busy life schedule.	2013	No	2 (weak)

3.2 Variables

As the point of our paper is not to model or improve on the assessment of incubation in general, but rather focus on the impact of incubation on user innovations, we decided to follow the analysis in Eveleens et al. (2019) closely and used the same data set and replicated most of their variables. We then made the data suitable to test our own hypotheses by adding our new variable to the existing data set. For our analysis we follow Eveleens et al. (2019) and used three dependent variables, two independent variables and seven control variables.

Start-up survival, start-up size, start-up growth and investments in the start-up provide measures of start-up performance (Brown, 2005). We dropped size in favor of growth as they are highly correlated (0.968 see *Table 6* below) and growth is the more common performance measure (e.g. Barbero, Casillas, Ramos, & Guitar, 2012). For our analysis GROW measures growth in terms of employees and has been generated by calculating the difference between employment size of the start-up at the point of application to the incubation program and employment at the point of data collection. SURV is a binary variable and indicates whether the start-up was still operating at the point of data collection. INV describes if the start-up has raised any external investments in form of equity and is as well measured as a binary variable.

To test our three hypotheses, we use start-up incubation, INC, and user innovation, UI, as our independent variables. INC has been used by Eveleens et al. (2019) and is measured in terms of incubation experience

which shows whether a start-up has participated in any incubation program between the point of application to the incubator and the point of performance data collection. Incubation experience includes incubation by one of the two main incubators of our data set as well as by any other incubator. Evidence for this has been collected by Eveleens et al. (2019) by systematically checking the websites of incubators as well as start-ups in the Netherlands (Barbero, Casillas, Ramos, & Guitar, 2012). Overall, 29 start-ups have been identified to have experienced incubation by other incubators after being rejected by the two main incubators of our data set.

Regarding our control variables we followed Eveleens et al. (2019). The first control variable is pre-incubation quality of the start-ups (QUAL) which is measured based on the assessment score allocated by the incubators. The variable has been normalized to a 5-point ordinal scale and has been calculated by dividing the start-up score by the highest score possible. Afterwards, the variable has been multiplied with 5 and averaged over the number of experts (Eveleens, van Rijnsoever, & Hekkert, 2019). We also control for size of the start-up at application to the incubation program measured in terms of employment (SAA), age at application (AAA) and the years since the point of application (YSA). In order to generate variable AAA we calculated the difference between the year of application to the incubation program and the founding year of the start-up. For the variable YSA we took the difference of the point of data collection and the point of application of the start-up to the program. The next control variable used was entrepreneurial experience (EXP) which typically correlates with

start-up performance (Hanák, 2018). EXP is a categorical measure of the number of years of entrepreneurial experience of the start-up. We generated this variable according to Eveleens et al. (2019) on an ordinal scale ranging from 1 to 3, 1 being aggregated entrepreneurial experience up until 2 years “low”, 2 being until 10 years “medium”, and 3 being more than 10 years “high”. Finally, we included two variables in our models that control for market and product type of the start-up (Cano, Carrillat, & Jaramillo, 2004). For this we used the binary variables B2C market (B2C) and hardware product (HDW).

Descriptives for all dependent, independent and control variables are in *Table 5* below as are correlations in *Table 6*. Overall, the replication of the descriptives and correlations of the variables from Eveleens et al. (2019) shows some slight deviations from the original. This variation can be explained by the fact that Eveleens et al. (2019) used multiple imputations to estimate missing values. We did not apply these in our dataset.

From *Table 6* it can be observed that our dependent variables SURV, GROW and INV are all significantly correlated. Furthermore, INC is positively correlated to all three dependent variables. This gives a first indication of an increase in survival, growth and investment if the start-up experiences increased incubation. Also, INC and HDW are positively correlated, implying that business incubators prefer incubating start-ups offering hardware products.[5]

[5] Note this cannot be due to hardware firms self-selecting into incubation as our population is startups that apply for incubation.

Table 5 Descriptive statistics of variables

Variables	Obs	Unit	Mean	St Dev	Min	Max	Description
Dependent:							
SURV	268	Bin.	0.642	0.480	0	1	If the start-up was in operation at point of data collection (yes/no)
GROW	267	Empl.	1.099	5.747	-8	36	Difference between employment at time of application and collecting data
INV	268	Bin.	0.097	0.297	0	1	If the start-up has raised investments (yes/no)
Independent:							
INC	269	Bin.	0.587	0.493	0	1	If the start-up has experienced any incubation (yes/no)
UI	254	Bin.	0.256	0.872	0	4	If the start-up is a user innovation (yes/no)
Control:							
QUAL	198	Ord.	3.079	1.013	1	5	Pre-incubation quality on a 5-point ordinal scale
SAA	267	Empl.	2.685	1.553	0	9	Employment size at application
AAA	269	Years	0.848	1.459	0	11	Difference between application year and minimum founding year
YSA	269	Years	3.264	0.966	1	5	Difference between data collection year and application year
EXP	250	Ord.	1.836	0.856	1	3	Aggregate number of years of entrepreneurial experience (low = until 2 years, medium = until 10 years, high = more than 10 years)
B2C	256	Bin.	0.391	0.489	0	1	Is the start-up operating in the B2C market (yes/no)
HDW	268	Bin.	0.414	0.494	0	1	Is the start-up developing a hardware product (yes/no)

Table 6 Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) SURV	1.000									
(2) SIZE	0.447*	1.000								
(3) GROW	0.430*	0.968*	1.000							
(4) INV	0.234*	0.348*	0.356*	1.000						
(5) INC	0.207*	0.236*	0.189*	0.173*	1.000					
(6) UI	-0.062	-0.085	-0.073	-0.001	-0.060*	1.000				
(7) QUAL	0.052	0.088	0.087	-0.016	0.209*	-0.005	1.000			
(8) SAA	0.045	0.080*	-0.173	-0.047	0.178*	-0.044*	-0.002	1.000		
(9) AAA	0.270*	0.020	-0.022	0.036	0.024	-0.079	-0.035	0.168*	1.000	
(10) YSA	-0.078*	0.071	0.097	0.152*	0.138	0.051	-0.097	-0.105	-0.131*	1.000
(11) EXP	-0.003	0.004	-0.024	0.040	0.016	-0.102	0.053	0.109	0.108	-0.159
(12) B2C	-0.152*	-0.118*	-0.086	-0.009	-0.073	0.159*	-0.033	-0.118*	-0.085	-0.123
(13) HDW	-0.084	-0.072	-0.089	0.032	0.153*	-0.078*	-0.267*	0.073*	0.090*	0.252

Note: *p<0.05

Table 6 Correlations (continued)

Variables	(11)	(12)	(13)
(11) EXP	1.000		
(12) B2C	-0.024	1.000	
(13) HDW	-0.166*	-0.036	1.000

Note: *p<0.05

Moreover, UI is significantly negatively correlated to INC. This shows the few User Innovations that do apply for incubation have a lower probability

than average to end up being incubated, which might be due to a selection bias of incubators. Furthermore, we can see that SAA and UI suggesting that user innovation startups are on average smaller in size. Additionally, user innovators tend to operate more in B2C markets and focus more on innovations other than hardware products such as for example software by the positive and negative correlations, respectively. Regarding our control variables we see that higher quality and size increase the probability of the start-up being incubated, while an increase in the age of the start-up at application increases its survival rate and an increase of the years since application increase the probability of external investments. These insights make sense intuitively, showing that a longer existence of start-ups increases their chance to survive, and that a longer period of incubation increases the chance of finding investors. Lastly it can be observed that operating in a B2C market decreases the chance of survival. This could be explained due to high competition in B2C markets, especially in the e-commerce sector (Latzer & Schmitz, 2004).

3.3 Empirical Strategy and Econometric model

In order to test our hypotheses, we use Stata (StataCorp, 2015) to run linear regression models and predict our dependent variables by using variable specific estimation models. For survival and investments, we use logistic regression models, whereas growth is estimated with an OLS model. Regarding the OLS model we can support linearity by looking at the individual correlations and rule out multicollinearity by checking the variational inflation factors. Plotting the studentized residuals supports a

normal distribution of the error terms. Additionally, we test for homoscedasticity by using the Breusch-Pagan test. Since we find heteroscedasticity we adjust all the models including the dependent variable growth (GROW) with robust standard errors. By plotting the residuals and squared residuals, we were able to identify outliers in our data set in the variable GROW. Dropping the outliers from the data set and retesting our models does not result in any significant changes and will therefore keep the original data set.

To test our first hypothesis, we estimated two models for each dependent performance variable. The first model includes only control variables. In the second model INC was added as an independent variable. If we find positive and significant estimates for incubation, we find support for hypothesis 1. In order to test our second and third hypothesis we estimated three models for each dependent performance variable. The first model included incubation (INC) as an independent variable and is equivalent to the model already tested for in the previous step. To test our second hypothesis, we add our user innovation index (UI) as an independent variable. If the estimate for UI is positive and significant, we find support for hypothesis 2. In our third model we add an interaction term between INC and UI. We find support for hypothesis 3 if the estimate of the interaction term is positive and significant.

4 Results and discussion

Table 7 provides an overview of our regression results and shows the effect of incubation experience of start-ups on their survival, growth and

investments rose. Again, not using multiple imputation has led to slight differences in our results compared to Eveleens et al. (2019).

Table 7 Regression models testing hypothesis 1

	(1) SURV *logistic*	(2) SURV *logistic*	(3) GROW *normal*	(4) GROW *normal*	(5) INV *logistic*	(6) INV *logistic*
INC		1.132***		2.981***		1.891**
		(0.381)		(0.852)		(0.803)
QUAL	0.114	-0.047	0.320	-0.056	-0.147	-0.364
	(0.170)	(0.181)	(0.431)	(0.341)	(0.276)	(0.305)
SAA	-0.035	-0.106	-0.741*	-0.903***	-0.182	-0.255
	(0.125)	(0.130)	(0.235)	(0.227)	(0.201)	(0.213)
AAA	0.681**	0.629***	0.078	0.082	0.135	0.156
	(0.208)	(0.199)	(0.166)	(0.160)	(0.153)	(0.177)
YSA	-0.069	-0.159	0.525	0.326	0.694**	0.601*
	(0.188)	(0.194)	(0.558)	(0.523)	(0.299)	(0.311)
EXP	-0.112	-0.159	-0.007	-0.081	0.429	0.406
	(0.208)	(0.215)	(0.528)	(0.522)	(0.311)	(0.315)
B2C	-0.532	-0.596*	-0.988	-0.939	0.095	0.148
	(0.341)	(0.352)	(0.911)	(0.906)	(0.524)	(0.543)
HDW	-0.391	-0.653*	-0.967	-1.520*	-0.003	-0.207
	(0.361)	(0.388)	(1.107)	(1.159)	(0.520)	(0.539)
Const.	0.792	1.355	1.105	1.841	-4.513***	-4.697***
	(1.064)	(1.097)	(1.765)	(1.819)	(1.690)	(1.777)
Observations	186	186	186	186	186	186
Pseudo R-squared	0.098	0.137	0.110	0.057	0.067	0.130

Note: Robust standard errors and normal R-squared for Growth ***
p<0.01, ** p<0.05, * p<0.1

Models 1, 3 and 5 show the baseline regression with control variables only. In the models 2, 4 and 6 incubation experience was added to the control variables. It can be observed that if we add INC, we receive positive and significant estimates for SURV, GROW and INV, holding all other variables constant. As a result, and in line with Eveleens et al. (2019) and many others, we find support for our first hypothesis that incubation positively influences the performance of start-ups. Note also that we find a more

negative and significant coefficient estimate for SSA on GROW when incubation is added. It seems that incubation benefits larger firms more in terms of growth, such that adding incubation to the model depresses the coefficient on size at application. A possible reason for this is that incubators try to select on growth potential and perhaps do a better job at picking them among the larger startups. Additionally, we find a positive effect of AAA on SURV at a 1 percent whether we include INC or not (Model 1-2). This shows that the age of the start-up plays an important role for its survival. The older a start-up is, the higher is its chance to survive. Furthermore, we find positive coefficients for YSA in INV when including incubation and when not, implying that a longer time period has a positive effect on raising investments, possibly since it takes time to find suitable investors. Our correlation outcomes and the findings of Eveleens et al. (2019) already supported this finding. B2C and HDW both show a negative effect on survival when incubation is added. As already pointed out in our correlation analysis B2C markets are characterized by strong competition (Latzer & Schmitz, 2004). Again, the result can be explained by incubators being able to select startups with higher survival probability better in B2C markets and Hardware developers.

Table 8 shows the regression results of the effect of adding user innovation, as a separate variable and as an interaction term with incubation, on start-up performance in terms of survival, growth and investments acquired. To prove the robustness of our findings we replaced the binary variable UI with a variable including the UI-Index values. This

has been done for UI separately as well as for the interaction term with INC. We then tested the new variable on all dependent performance variables and did not obtain any changes in values regarding their significance. The results can be found in Appendix D.

Table 8 Regression models testing hypotheses 2 & 3

	(1) SURV *logistic*	(2) SURV *logistic*	(3) SURV *logistic*	(4) GROW *normal*	(5) GROW *normal*	(6) GROW *normal*	(7) INV *logistic*	(8) INV *logistic*	(9) INV *logistic*
INC	1.132***	1.093***	0.990**	2.981***	2.663***	2.623***	1.891**	1.718**	1.567*
	(0.381)	(0.388)	(0.399)	(0.852)	(0.845)	(0.897)	(0.803)	(0.806)	(0.817)
UI		-0.317	-1.165		-1.675	-1.969		0.280	-12.993
		(0.739)	(1.207)		(0.990)	(1.160)		(1.205)	(1501.427)
INC*UI			1.700			0.577			13.644
			(1.715)			(1.590)			(1501.428)
QUAL	-0.047	-0.069	-0.071	-0.056	0.050	0.051	-0.364	-0.223	-0.225
	(0.181)	(0.185)	(0.186)	(0.341)	(0.335)	(0.335)	(0.305)	(0.316)	(0.323)
SAA	-0.106	-0.083	-0.070	-0.903***	-0.824***	-0.819***	-0.255	-0.210	-0.195
	(0.130)	(0.132)	(0.133)	(0.227)	(0.226)	(0.229)	(0.213)	(0.209)	(0.209)
AAA	0.629***	0.653***	0.643***	0.082	0.073	0.070	0.156	0.162	0.152
	(0.199)	(0.204)	(0.203)	(0.160)	(0.160)	(0.161)	(0.177)	(0.177)	(0.177)
YSA	-0.159	-0.164	-0.126	0.326	0.415	0.425	0.601*	0.567*	0.595*
	(0.194)	(0.197)	(0.202)	(0.523)	(0.523)	(0.528)	(0.311)	(0.317)	(0.323)
EXP	-0.159	-0.220	-0.233	-0.081	-0.195	-0.198	0.460	0.291	0.280
	(0.215)	(0.220)	(0.220)	(0.522)	(0.523)	(0.524)	(0.315)	(0.332)	(0.332)
B2C	-0.596*	-0.674*	-0.694*	-0.939	-0.933	-0.939	0.148	0.099	0.058
	(0.352)	(0.363)	(0.364)	(0.906)	(0.957)	(0.959)	(0.543)	(0.578)	(0.585)
HDW	-0.653*	-0.677*	-0.705*	-1.520*	-1.577*	-1.577*	-0.207	-0.154	-0.163
	(0.388)	(0.395)	(0.400)	(1.159)	(1.172)	(1.175)	(0.539)	(0.569)	(0.570)
Const.	1.355	1.529	1.488	1.841	1.435	1.424	-4.697***	-4.866***	-4.816***
	(1.097)	(1.123)	(1.128)	(1.819)	(1.782)	(1.789)	(1.777)	(1.866)	(1.768)
Obs	186	180	180	186	180	180	186	180	180
Pseudo R-squared	0.137	0.146	0.151	0.110	0.110	0.110	0.130	0.110	0.130

Note: Robust standard errors and normal R-squared for Growth *** p<0.01, ** p<0.05, * p<0.1

As already used to test our first hypothesis, models 1, 4 and 7 include incubation experience and all control variables and provide the same results as our first regression analysis shown in *Table 7*. The models 2, 5 and 8 add user innovation as an independent variable to the incubation model. Finally,

the models 3, 6 and 9 add the interaction term between UI and INC to the previous model. We can observe that adding UI as well as adding the interaction term between INC and UI does not impact the significance of the results of the incubation model. The estimates stay almost constant within all three models for each performance measure. Only the estimates of INC with SURV and INV are reduced in their confidence percentage when adding the interaction term. However, we cannot find any significant or positive estimates of user innovation when adding the UI variable to our incubation model. From this we can conclude that the performance of user innovations in terms of survival, growth and investments is not affected by the user innovation being incubated or not. Since we did not find any significant results, we have to reject our second hypothesis that business incubation positively influences the performance of user innovations. Furthermore, no significance can be found for the positive estimates of the interaction term between INC and UI. Hence, we can conclude that user innovations do not benefit more or less from incubation regarding their performance in terms of survival, growth and investments than non-user innovations. Since we did not find any significant results we also have to reject our third hypothesis that user innovation positively moderates the influence of incubation on performance.

Incubation experience has been shown to positively affect start-up performance and start-up performance inside or outside incubation programs does not differ between user and non-user innovations. Our findings furthermore indicate that incubation does not affect the

performance of user innovations and that user innovation and non-user innovations do not benefit more or less from incubation. Of course, the low number of user innovations found in our data set and the low number of user innovations thereof being incubated may have reduced the power of our statistical testing to the point of no longer being able to distinguish the differences. This could have caused our imprecise estimates and large errors. We believe self-selection and a selection bias of incubators against user innovations are most likely to be responsible for this low number of user innovations in our dataset.

Reasons for this could be the satisfaction obtained by developing a solution for a usage problem instead of focusing on financial profitability as a primary goal (Shah & Tripsas, 2007). Since business incubators support start-ups in becoming successful in terms of profitability and scale (Lose & Tengeh, 2016), it is unlikely that user innovations feel attracted by the services offered and therefore do generally not apply to these programs in the first place. Not having found many user innovations that have experienced incubation among the ones that applied indicates a selection bias from sides of the incubators as well. The existence of such bias can be further supported by our finding that user innovations do not benefit from incubation more than non-user innovations. This could imply that business incubators are indifferent between user innovations and non-user innovations and therefore solely base their selection of the start-ups on existing performance criteria, for instance the strength of the founding team or profit opportunity (Aerts, Matthyssens, & Vandenbempt, 2007). In such

evaluations, user innovations are likely to perform worse than non-user innovations based on their negative correlation with size at the point of application which was found in our analysis.

5 Conclusions

Our findings show that start-ups' performance is increased by the participation in incubation programs. We found this effect to be similar (insignificantly different) for user innovations. However, we only found a limited number of user innovations in our data set, so we must assume our estimates to be imprecise. Finding only a small number of user innovations that have applied to the incubation programs as well as only a small number of the identified user innovations that have experienced incubation further suggests a double bias: A negative self-selection bias of user innovations and a selection bias of incubators against user innovations. We therefore suggest future research to conduct interviews with the incubators as well as the user innovators found to target these biases specifically. Regarding further validation of the UI-Index to identify user innovations in broad data sets developed in this paper, we suggest testing its usefulness on additional data sets and additional verification of its components by discussing these with the user innovations found.

References

Adegbite, O. (2001). Business incubators and small enterprise development: the Nigerian experience. *Small Business Economics, 17*(3), 157-166.

Aerts, K., Matthyssens, P., & Vandenbemt, K. (2005). Critical role and screening practices of european business incubators. *SSRN Electronical Journal, 27*(5), 254-267.

Arlotto, J., Sahut, J., & Teulon, F. (2011). What is the performance of incubators? The point of view of coached entrepreneurs. *International Journal of Business, 16*(4), 341-352.

Baldwin, C., Hienerth, C., & Von Hippel, E. (2006). How user innovations become commercial products: A theoretical investigation and case study. *Research Policy*, *35*(9), 1291-1313.

Baldwin, C., & Von Hippel, E. (2011). Modelling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science*, *22*(6), 1399-1417.

Barbero, J., Casillas, J., Ramos, A., & Guitar, S. (2012). Revisiting incubation performance how incubator typology affects results. *Technological Forecasting & Social Change, 79*, 888-902.

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

Bradonjic, P., Franke, N., & Lüthje, C. (2019). Decision-makers‘ underestimation of user innovation. *Research Policy. 48*(6), 1354-1361.

Brown, J. (2005). Venture capital and firm performance over the long-run: evidence from high-tech IPOs in the united states. *The Journal of Entrepreneurial Finance, 10*(3), 1-33.

Cano, C., Carrillat, F., & Jaramillo, F. (2004). A meta-analysis of the relationship between market orientation and business performance: evidence from five continents. *International Journal of Research in Marketing, 21*(2), 179-200.

De Jong, J. P., & von Hippel, E. (2008). User innovation in SMEs: incidence and transfer to producers. *EIM's Research Program on SMEs and Entrepreneurship Research Reports*, H200814.

De Jong, J. P. J., & von Hippel, E. (2009). Measuring user innovation in Dutch high-tech SMEs: Frequency, nature & transfer to producer. *Elsevier B.V.* doi:10.1016/j.respol.2009.04.005.

De Jong, J. P., von Hippel, E., Gault, F., Kuusisto, J., & Raasch, C. (2015). Market failure in the diffusion of consumer-developed innovations: Patterns in Finland. *Research Policy, 44*(10), 1856-1865.

De Jong, J. P. (2016). The empirical scope of user innovation. Revolutionizing Innovation: Users, Communities, and Open Innovation, Chap. 4 (MIT Press, Cambridge, MA).

Eveleens, C., van Rijnsoever, F., & Hekkert, M. (2019). XXXX Working Paper.

Flowers, S., von Hippel, E., de Jong, J., & Sinozic, T. (2010). Measuring user-innovation in the UK - the importance of product creation by users. *National Endowment for Science, Technology and the Arts*.

Franke, N., & Shah, S. (2002). How communities support innovative activities: an exploration of assistance and sharing among end-users. *Research Policy, 23*, 157-178.

Franke, N., Von Hippel, E., & Schreier, M. (2006). Finding commercially attractive user innovations: A test of lead-user theory. *Journal of product innovation management, 23*(4), 301-315.

Gault, F., & von Hippel, E. A. (2009). The prevalence of user innovation and free innovation transfers: Implications for statistical indicators and innovation policy. *MITSloan Management*.1-29.

Gambardella, A., Raasch, C., & von Hippel, E. (2016). The user innovation paradigm: impacts on markets and welfare. *Management Science, 63*(5), 1450-1468.

Hanák, R. (2018). Effect of experience on entrepreneurial performance: meta-analytical review. Conference Paper.

Henkel, J., & von Hippel, E. (2005). Welfare implications of user innovation. *Journal of Technology Transfer, 30*(1/2), 73-87.

Hienerth, C. (2006). The commercialization of user innovations: the development of the rodeo kayak industry. *R&D Management*, *36*(3), 273-294.

Kirsty, D. (2010). The State of Entrepreneurship in South Africa. Mount Nelson Hotel. White Paper Deliberation and Key Findings.

Kraft, C. (2012). *User experience innovation: User centered design that works*. New York: Apress.

Latzer, M., & Schmitz, S. (2004). B2C commerce: a frictionless market is not in sight – arguments and policy implications. *Conference Paper.*

Lose, T., & Tengeh, R. (2016). An evaluation of the effectiveness of business incubation programs: a user satisfaction approach. *Investment Management and Financial Innovations, 13*(2), 370-378.

Lüthje, C., Herstatt, C., & von Hippel, E. (2002). The dominant role of 'local' information in user innovation: the case of mountain biking. *MIT Press*, 1-32.

Lüthje, C. (2004). Characteristics of innovating users in a consumer goods field: An empirical study of sport-related product consumers. *Technovation, 24*, 683–695.

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

Patton, D. (2013). Realising potential: the impact of business incubation on the absorptive capacity of new technology-based firms. *International Small Business Journal, 32*(8), 897-917.

Peters, L., Rice, M., & Sundararajan, M. (2004). The role of incubators in the entrepreneurial process. *The Journal of Technology Transfer, 29*(1), 83-91.

Sedita, S., Apa, R., Bassetti, T., & Grandinetti, R. (2017). Measuring the effect of business incubators on the innovation performance of start-ups. *Academy of Management Annual Meeting Proceedings, 1*, 1-34.

Shah, S., & Tripsas, M. (2007). The accidental entrepreneur: the emergent and collective process of user entrepreneurship. *Strategic Entrepreneurship Journal, 1*, 123-140.

Shepard, J. (2013). Small business incubators in the USA: a historical review and preliminary research findings. *Journal of knowledge-based innovation in China, 5*(3), 213-233.

StataCorp (2015). Statistical Software: Release 14. College Station, TX: StataCorp LP.

Thobekani, L., & Robertson, T. (2016). An evaluation of the effectiveness of business incubation programs: a user satisfaction approach. *Investment Management and Financial Innovations, 13*(2), 370-378.

Urban, G. L., & Von Hippel, E. (1988). Lead user analyses for the development of new industrial products. *Management Science, 34*(5), 569-582.

Von Hippel, E. (2005). Democratizing innovation: the evolving phenomenon of user innovation. *Journal fuer Betriebswirtschaft*, 55(1). 63-78.

Von Hippel, E., S. Ogawa and J.P. De Jong (2011). The Age oft he Consumer-Innovator. MIT Sloan Management Review, 53(1). 1-16.

Von Hippel, E., De Jong, J. P., & Flowers, S. (2012). Comparing business and household sector innovation in consumer products: findings from a representative study in the United Kingdom. *Management Science, 58*(9), 1669-1681.

Appendix

Appendix A Repetition of User Innovation Index (complement for understanding *Table 10*)

Table 3 Value assignment to user innovation characteristics - repeated

Item	**Value *v***
User innovation identification	
4. Individual consumer / firm / community user innovator	0 **|** 1
5. Modification / new creation	0 **|** 1
6. For personal / in-house use	0 **|** 1
User innovation intensification	
e. Tailor-made / customized	0 **|** 1
f. High expected benefit / value	0 **|** 1
g. Satisfies / better suits own needs	0 **|** 1
h. New to market (novelty)	0 **|** 1
Note:	0 = false **|** 1 = true

Formula to calculate user innovation indices:

$$UI\ Index = (\text{Item } 1 * \text{Item } 2 * \text{Item } 3) * (1 + \text{Item } a + \text{Item } b + \text{Item } c + \text{Item } d) \quad (1)$$

Graphic 1 User Innovation-Index – repeated

0	1	2	3	4	5
Non-UI	*Very weak*	*Weak*	*Moderate*	*Strong*	*Very strong*

Appendix B Detailed Overview of user innovations identified

Table 9 Detailed descriptive overview of user innovations identified

Start-up	Descriptions	Found. Y	Incub	UI-Index	Item 1	Item 2	Item 3	Item a	Item b	Item c	Item d
Plane and Train	International travel planner worldwide with detailed description of how to travel from and to the airport or railway station by using public transport. *Reason:* too much time spent on finding the next destination while traveling the world after studies.	2012	Yes	4 (strong)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	1 (true)	1 (true)
Ukky	Printed memory book for children including the use of photos, videos, stories, songs. *Reason:* problems of too many photos of son that were not touched again and difficulty of cretaing online photo books.	2013	Yes	4 (strong)	1 (true)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	1 (true)
Goodiestore	Interactive, dynamic vending machine that gives people inspiration and lets them be introduced by others through products with a meaning and on social, environmental basis. *Reason:* personal need for more personalised vending machines for lunch at the workplace.	2014	No	4 (strong)	1 (true)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	1 (true)
Stoov	Sustainable people warming solution for churches, terraces of bars, restaurants and hotels and offices. We warm sitting people direct from their seats. *Reason:* wanted to reduce the seat heating from his car to be more	2014	Yes	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	0 (false)	1 (true)
Sust Analyze	Provides a R&D decision making tool (Sustanalyzer) which helps incorporate multiple sustainability criteria at a very early stage in chemical process development. *Reason:* to improve research process within own CatchBio project.	2014	Yes	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
VetVat	Collect baking residues from households to reduce CO2. *Reason:* to answer the question what to do with gravy.	2016	Yes	3 (moderate)	1 (true)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)
2 Build	Crowdfunding application that oversees where the money goes. *Reason:* Sponsor as a child from Basil not knwoing where the money goes.	2016	Yes	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
4Kelvin	Digital environment for teachers in secondary education, in which they gradually build up lessons that are structured in such a way that the pupils can practice their 21EV daily within the requirements of the existing curriculum. *Reason:* Started by teachers and used in schools.	2014	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
Move to Run	Application for running therapy that focuses on the changes in mood, energy and relaxation before and after running with interventions aimed at motivation and persevering exercise behavior. Reason: used by herself for patients as a psychomotoric therapist.	2013	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	0 (false)	1 (true)
Part of Science	Capturing science in print. *Reason:* Technique develoepd and then made public.	2016	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
Devlin	Device which takes a computed tomography scan of a fractured bone, uses CAD style engineering software to design a surgically implantable fixation and mechanical support device unique to the effected patient and bone. *Reason:* Collegiate Athlete and coach who does not think the procedures used are the best.	2012	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	0 (false)	1 (true)
Boekzorg	Make the healthcare easier to find, accessible and bookable for everyone in the Netherlands. *Reason:* due to personal experience with care seeking and searching online.	2016	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
BuzNezzCard	Mobile business card and contact management service. *Reason:* personal experience of contact administration efforts.	2016	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
Goede Voorwaarden	Online reviews of different businesses. *Reason:* personal experience in finding the right offices.	2013	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	1 (true)	0 (false)
OnePenny	Online community and collaboration space for entrepreneurs and startups to develop and validate early-stage business ideas.	2013	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	0 (false)	1 (true)

	Reason: perosnal experience and participation in start-up contests and profitability from idea sharing.										
Highbrow	E-mail based learning platform that brings bitesized courses straight to readers in their inboxes every morning. *Reason:* experience in not finishing online courses.	2014	No	3 (moderate)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	1 (true)
Nebulair	Small scale fully automated aquaponics and aeroponics systems within aesthetically beautiful furniture pieces. This allows people to grow food within their house without compromising on their interior design. *Reason:* Originally a hobby project	2016	No	2 (weak)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	0 (false)	1 (true)
Dialogue Trainer	Online, game-based e-learning environment in which students and professionals can practice with conversation skills. *Reason:* developed and used for in-house by UU.	2015	No	2 (weak)	1 (true)	1 (true)	1 (true)	0 (false)	1 (true)	0 (false)	0 (false)
Crony	First real social APP that ensures that scheduling an appointment for all parties involved is a piece of cake without long consultation. *Reason:* Experiencing problems in making appointments with family or friends during busy life schedule.	2013	No	2 (weak)	1 (true)	1 (true)	1 (true)	0 (false)	0 (false)	1 (true)	0 (false)

Appendix C Literature Table

Table 10 Detailed Literature Table

Study	Research	Title	Description	UI Variable	UI definition	UI operationalisation	Methodology	Sample
Baldwin, von Hippel (2011)	Theoretical	Modelling a paradigm shift: From producer innovation to user and open collaborative innovation	Assessment of the economic viability of innovation by producers relative to two increasingly important alternative models: innovations by single user individuals or firms, and open collaborative innovation.	Single user innovator	- Single user innovator is a single firm or individual that creates an innovation in order to use it. Examples are a single firm creating a process machine in order to use it, a surgeon creating a new medical device in order to use it, and an individual consumer creating a new piece of sporting equipment in order to use it {p. 9} - Individual user innovators depend only on their own in-house use of their design to recoup their innovation-related investments {p. 2}	*Implicitly stated:* - Investment in a design whose value to her is vs (includes all aspects of the innovation that the user values (i.e. improved performance, lower cost, lower environmental impact, greater flexibility, and/or enhanced capabilities) {p. 13} - Effort of innovation is worthwhile (for this innovator and this design) if this value is greater than the user's design cost: ds < vs {p. 13} - To attract users who can innovate on their own, the producer's price must be less than the user's design cost, which by definition is less than the user's value: p<ds <vs {p. 26}	Statistical analysis; development of theoretical model	*Not given*
				Firm user	*Not explicitly stated*	- Process innovations developed by user firms, reduce the process user's costs (production, transactions, communication, design) without changing consumers' willingness to pay for the product {p. 14}		
				Collaborative inovation	*Not explicitly stated*	pen collaborative innovation: - User innovators will choose to participate in an open collaborative innovation project if the increased communication cost each incurs by joining the project is more than offset by the value of designs obtained from others {p. 17}		
De Jong & von Hippel (2008)	Empirical	User innovation in SMEs: incidence and transfer to producers	Measure of the incidence of user innovation in a broad sample of firms and assessment if current innovation surveys adequately capture user innovation.	User Innovation	- User innovation refers to innovations developed by end users, rather than by producers. Users can be either firms or individual consumers, they are distinguished from producers by the fact that they expect to benefit from using a product or a service (von Hippel, 2005) {p. 6} - Users primarily innovate to satisfy their process-related	- User creation: developing entirely new techniques, equipment or software for your own use, because there is no appropriate market supply {p. 12} - User modification: any modification your firm may do to existing techniques, equipment or software to improve their usefulness to your business. This does NOT	Survey	2,416 SMEs in NL Technology based small firms in NL

					needs which producers are (initially) unable or unwilling to solve. User innovators tend to be found at the early stages of the life-cycles of products, technologies and industries (von Hippel, 2005) {p. 6}	include modifications of your own products for customers {p. 13}		
Baldwin, Hienerth, & von Hippel (2008)	Empirical	How user innovations become commercial products: A theoretical investigation and case study	Modelling of the pathways commonly traversed as user innovations are transformed into commercial products.	User innovators	- User innovators seek to develop new designs for their own personal use or (in the case of user firms) internal corporate benefit They do not anticipate selling goods or services based on their innovations, although they may later go into business as user-manufacturers. Designing for use and testing by use are the essential characteristics of user-innovators: they may subcontract production and parts supply, but they cannot subcontract the innovation's design or testing and be user-innovators under our definition {p. 7} - Our theory views user-innovators as economic actors who perceive their time and effort to be valuable and respond rationally to changing incentives {p. 12}	*Implicitly stated:* - Users develop innovations in order to satisfy their own needs - Users identify new market opportunities - User innovation platforms are built on easily modifiable innovations - User innovations are tailor-made products - Design searches by user-innovators are motivated by the users' own desires for a better product {p. 8} - Modification of existing /mass products - User innovators innovate if there is a high probability that the new design will be better than the old design - Users create new designs as long as the expected value is higher than the opportunity cost	Case study; statistical analysis	Case study – Kayak industry
De Jong & von Hippel (2009)	Empirical	Measuring user innovation in Dutch high-tech SMEs: Frequency, nature & transfer to producer	Detailed survey of 498 "high tech" SMEs in the Netherlands shows process innovation by user firms to be common practice.	User innovators	We define user-innovators as firms or individual consumers that benefit from using a product or a service they develop {p. 4}	*Explicitly stated* {p. 11} - Had the respondent developed new processes equipment or software for his own use within the last 3 years - Had the respondent modified existing process equipment or software for his own use - User developed process innovations - Even for new developments, innovating actors adapt and incorporate the components of existing machines and software into their new designs (von Hippel, 1988, 2005) {p. 16}	Survey	498 high tech SMEs (NL) spanning a broad range of industries
				Producer innovators (Non-UI)	Producer-innovators are firms or individuals that benefit from selling a product or a service they develop {p. 4}			
Gault & von Hippel, (2009)	Empirical	The prevalence of user innovation and free innovation transfers: Implications for statistical indicators and innovation policy	Report upon a pilot project in which a novel set of statistical indicators were deployed in a 2007 survey of 1,219 Canadian manufacturing plants. Responses to the survey showed that data on both user innovation	Producer innovators (Non-UI)	Producer-innovators are firms or individuals that benefit from selling a product or a service they develop (von Hippel, 1988, 2005) (p. 3)	*Explicitly stated in survey question* - Significantly modified one or more AMT process equipment types to better suit their production needs {p. 13} - Whether they had developed	Survey	Statistics Canada (2007) 1,219 Canadian manufacturing plants

			and the transfers of these innovations could be reliably collected, and that novel findings important to policymaking would result.			entirely new equipment within one of the 26 AMT categories within the last 3 years {p. 13} - Development of new technologies for in-house use {p. 13}		
				End-users	*Not explicitly stated*	End-users/consumers: working individually or in groups, are the actual developers of many consumer products later commercialized and sold to the general marketplace by producers {p. 3}		
				User innovators	We define user-innovators as firms or individual consumers that benefit from using a product or a service they develop (von Hippel, 1988, 2005) (p. 3)	*Not given*		
Flowers, von Hippel, de Jong, & Sinozic (2010)	Empirical	Measuring user-innovation in the UK - the importance of product creation by users	This report sets out to address this gap in the understanding of the role of users – including individual consumers and business firms – in processes of innovation across a range of sectors.	Consumer-level innovation	Widespread creation and modification of consumer products by consumers themselves independent of producer involvement {p. 5} > Creating or modifying products or software they use in their daily lives with the goal of better addressing their own personal needs {p. 14-15}	- Content Production - User modification (software/product) - User creation from scratch (software/product) - User innovation (combining user modification, user creation, software & product) {p. 37}	Research report; closed questionnaire survey	Firm survey: 1,004 UK firms with 10-250 employees Initial Consumer survey: 2,109 UK consumers aged 15 and over Consumer follow-up survey: 344 UK consumers aged 15 and over
				Firm-level innovation	Flowers, von Hippel, de Jong,, & Sinozic (2010)	- User modification (software, physical products) - User creation from scratch (software, physical products) - User innovation (combination of 'user modification' and 'user creation') { p. 35}		
				Non-UI	*Not explicitly stated*	- Developed as part of their jobs - Had been developed for commercial – rather than user – purposes - Simply homemade replicas of products already available on the marketplace - Modifications and improvements that manufacturers had anticipated users would undertake and had made provisions for – such as software upgrades {p. 14}		
Morrison, Roberts, & von Hippel (2000)	Empirical	Determinants of user innovation and innovation sharing in a local market	Exploring the characteristics of innovation, innovators, and innovation shar ing by library users of OPAC information search systems in Australia.	Lead users	Lead users of a novel or enhanced product, process, or service are defined as those who display two characteristics with respect to it: -Lead users face needs that will be general in a marketplace-but face them months or years before the bulk of that marketplace encounters them, and -Lead users are	*Not given*	Questionnaires,;personal interviews	464 Australian libraries selected using stratified random sampling

					positioned to benefit significantly by obtaining a solution to those need {p. 569}			
				User innovations	*Not explicitly stated*	*Implicitly stated:* - OPAC modifications/additional improvements by employees - Customization of OPACs according to owns novel ideas and local settings {p. 6} - Easily modifiable - Low cost		
Urban, & von Hippel (1988)	Empirical	Lead user analysis for the development of new industrial products	Integration of market research within this lead user methodology and reporting of a test of it in the rapidly evolving field of computer-aided systems for the design of printed circuit boards (PC-CAD).	Lead users	Lead users of a novel or enhanced product, process, or service are defined as those who display two characteristics with respect to it: -Lead users face needs that will be general in a marketplace-but face them months or years before the bulk of that marketplace encounters them, and -Lead users are positioned to benefit significantly by obtaining a solution to those need {p. 569}	*Not given*	Case study with focus on n computer aided design (CAD) systems which used to design the printed circuit boards used in electronic products, PC-CAD	market of over 40 competing firms
				User innovations	*Not explicitly stated*	*Explicit criteria to extract user innovation from sample* - High expected benefit from solving a need - Evidence of user product development or product modification - User dissatisfaction with existing products (services or processes)		
Von Hippel (2005)	Theoretical	Democratizing innovation: the evolving phenomenon of user innovation	Provide an overview of what the international research community now understands about user-centred innovation.	User innovators	Can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents {p. 2} > Do not have to develop everything they need on their own: they can benefit from innovations developed and freely shared by others {p. 2}	*Explicitly stated*: - Developed for in-house/own use {p. 3} - Development of improvement {p. 4} - Developed because of strong need {p. 5} - Developing or modifying product {p. 5} - Drivers: Agency costs & Enjoyment (individual) {p. 9} - Functional novelty {p. 11} - Require user-need information & use context information {p. 11} - Low cost {p. 11} - Types: new functional capability, sensitivity, resolution or accuracy improvement, convenience or reliability improvement	*Not given*	*Not given*

				Manufacturer innovators (Non-UI)	Manufacturer-centric model, in which products and services are developed by manufacturers in a closed way, with the manufacturers using patents, copyrights, and other protections to prevent imitators from free riding on their innovation investments {p. 2}	*Not given*		
Franke, von Hippel, & Schreier (2006)	Empirical	Finding commercially attractive user innovations: A test of lead-user theory	The present study empirically tests and confirms the basic tenets of lead-user theory. It also uncovers some new refinements and related practical applications.	Lead users	Lead users are defined as members of a user population who (1) anticipate obtaining relatively high benefits from obtaining a solution to their needs and so may innovate and (2) are at the leading edge of important trends in a marketplace under study and so are currently experiencing needs that will later be experienced by many users in that marketplace (von Hippel, 1986) (p. 302)	*Not given*	Survey; attractiveness evaluation by 6 external experts	Memberships of several important European kite-surfing communities via a multisampling method 15 samples of kite surfers
				User innovations	*Not explicitly stated*	*Implicitly stated:* - User innovation: - User perceive high-expected benefit from innovation - Innovation-related resources are provided - Improvements - Innovations are meaningful - More attractive innovations & high expected benefit (diagram, p. 311)		
De Jong,, von Hippel, Gault, Kuusisto, & Raasch (2015)	Empirical	Market failure in the diffusion of consumer-developed innovations: Patterns in Finland	Utilization of a broad sample of consumers in Finland to explore the extent to which innovations developed by individual users are deemed of potential value to others, and the extent to which they diffuse as a function of perceived general value.	Consumer innovation	Consumers as user innovators are motivated to create innovations to serve their own needs, not those of others, and consumer needs have shown to be heterogeneous {1857}	- Creation/modification of products or applications for personal use in the past three years during leisure time {1858} - Innovations that produce some level of functionality (development of customized versions of existing products that are not available on the market & that provide important value for the developer {p. 1858}	Survey	Random sample of Finland's population
				Non-UI	*Not explicitly stated*	- If developed as part of the respondent's job or whether the respondent knew of an equivalent product available on the market that he could have bought {p. 1858} - Purely aesthetic improvements {p. 1858}		
Henkel, & von Hippel (2005)	Theoretical	Welfare implications of user innovation	In this paper we explore the implications of adding innovation by users to existing models of social welfare that currently assume innovation by manufacturers only.	User innovators	- Users tend to develop innovations that only they or a few may want, and that create a high consumer surplus for themselves { p. 73}	*Explicitly stated:* - Users tend to develop innovations that only they or a few may want, and that create a high consumer surplus for themselves	Analysis	*Not given*

					- Users tend to develop new functionality which they require {p. 74}	{p. 74} - Users will tend to develop products having (so far) relatively small marketplace demand—because manufacturer products are not likely to be present there—and for which the user itself has high and inelastic demand (very precise requirements) { p. 78} - Costs (product development) are fully covered by the benefit the user innovator derives from in-house use of the innovation {p. 79} - Users are the generators of information regarding their needs {p. 80} - Innovative products fill small niches of high need {p. 82}		
				Manufacturer innovators (Non-UI)	Manufacturers tend to develop products that many will want, and where they see a chance to capture a large share of the surplus the innovations will create {p. 73}	- Manufacturers tend to develop products that many will want, and where they see a chance to capture a large share of the surplus the innovations will create - Manufacturers can study these early user innovations to gain information about both emerging market needs and possible solutions that would be difficult to obtain otherwise		
Franke, & Shah (2002)	Empirical	How communities support innovative activities: an exploration of assistance and sharing among end-users	This study is the first to explicitly examine how user-innovators gather the information and assistance they need to develop their ideas and how they share and diffuse the resulting innovations.	User innovators	- Research has shown that many important industrial product and process innovations are developed within firms where the product is used, rather than by firms who manufacturer the product for sale to others (von Hippel, 1988) {p. 157} - User-innovators expect to benefit by direct use (Enos, 1962; Knight, 1963; Freeman, 1968; Shaw, 1985; von Hippel, 1988) {p. 158}	*Explicit characteristics identified in sample (UI):* - Newness, Urgency, Market Potential, Commercialisation {p. 163}	Interviews with questionnaires	Sample of communities engaged in innovative activity (sailplaning, kayoing, boarder cross, handicapped cycling)
Hienerth (2006)	Empirical	The commercialization of user innovations: the development of the rodeo kayak industry	In this study, we analyse the commercialization process of user innovations in open communities.	User innovators	- User innovators generate new applications, products and problem solutions (in different development stages) themselves, often based on existing products from manufacturers, developing new uses and techniques or completely new products and solutions - User innovators have a direct personal need but usually no commercial interest. Thus, no manufacturer is involved in their	*Explicit sample criteria*: {p. 279} - Type of innovation: radical innovation - Innovation motive: individual needs, fun - Competition (technical/economical): no competition - Industry life-cycle: pre-industry stage Implicitly stated: - Innovated, designed and shaped new products and	Case study analysis	Sample of 410 registered starters and staff members in the rodeo kayak industry

					innovative activities; users themselves test and retest their innovations (von Hippel, 1988; von Hippel and Tyre, 1995; Thomke and von Hippel, 2002) {p. 275}	materials according to their personal needs {p. 280} - Modification of existing products {p. 280} - Want to create something new for own use {p. 281}		
Bogers, Afuah, & Bastian (2010)	Theoretical	Users as Innovators: A Review, Critique, and Future Research Directions	In this article, the authors review this growing literature, critique it, and develop some of the research questions that could be explored to contribute to this literature and to the theoretical perspectives that underpin the literature.	Intermediate user as innovator	Intermediate users are users such as firms that use equipment and components from producers to produce goods and services. Intermediate users also include, for example, scientists, librarians, webmasters, and surgeons {p. 859}	*Explicitly stated:* Users innovate because their knowledge is sticky and they expect to benefit significantly from using the innovation {p. 861}	Review & critique	*Not given*
				Consumer user as innovator	Consumer users- users of consumer goods are typically individual end customers or a community of end users {p. 859}	Users innovate because they draw on sticky and local knowledge, and they expect to benefit from using and possibly selling the innovation and from enjoying the innovation process {p. 861}		
Luthje, Herstatt, & von Hippel (2002)	Empirical	The dominant role of 'local' information in user innovation: the case of mountain biking	In this paper we examine the specificity with which innovations developed by user-innovators address their in-house needs.	User innovators	- User innovators do tend to develop innovations to serve precisely their own needs. - They do not do this out of ignorance of the market: user-innovators in our sample have an accurate understanding of the breadth of potential marketplace demand for the innovations that they have developed (p. 2)	*Explicitly stated characteristics:* - Newness, technical sophistication, personal benefit, market potential *Findings:* - User-innovators do not stray significantly from attempting to solve their own in-house needs {p. 2} - User-innovators tend to use only their own pre-existing stocks of solution-related knowledge to develop their innovations {p. 2} - Users operate in a "low-cost innovation zone" when they develop innovations precisely responsive to problems they encounter in the normal course of their activities, and that they address by using solution information already in hand {p. 3} Reported that they gained a high personal benefit from using their innovations in their own mountain biking activities {p. 16} The higher the amount and "extreme nature" of use experience, the more probable that a user has ideas and concepts for new or improved products {p. 19}	Survey	2 samples of Mountain bikers (255 members of MTB clubs, 1,209 members of MTB online forums)
Luthje (2004)	Empirical	Innovating consumers	The author reports on a survey of the innovation activities and characteristics of 153 users of	Innovating consumers	*Not explicitly stated*	*Explicit findings:* - Expectation of innovation related benefits {p. 5} - Level of user expertise	Survey	153 users of outdoor-related consumer product

			outdoor-related consumer products.			- Use expertise: frequent use of products {p. 6} - Product related knowledge: know-how about the product architecture and the used materials and technologies of the existing products in the market {p. 6} - Modifications of existing product parts as well as the addition of new elements to existing goods {p. 9-10} - Significant: commitment to product & innovation related core benefit {p. 14} - Not-significant: expected financial reward {p. 14}		
Gambardella, Raasch, & von Hippel (2016)	Theoretical	The User Innovation Paradigm: Impacts on Markets and Welfare	We build a microeconomic model of a market that incorporates demand side innovation and competition.	Single user innovator	- Single firm or individual that creates an innovation in order to use it - Examples: single firm creating a process machine in order to use it, a surgeon creating a new medical device in order to use it, and an individual consumer creating a new piece of sporting equipment in order to use it (von Hippel 2005) {p. 1452} - Innovating users find it viable to develop and self-provide innovative designs related to the producer	*Explicit criteria & implicit through model:* - User activities with no producers involved {p. 1452} - Users developing new products/services to serve their own in-house needs {p. 1453} - Users possess sticky information regarding their needs and context of use (von Hippel 2005) {p. 1453} - Innovations produced for own use but many users have similar interests {p. 1453} - Users derive utility from using the innovation they have created & from the innovating process (fun, learning) {p. 1456} - Maximise utility {p. 1456}	Logical analysis; theoretical model	*Not given*
				Producer innovator (non UI)	- Single firm or individual anticipating profiting from their designs by selling design information or products based on that "recipe" to others: by definition, they obtain no direct use-value from them. - Examples: firm or individual that patents an invention and licenses it to others and a firm that develops a new product or service to sell to its customers (von Hippel 2005, Baldwin & von Hippel 2011). {p.1452} Non-innovating users do not have a viable option of innovating. - Their costs may be too	*Not given*		

					high, for example, because they lack needed skills or access to tools {p. 1455}			
De Jong (2016)	Theoretical	The empirical scope of user innovation	This chapter summarizes and discusses the empirical work concerned with the scope of user innovation in broader samples.	User innovators	- User innovation refers to innovations developed by end users, rather than by producers {p. 3} - 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) {p. 3} - 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) {p. 4}	*Explicitly stated*: - 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 {p. 5} > Consumers may innovate in their leisure time by creating and/or modifying everyday items for their own benefit {p. 7} - 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 {p. 7-8} - Consumer surveys shows that in absolute numbers, many consumers develop or modify products for personal use, and spend considerable time and money on it {p. 8} - It is important to distinguish user innovation from broader process innovation indicators --> no adoptions {p. 5}	Summary of other work	*Not given*
Von Hippel, De Jong, & Flower (2012)	Empirical	Comparing business and household sector innovation in consumer products: findings from a representative study in the United Kingdom	Measuring the development and modification of consumer products by product users in a representative sample of 1,173 UK consumers aged 18 and over.	User innovators	- Individual consumers who develop or modify consumer products are "household sector innovators," where the household sector is defined as com prising individuals in all resident households and also includes their unincorporated businesses (Ferran, 2000) {p. 1670} - User innovators are defined as innovators who expect to benefit from their innovation via use rather than from production and sales (von Hippel 1988, 2005). User innovators can be firms or individual consumers. When they are consumers working independently of their jobs to solve their own consumer needs, they also fall within the category of household sector innovators (Ferran 2000) {p. 1670}	*Explicitly from survey questions:* - Created a product from scratch or modified a product {p. 1672} - They often accomplish this by modifying and combining items that they have around the house or purchase at low cost to create a new or modified product to serve a n		
				Non-UI	*Not explicitly stated*	- The respondent knew of an equivalent product available on the market {p.1673}		

						- That he or she could have bought, rather than creating a "homebuilt" one - Whether the innovation had been developed as part of the respondent's - Lack of novel user-developed content		

Appendix D Robustness checks

Table 11 Robustness check including user innovation as a binary variable

	(1) SURV *logistic*	(2) SURV *logistic*	(3) SURV *logistic*	(4) GROW *normal*	(5) GROW *normal*	(6) GROW *normal*	(7) INV *logistic*	(8) INV *logistic*	(9) INV *logistic*
INC	1.132***	1.094***	1.006**	2.981***	2.658***	2.624***	1.891**	1.713**	1.587*
	(0.381)	(0.387)	(0.399)	(0.852)	(0.844)	(0.895)	(0.803)	(0.806)	(0.817)
UI ORD		-0.057	-0.255		-1.552	-0.627		0.018	-4.887
		(0.229)	(0.346)		(0.313)	(0.374)		(0.370)	(599.765)
INC*UI ORD			0.439			0.148			5.002
			(1.526)			(0.486)			(599.765)
QUAL	-0.047	-0.068	-0.067	-0.056	0.052	0.054	-0.364	-0.225	-0.225
	(0.181)	(0.184)	(0.185)	(0.341)	(0.334)	(0.335)	(0.305)	(0.316)	(0.322)
SAA	-0.106	-0.083	-0.072	-0.903***	-0.825***	-0.821***	-0.255	-0.211	-0.198
	(0.130)	(0.132)	(0.133)	(0.227)	(0.226)	(0.229)	(0.213)	(0.210)	(0.210)
AAA	0.629***	0.656***	0.647***	0.082	0.076	0.074	0.156	0.163	0.153
	(0.199)	(0.204)	(0.203)	(0.160)	(0.159)	(0.161)	(0.177)	(0.177)	(0.177)
YSA	-0.159	-0.163	-0.130	0.326	0.435	0.444	0.601*	0.567*	0.586*
	(0.194)	(0.197)	(0.202)	(0.523)	(0.529)	(0.535)	(0.311)	(0.318)	(0.322)
EXP	-0.159	-0.216	-0.227	-0.081	-0.200	-0.204	0.460	0.285	0.274
	(0.215)	(0.220)	(0.220)	(0.522)	(0.524)	(0.525)	(0.315)	(0.331)	(0.331)
B2C	-0.596*	-0.684*	-0.703*	-0.939	-0.927	-0.934	0.148	0.114	0.079
	(0.352)	(0.363)	(0.364)	(0.906)	(0.957)	(0.960)	(0.543)	(0.578)	(0.584)
HDW	-0.653*	-0.672*	-0.692*	-1.520*	-1.599*	-1.598*	-0.207	-0.167	-0.172
	(0.388)	(0.395)	(0.398)	(1.159)	(1.178)	(1.181)	(0.539)	(0.570)	(0.571)
Const.	1.355	1.508	1.458	1.841	1.394	1.380	-4.697***	-4.828***	-4.778***
	(1.097)	(1.121)	(1.124)	(1.819)	(1.783)	(1.793)	(1.777)	(1.857)	(1.856)
Obs	186	180	180	186	180	180	186	180	180
Pseudo R-squared	0.137	0.146	0.149	0.111	0.111	0.111	0.130	0.109	0.113

Note: Robust standard errors and normal R-squared for Growth *** p<0.01, ** p<0.05, * p<0.1

In order to test the robustness of the regression results obtained in *Table 8*, we replaced the binary variable UI with an ordinal variable representing the UI-Index values from 1-5 (“very weak”, “weak”, “moderate”, “strong”, “very strong”) as well as 0 (“Non-UI”). The same changes have been made for the interaction term between UI and INC. Replacing the binary variable UI with an ordinal variable provides us with the same results as we have already seen in *Table 8*. Besides minor deviations of the estimates, no

effects on the significance of the results can be observed. We are therefore able to show robustness of our results since changing one or more variables does not affect our overall outcome.