VTT Technical Research Centre of Finland

User knowledge utilisation in innovation of complex products and systems

Abrell, Thomas; Andreas, Benker; Pihlajamaa, Matti

Published in:
Creativity and Innovation Management

DOI:
10.1111/caim.12244

Published: 01/06/2018

Document Version
Peer reviewed version

Abrell, T., Benker, A., & Pihlajamaa, M. (2018). User knowledge utilization in innovation of complex products and systems: An absorptive capacity perspective. *Creativity and Innovation Management*, *27*(2), 169-182.

https://doi.org/10.1111/caim.12244

User knowledge utilisation in innovation of complex products and systems: an absorptive capacity perspective

Abstract

Firms tap into user knowledge to learn about their users' needs. While users have been recognised as a valuable source of knowledge for innovation, few studies have investigated how their knowledge is integrated into innovation processes in the context of complex products and systems (CoPS). The purpose of this study is to reveal the practices of CoPS manufacturers to facilitate user knowledge utilisation for innovation. We investigate two case companies, a medical device manufacturer and an aircraft manufacturer, and report on seven managerial practices for utilising user knowledge. We adopt the absorptive capacity model in structuring our findings and elaborate three of the model's sub-capabilities (recognition of the value of user knowledge, acquisition of user knowledge, and assimilation/transformation of user knowledge) by proposing that each is associated with a distinct managerial goal and related practices: 1) Sensitising the organisation to the innovation potential of user knowledge, 2) identifying and gaining access to suitable user knowledge, and 3) analysing and interpreting user knowledge and integrating it into product development. Our study contributes to the innovation management literature by *analysing the capabilities required to utilise user knowledge throughout the CoPS innovation process.*

Keywords: user knowledge, innovation management, absorptive capacity, CoPS innovation

1. Introduction

The benefits of inbound activities have been widely reported in the open-innovation literature (Du, Leten, & Vanhaverbeke, 2014; Schemmann et al., 2016; West & Bogers, 2014): acquiring knowledge from partners like universities, suppliers, customers, and research institutes (Enkel, Gassmann, & Chesbrough, 2009; Tether & Tajar, 2008) has been found to complement organisations' internal knowledge bases (Dahlander & Gann, 2010; Lakemond et al., 2016), increasing their innovative performance (Bianchi et al., 2015; Cheng & Huizingh, 2014; Faems, van Looy, & Debackere, 2005) and overall firm performance (Sisodiya, Johnson, & Grégoire, 2013). An influential research stream has focused on how companies collaborate with users to promote innovation (Bogers, Afuah, & Bastian, 2010; Randhawa, Wilden, & Hohberger, 2016). Users have been found to be valuable sources of knowledge that companies must take into account in order to develop innovations that have relevance and demand (Lüthje, 2004; Schweisfurth & Herstatt, 2016). *User knowledge* includes knowledge of current and future needs (Lüthje, 2004; Schweisfurth & Herstatt, 2016), ideas (Holt, 1988; Magnusson, 2009), the context of use (von Hippel, 1994), and what creates value for users and in which situations (Lüthje, 2004). Understanding users' needs and translating them into new product designs is a critical factor in development processes (Callahan & Lasry, 2004) and innovation (Griffin & Hauser, 1993; von Hippel, 1986). However, there is still little we know about managerial processes and practices for user innovation (Lichtenthaler, 2011), especially with regards to the nature of user knowledge underpinning innovation (Bogers et al., 2010).

In the context of the development of complex product systems (CoPS), user involvement is particularly challenging. While manufacturing firms often have extensive technical knowledge, they cross company boundaries and interact with users to gain an understanding about their users' needs (Kujala, 2003; von Hippel, 1994). Even though users often have substantial interest in influencing the outcome of development projects in the CoPS context (Hobday, 1998), access to them is often limited (Bogers et al., 2010) and their needs might be hidden or remain unrecognised (Kärkkäinen, Piippo, & Tuominen, 2001). CoPS are also associated with long development cycles (Griffin & Belliveau, 1997) during which the availability of users may vary. The CoPS innovation process includes the development of mechanical, electronic, and software components that may advance at different paces (Bosch-Sijtsema & Bosch, 2015), which may make it difficult for users to evaluate intermediate designs. Furthermore, the companies that manufacture CoPS are often engineering-intensive and dominated by technical considerations. At the same time user input is very important for CoPS development. The products are produced in small batches and are highly customised which makes it crucial to understand user-specific needs (Hobday, 1998; Miller et al., 1995). Their usage times in the context they are embedded are also very long, often even decades. This makes it even more important to consider users' values in the development process to ensure the CoPS design matches users' perceived benefits (Klein & Sorra, 1996). The characteristics of the CoPS context are illustrated, for example, in airplane manufacturing where the products are expensive, have typical life spans of multiple decades, require complex engineering, have multiple users such as pilots, cabin crew, and consumers, the passengers, and where many aspects related to branding and operations are customised (Ackert, 2013).

This study answers this research question: How do manufacturing companies of complex products and systems facilitate user knowledge utilisation for innovation?

In order to improve our understanding about the processes and practices for utilising user knowledge, we conducted an in-depth multi-case study of two B2B manufacturing firms, an aircraft manufacturer and a medical device manufacturer. The case settings are considered appropriate to the purpose of this study since both develop complex products and systems and involve users in their innovation processes. In particular, we focus on individual users (Abrell et al., 2016) such as maintenance personnel and operators and not consumers such as passengers or patients.

We adopt the absorptive capacity framework to investigate the utilisation of user knowledge in CoPS innovation processes. Absorptive capacity is the ability to recognise new knowledge, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1989; 1990). We propose managerial goals and practices that are deemed important for integrating users into CoPS innovation processes, and report how they link to three capabilities of the absorptive capacity: 1) value recognition, 2) acquisition, and 3) assimilation/transformation of user knowledge. In order to utilise user knowledge, the absorption of user knowledge including these three capabilities is required to exploit the new knowledge in the form of commercialisation.

The study contributes to the literature on user innovation by conceptualising the capabilities facilitating user knowledge utilisation in innovation processes through the absorptive capacity framework and proposing managerial goals and practices for successful integration of that knowledge into the process. The findings also help to understand CoPS-related innovation processes in the B2B manufacturing industry and add to the literatures of user innovation and absorptive capacity in that context.

This study is organised as follows: Section 2 establishes a theoretical background concerning open innovation, user innovation, and absorptive capacity as foundations of the study. Section 3 explicates the research methodology. Section 4 presents the findings, which we discuss in Section 5 along with outlining the practical implications and limitations of our research. Finally, we present concluding remarks in Section 6.

2. Background

2.1. Users in CoPS Innovation

The role of users in innovation has become an important stream of research, starting with the seminal works of Rothwell et al. (1974) and von Hippel (1976). Recent review articles recognise it as one of the most important topics in open innovation (Dahlander & Gann, 2010; Lichtenthaler, 2011; Randhawa et al., 2016; West & Bogers, 2014). Extant studies on users in innovation can be divided into two perspectives (Bogers et al., 2010): The first considers the phenomenon of users as independent innovators when they create new or modify existing products individually (Baldwin & von Hippel, 2011), in communities (Dahlander & Frederiksen, 2012; Franke & Shah, 2003; Marchi, Giachetti, & de Gennaro, 2011), or even by becoming entrepreneurs (Haefliger, Jäger, & von Krogh, 2010; Lettl, Herstatt, & Gemuenden, 2006; Shah & Tripsas, 2007; Smith & Shah, 2013). The second perspective addresses the benefits producers may gain from users as sources of innovation-related knowledge (Bogers et al., 2010). This perspective includes the idea of interacting with lead users to gain insights into future market needs (Morrison, Roberts, & Midgley, 2004; Ozer, 2009; Urban & von Hippel, 1988; von Hippel, 1986), crowdsourcing innovative ideas (Huang, Vir Singh, & Srinivasan, 2014; Leimeister et al., 2009; Palacios et al., 2016; Schemmann et al., 2016), and co-creating innovations with users (Zwass, 2010). Our study belongs to this second group, as it addresses users as a valuable source of knowledge (Bogers et al., 2010; Bosch-Sijtsema & Bosch, 2015; Kaulio, 1998; Lüthje, 2004; Rothwell & Gardiner, 1985; von Hippel, 1976) that the B2B manufacturing companies can integrate in their innovation processes.

User involvement is particularly interesting in the context of CoPS due to the complexity of products that makes them often difficult to use and the fact that individuals operating them are usually specialists that may have particularly valuable inputs to the development process. Users are frequently mentioned in the literature on CoPS, and CoPS innovation has been even defined as a delivery of a “system with functionalities required by the users” (Chen, Tong, & Ngai, 2007, p. 139). The users have been noted to have a substantial interest in the development of CoPS because large parts of their own products and services delivery depend on them (Hobday & Rush, 1999). In their study of the aircraft industry, Mowery and Rosenberg (1982, p. 125) argue that the “number and complexity of the systems that are combined in a modern aircraft design are partly responsible for the fact that, to an unusual extent, the aircraft industry has benefited from innovations and research support from sources outside the industry,” leading to a “user-active pattern of new product development” in which initial customers in particular have heavy influence on new product development (Mowery & Rosenberg, 1982).

Accordingly, there have been studies that address how to involve users as part of interorganisational innovation networks (Chen et al., 2007; Dedehayir, Nokelainen, & Mäkinen, 2014; Ngai, Jin, & Liang, 2008). However, there is variety and ambiguity in what is meant by “users” in the literature. Bogers et al. (2010, p.857) distinguish between intermediate users who “use the products as inputs to their own production processes” and end-consumer users “who use the products to satisfy their personal needs”. In the CoPS context, intermediate users are, however, not a homogeneous group. The users of CoPS are typically discussed as business users (Hobday, 2000) or user firms (Miller et al., 1995), however Baraldi (2009) emphasises the complexity in the debate and points out that there may be multiple users—organisations as well as end users, such as operative personnel. Part of the complexity in B2B is that users and customers may be in the same organisation. Abrell et al. (2016) acknowledge this complexity by defining users as individuals who use CoPS, while customers are those who make the purchasing decisions. Abrell (2017) points out a difference between primary users, who operate aspects of a complex product, and secondary users, who gain economic benefit from the product. For the purposes of this study, we define users as individuals (Abrell et al., 2016) who operate aspects of CoPS (Abrell, 2017) as inputs to their own work processes (Bogers et al., 2010). Such users include cabin crew, maintenance personnel, and operators. We therefore exclude consumers such as passengers, or patients to focus on a group of users that is characteristic to CoPS and has been poorly addressed in the previous studies.

The role of users in innovation can be approached via the concept of user knowledge. User knowledge—that is, knowledge *from* and *about* users (Khodakarami & Chan, 2014)—is particularly valuable for innovation, as it provides insights into users' current and future needs (Lüthje, 2004; Schweisfurth & Herstatt, 2016), contributing to manufacturers' understanding of what creates value for users in what kind of situations (Lüthje, 2004). However, difficulties arise from the challenges related to acquiring user knowledge and from the cost of transferring and using it (von Hippel, 1994). Users' needs are often in the form of tacit knowledge (Schweisfurth & Herstatt, 2016; Schweisfurth & Raasch, 2015) —knowledge that is contextually rooted in action (Polanyi, 1966)—that is difficult for the users to articulate (Nonaka, 1994). As Alavi and Leidner (2001, p. 109) state, tacit knowledge "becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms." Moreover, translating user needs into something that is technically feasible within the organisational context is challenging. Users might have original ideas and express their needs accordingly but they lack knowledge about companies' innovation processes (Magnusson, Matthing, & Kristensson, 2003; Poetz & Schreier, 2012;).

To overcome the difficulties in acquiring and using knowledge from the users, prior studies have investigated a variety of arrangements for engaging users. Those include asking users for input during the early ideation stages (Kristensson, Gustafsson, & Archer, 2004; Magnusson, 2009) and interacting with users throughout development and implementation phases (da Mota Pedrosa, 2012). Users may propose concrete improvement ideas (Di Gangi & Wasko, 2009), forecast trends and envision new products, participate in design, or test and evaluate prototypes and early versions of new products (Hyysalo, 2009). Bosch-Sijtsema and Bosch (2015) reveal how new technologies like Web 2.0, social network systems, and software-as-a-service allow producers to acquire user input throughout the innovation process, rather than only in the early conceptual phase. Users can also form intermediate user organisations that can play a significant role in articulating demands concerning new technologies (Boon et al., 2011).

In the context of CoPS, there are some idiosyncrasies in involving the users. It has been argued that in engineering-intensive environments, users that are involved should have high professional and technological competencies (Enkel, Perez-Freije, & Gassmann, 2005). As a result, the availability of suitable users may be limited (Bogers et al., 2010). There have, however, been reports of companies using so-called embedded users, that is their employees who also use the company's products, to contribute to innovation processes as they are likely to be knowledgeable of both market needs and technological solutions (Block et al., 2016; Roy & Sarkar, 2016). Another issue arises from the high process complexity in the CoPS innovation processes, which means there are several interrelated sub-processes required to develop a system that consists of various components and sub-systems (Hobday, 1998). Because of this complexity, developers must pay special attention to technical considerations that may result in less attention to the users' needs. Additionally, users may also have difficulties in providing feedback of intermediate designs as the parts may be developed at different paces. As there might not be a full product to test and evaluate, users might not be able to judge "the fit of the innovation to their values" (Klein & Sorra, 1996, p. 1063) before it is embedded in their use context.

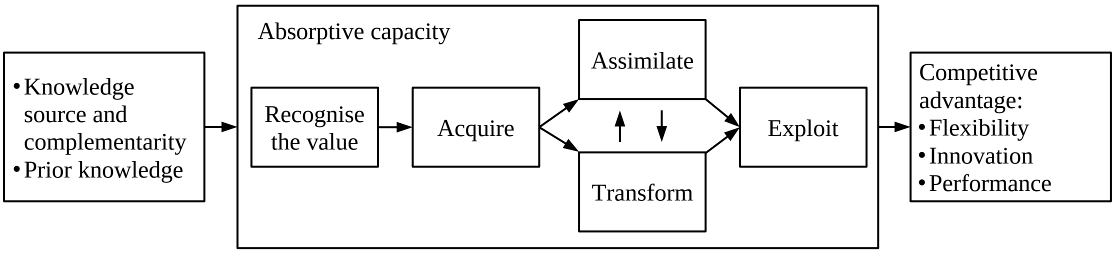
2.2.Absorptive capacity

Absorptive capacity refers to an organisation's ability to recognise new knowledge, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1990). It is a competence that companies can build, typically in their R&D units, in order to access knowledge, ideas, and technologies from external sources (Christensen, Olesen, & Kjær, 2005). Therefore, it fits well with the overall idea of inbound open innovation (Lichtenthaler & Lichtenthaler, 2009).

Zahra and George (2002) suggest that absorptive capacity is comprised of several sub-capabilities that are needed in different parts of the absorption process, while other studies suggest various process models and related capabilities (see, e.g., Lane, Koka, & Pathak, 2006; Van den Bosch, Van Wijk, & Volberda, 2003; Zahra & George, 2002). Here we adopt the model (Figure 1) first proposed by Todorova and Durisin (2007), which proceeds through four stages: 1) recognising the value of external knowledge, 2) acquiring the knowledge, 3) assimilating and/or transforming the knowledge, and 4) exploiting the knowledge.

Considering the first step, before seeking to gain access to external knowledge, one must understand its value (Todorova and Durisin, 2007). If an organisation's search scope is limited, it cannot benefit from many knowledge sources. After identifying and gaining access to (acquiring) potentially valuable knowledge, the knowledge must be analysed, interpreted, and combined with existing knowledge. Depending on the degree to which the new knowledge is compatible with the organisation's knowledge base, it might challenge established ways of thinking (Noblet, Simon, & Parent, 2011) and require reframing and transformation of the existing knowledge structures (Zahra & George, 2002). On the other hand, if it fits well into the existing knowledge structures, it may be assimilated into them. Todorova and Durisin (2007) suggest that these two processes are closely related and often interact with each other until the new knowledge is incorporated, which is why we group them together. Finally, the last capability, exploitation, refers to the ability to put the knowledge to use in, for example, the form of patents (Forés & Camisón, 2016), new products (Todorova & Durisin, 2007), and ventures (Zahra & George, 2002).

Figure 1: Model of absorptive capacity (modified from Todorova & Durisin, 2007)



Absorptive capacity was once understood as primarily an outcome of prior related knowledge (Cohen & Levinthal, 1990), but consideration of the sub-capabilities has brought attention to the internal factors that promote absorption. However, since the literature has been dominated by conceptual papers, recent studies have called for more empirical research on the intraorganisational factors that generate absorptive capacity (Lane et al., 2006; Volberda, Voss, & Lyles, 2010). Moreover, most extant studies examine absorptive capacity at the firm level, while there is scarce research that addresses the micro-level processes that shape capabilities (Easterby-Smith et al., 2008; Martinkenaite & Breunig, 2016; Volberda et al., 2010).

In this study, we investigate the practices and capabilities facilitating user knowledge utilisation in CoPS innovation processes. While exploitation in the form of commercialisation is an important capability in realising the benefits of user knowledge (Shaw, Giglierano, & Kallis, 1989), our focus is on how it can be embedded in product designs. Accordingly, we concentrate on the three stages prior to exploitation: recognition of the value, acquisition, and assimilation/transformation. By investigating the management practices that companies use to benefit from users as a source of innovation-related knowledge, we shed light on how to implement inbound open-innovation arrangements with users and how absorptive capacity emerges from micro-level actions.

3. Methodology

To answer questions related to how and why user knowledge is used, we chose a multiple-case-study design (Eisenhardt, 1989) with two case companies, based on a systematic combining approach (Dubois & Gadde, 2002; 2014). Before selecting the cases and entering the field, we reviewed the literature on user knowledge in order to gain a first impression about existing concepts and to increase our theoretical sensitivity (Glaser, 1978). Applying abductive reasoning (Peirce, 1931) and alternating between theory and practice allowed us to let the initial theoretical preconceptions co-evolve with the cases and empirical observations throughout the research process (Dubois & Gadde, 2002).

Following the CoPS concept (Hobday, 1998), we used theoretical sampling (Eisenhardt & Graebner, 2007) to select two companies that manufacture complex, engineering-intensive products—aircraft cabins and magnetic resonance imaging devices, respectively. We chose the companies because they develop complex products with long development cycles and usage times which correspond to the depiction of CoPS in the literature. Another criterion was their experience in involving operative users, such as cabin crew and nurses, in their innovation processes. Therefore, both case companies are appropriate subjects with which to investigate how user knowledge utilisation is facilitated in the CoPS context.

We used both interviews and focus groups to collect the data for this study. The data collection and analysis proceeded in four main phases. We conducted two interview rounds, with a total of twenty-one interviews, and two focus groups. The first fourteen interviews were conducted in April 2014, the focus groups were conducted in June and July 2014, and the second round of seven interviews was conducted between July and October 2014. Two researchers were present for all interviews and the focus groups, and all interviews and focus groups were recorded and transcribed verbatim in order to establish a chain of evidence and strengthen the validity of the emerging constructs (Yin, 2003). Table 1 contains an overview of the interviewees and focus group participants. In the last phase, we linked our findings to the absorptive capacity framework.

Case	Company A	Company B
Field	Aircraft manufacturing	Medical device manufacturing
Location	Germany	Finland
First round of interviews		
Interviewees' profiles	Innovation Manager (2), Senior Innovation Manager (4), R&D Manager	R&D Manager (3), Senior R&D Manager (2), Marketing Manager, Senior Marketing Manager
Number of interviews	7	7
Duration	55–80 minutes (mean: 67 minutes)	45– 60 minutes (mean: 58 minutes)
Focus Group		
Participants' profiles	Senior Innovation Manager (3), Senior User Expert	R&D Manager, Developer, Senior R&D Manager (3), Senior Innovation Manager, User Expert, Senior Marketing Manager
Duration	120 minutes	120 minutes
Second round of interviews		

Interviewees' profiles	User Expert (2), Senior User Expert	User Expert (3), Senior User Expert
Number of interviews	3	4
Duration	75–150 minutes (mean: 102 minutes)	57–60 minutes (mean: 59 minutes)

Table 1: Data collection methods and sources

Phase 1. Becoming familiar with user innovation practices in the organisational context. We began our data collection process with series of fourteen semi-structured interviews. We asked key informants in the case companies to suggest a set of suitable individuals (Patton, 2014) who are responsible for shaping innovation processes and driving innovation projects in the company. The selection criteria for these fourteen interviews were that interviewees (a) know about the innovation processes in their organisations and (b) have an active role with regards to the practices for integrating user knowledge in these processes. We interviewed people from a variety of functional areas (i.e., marketing and R&D) and hierarchical levels (i.e., senior and management positions) in order to avoid bias in their retrospective sensemaking processes (Eisenhardt & Graebner, 2007). This range of interviewees enabled us to ask questions about how the companies collect and integrate user knowledge, and in which stages of the innovation process user knowledge is needed. The answers addressed both how the companies are absorbing user knowledge at the moment and their future objectives.

After conducting the interviews with managers from both companies, the researchers transferred their interview notes into a structured form that summarised each interview's main findings (Miles & Huberman, 1994). We structured these contact-summary forms to include the interview questions, key findings, quotations, and ideas on which to follow up, thus allowing the researchers to interpret and make sense of their own interview notes and highlight the aspects of the notes that were most relevant in respect of users and the innovation process in general. In the second documentation step, we discussed each researcher's individual contact summary forms before combining them to one contact summary form per interviewee. During this process, we discussed what aspects of the interviews were highlighted and why in order to resolve any discrepancies in our interpretations and derive first key findings from each informant. Third, we conducted a within-case analysis (Eisenhardt, 1989) and developed a case description for each company as an intermediate step (Yin, 2003) to mapping key findings and grouping them into clusters based on similarity. This process was done in a non-digital way, as Coviello (2014) suggests, using white boards and "sticky notes" to identify patterns in the findings. Fourth, we combined the findings from both cases and compared the identified clusters for complementarity to establish a list of seven categories: type of user information, user selection, initial user understanding, translation of user needs, continuous user understanding, timely user evaluation, and value of product usability. Table 2 shows an example of our data analysis approach and how the initial first-order codes emerged from our interview summaries. The first-order codes and categories identified were derived from the combined case summaries.

Quotation	First-order codes	Category
"If you know the problem rather than proposed technological solutions, then you can innovate. If you don't know the problem, then you start innovating only on the technology side, and we easily make complex or expensive solutions where there is no real need." - Senior R&D Manager, Company B	Problem definition User needs Innovation source Technology-push	Initial user understanding

Table 2: Data analysis approach

Phase 2. Establishing the validity of the identified categories. We conducted two focus groups, one in each organisation, using our initial research findings from the interviews as stimulus material for the discussion (Liamputtong, 2011). We selected focus group participants that we interviewed before (three out of four group participants in company A and six out of eight in company B), in order to get the focus group participants' interpretations of our results (Morgan, 1997). Furthermore, key informants in both companies recommended the inclusion of a senior user expert in company A as well as an innovation manager and user expert in company B to complement the groups' expertise regarding practices facilitating user knowledge utilisation in the innovation process. We emphasised the interactive aspect of data collection (Flick, 2009) since a focus group setting allows respondents to react and build on others' responses (Stewart, Shamdasani, & Rook, 2007), facilitating data and insights that would be difficult to obtain from individual interviews (Morgan, 1997).

We presented the seven categories from our case summary to the key informants in each case company during the two focus groups (Yin, 2003) to increase the reliability of our interpretations of the interview data. We adopted a structured approach to the focus groups, guiding the discussion using our findings from the individual interviews. While this approach might produce limited data (Morgan, 1997), we chose it in order to get the participants' opinions on the findings and future research directions. After presenting the interview results, we captured immediate responses from the participants; the length of the discussion on each finding gave us an impression of its importance. We handed out sheets with the seven identified categories listed. We asked participants to rate them on a scale from one to five in terms of each category's relevance to user knowledge utilisation in their company, impact on the innovation process, and feasibility to implement. Relevance refers to whether the category is useful to the interviewees in their work. Impact stands for the effect the category has on the innovation process. Finally, feasibility denotes how likely the category is to be achieved.

	Relevance			Impact			Feasibility		
	A&B	A	B	A&B	A	B	A&B	A	B
Type of user information	3.6	4.0	3.3	3.6	3.5	3.7	3.5	3.3	3.7
User selection	4.2	4.7	4.0	4.4	5.0	4.2	3.0	2.7	3.2
Initial user understanding	4.2	3.8	4.5	4.3	4.0	4.5	3.6	2.8	4.2
Translation of user needs	4.1	5.0	3.5	4.2	5.0	3.7	3.1	1.8	4.0
Continuous user understanding	4.1	4.0	4.2	4.1	3.5	4.5	2.7	2.3	3.0
Timely user evaluation	4.2	3.0	5.0	4.0	2.8	4.8	3.7	3.3	4.0
Value of product usability	4.2	4.7	4.0	3.8	3.7	3.8	3.1	1.7	3.8
Average of all categories	4.1	4.2	4.1	4.1	3.9	4.2	3.2	2.5	3.7

Note: A refers to one company's focus group, B to the other company's focus group, and A&B to the average of the two groups.
Table 3: Focus group individual response sheets

The main intention of this exercise was prompting the participants to think about each of the findings individually as a starting point for the group discussion. The resulting response sheets verified our interim findings regarding the findings' potential impact and relevance to user knowledge utilisation in the case company (Table 3). It also showed us that both companies recognise the challenges in facilitating user knowledge utilisation based on the lower ranking of feasibility compared to relevance and impact. We were cautious about making strong conclusions other than that at this stage since the response sheets were primarily a conversation trigger and complemented the observations of the groups' discussions (Flick, 2009), which allowed us to gain further insight into what each category means in each case company's context. Finally, we discussed the study itself on a meta-level with the focus groups' participants in each company so the cases could co-evolve based on empirical observations (Dubois & Gadde, 2002). This discussion, as well as the ex post analysis of the two focus groups, led to the conclusion to include user experts in our study in order to gain a more holistic perspective of the phenomenon of users' knowledge in innovation.

Phase 3. Complementing findings from user expert perspective. Acknowledging that the user experts' perspective had been underrepresented in our data collection process, we conducted semi-structured interviews with seven user experts, three from Company A, and four from Company B. These user experts were employees who represent users (e.g., cabin crew members or nurses), and/or have specific expertise in involving users in the innovation process. We use the term "expert" because these users' reasoning derives from specialised knowledge about users, so they can draw meaningful patterns from this knowledge base to guide their problem-solving efforts (Glaser, 1999). Based on the response sheets and the outcome of the focus group discussions, we developed a new interview guide that emphasised user experts' practical role in the innovation process and asked about practices they apply to utilise user knowledge. More specifically, the guide included questions related to user experts' role in the innovation process; how user knowledge is accessed, maintained and translated into the process; and the value the user experts attribute to user knowledge.

The interviews with user experts allowed us to critically revisit and refine our categories in Phase 3 of our data analysis. We then revisited our raw data to ensure close adherence of the findings to the data (Eisenhardt & Graebner, 2007), using qualitative data analysis software to code our transcripts and improve validity and rigor (Wolfe, Gephart, & Johnson, 1993). We used our categories as codes for all transcripts of the interviews with user experts and managers. During this analysis process, we rephrased our relatively abstract "categories" (e.g. initial user understanding) in terms of more tangible "managerial practices" (e.g. understanding the users' problems), which are more in line with our research question and the related literature (e.g. Rajala et al., 2013). Here, we define practices as techniques, methods, processes, activities, and mechanisms which larger organisational capabilities are based on (Teece, 2007; Xu & Yeh, 2012).

Phase 4. Adopting a theoretical framework. After the initial analysis, we started a search for complementary literature that could be used to increase the relevance of our findings by positioning them in respect to relevant theoretical discussions (Ridder, Hoon, & McCandless Baluch, 2014). We consider that the absorptive capacity theory fits well with the findings based on its strong concern with innovation, its discussion of knowledge as a key concept, and its examination of the interactions between a company and external actors (Cohen & Levinthal, 1990). Its key constructs are well-grounded in major theories on the firm, technological change, and individual and collective learning, and they have gained strong empirical support from studies conducted during the last twenty-five years.

Guided by the theoretical understanding of absorptive capacity and its sub-capabilities (Todorova & Durisin, 2007), we reinterpreted and grouped our findings to ground them to extant theory. We sought similarities and differences between our managerial practices and the capabilities related to absorptive capacity to describe aspects of the generic capabilities that are specific to our context. As a result, we generated three managerial goals that illustrate the thought and purpose behind the managerial practices: 1) sensitising the organisation to the innovation potential of user knowledge, 2) identifying and gaining access to suitable user knowledge, and 3) analysing and interpreting such knowledge and integrating it into product development. The outcomes are illustrated in Table 4.

A defining feature of organisational capabilities is that they have a purpose (Dosi et al., 2000). The managerial goals describe the purpose of the capabilities derived from absorptive capacity theory in a specific context of users and CoPS. The identified practices are proposed as capability microfoundations, that is the activities and elements that underlie the capabilities themselves (Felin et al., 2012; Lewin, Massini, & Peeters, 2010; Teece, 2007).

The next section describes the seven managerial practices that form the empirical core of our study. Then Section 5 discusses the managerial goals and their relevance to theory and practice.

Capability	Goal	Practice	Description
Recognition of the value	Sensitising the organisation to the innovation potential of user knowledge	Endorsing the value of user knowledge	Recognising the positive impact that using users' knowledge can have on the product-to-be.
		Understanding the users' problems	Starting from users 'real needs' at the beginning of an innovation project in order to avoid over-engineered development outcomes.
		Enabling continuous access to users	Providing developers with continuous access to users' knowledge as users' needs can change during long development cycles.
Acquisition	Identifying and gaining access to suitable user knowledge	Selecting suitable user profiles	Choosing the right user profiles and prioritising needs at the beginning of the innovation process to ensure that the acquired knowledge leads to the right outcomes.
		Matching types of user knowledge and project phases	Obtaining suitable type of user knowledge that is required at various stages of the innovation process changes from general at the beginning to more specific in the later stages.
Assimilation / Transfor-mation	Analysing and interpreting user knowledge and integrating it	Translating user knowledge into specifications	Translating tacit users knowledge, which exists in many forms, into design specifications to be used by developers.

	into product development	Validating design choices through timely user feedback	Seeking timely feedback from users at specific decision-making stages of the innovation process.

Table 4: Capabilities, goals and practices facilitating user knowledge utilisation in CoPS

4. Findings

We identified seven managerial practices that were considered important in the utilisation of user knowledge in the case companies: endorsing the value of user knowledge, understanding the users' problems, enabling continuous access to users, selecting suitable user profiles, matching types of user knowledge and project phases, translating user knowledge into specifications, and validating design choices through timely feedback from users. Table 5 provides an overview of the seven managerial practices.

Practice	Representative quote
Endorsing the value of user knowledge	"Usually, we follow the engineering specs if we have to make something functional, even at the expense of usage. Typically it's the engineering spec we follow since we have to make a safe, functional product. Of course, we try to invent some other great ideas that could benefit both perspectives, but there are these compromises that are really difficult to make." - R&D manager, Company B "Quite often big decisions are made based on what is usable what is not. […] In the feasibility phase there were alternative concepts, and all of those were given in the hands of the users [...]. That, of course, was one of the items affecting the design choice." - Senior R&D manager, Company B
Understanding the users' problems	"It starts with a kind of global picture of the issues or the needs. Then we get information so we can decide on what to do next." - Senior marketing manager, Company B "Before doing requirements, usually we try to find out how the planned system is going to be used, why it is used and what is the end result when using the device—so having already a good understanding before writing the requirements." - User expert, Company B
Enabling continuous access to users	"The information is there but there is never enough of it and it is continuously changing, so the person who was the person to be asked the questions in the clinic three years ago may not be the same person any more. It is another person that you have to ask. It is [the same way] in the clinics in the hospitals. People change, so if you stick to

	"your favourite clinic and hospital, you will be misled." - Senior user expert, Company B "Our challenge is to involve the user systematically, particularly in the development process, at systematic, regular intervals." – Innovation manager, Company A
Selecting suitable user profiles	"Our science representatives are working with big hospitals, where they have researchers as their counterparts. Those linkages are maybe too much, even guiding our choices in what we choose for the product requirements." - R&D manager, Company B "One person is using the device in a different way than another one. They do totally different things with the same device." - User expert, Company B
Matching types of user knowledge and project phases	"At the beginning you will likely be more undirected, unspecific—and at the end, or the farther you go, you can ask more from users." - Innovation manager, Company A "You need to be able to show the [...] users something because most of them are not able to grasp abstract explanations. […] They don't see what we are going to do unless we show them something." - Senior R&D manager, Company B
Translating user knowledge into specifications	"We try to introduce [the user perspective] as additional information into the development process as a recommendation for how to align the product. We tried to actually formulate requirements because that is how the company works." - Innovation manager, Company A "After the user requirements formulation is done, then there is not too much discussion because then it's done. Then you need to go to the next step. But it's a very important step when you do that. We really need to think about all the possibilities. Because if it's not in the user requirements, then the software people are not going to do it." - User expert, Company B
Validating design choices through timely feedback from users	"Between the establishment of requirements and the first evaluation […], we are talking about a timespan of a year. If we develop modules, we talk about a few days, so that is very difficult." - Senior user expert, Company A "I have the feeling we are still lacking a real systematic approach where you would rationalise that this is the right choice, as it fulfils the user needs better than the other choices. [...] It's typical for time pressure that you have to decide quickly and you can't have endless discussions, but still I think there would be room for further checking that you made the correct choices." - Senior R&D manager, Company B

Table 5: Overview of the seven managerial practices

4.1. Endorsing the value of user knowledge

In our case companies, the value of user knowledge was tightly coupled with organisational core values like safety and quality. If increasing the understanding of user knowledge positively influenced product safety and quality, the case companies prioritised user knowledge over other considerations. The companies were, however, less receptive to other kinds of inputs from users. CoPS development processes are long and often the result of numerous compromises. The interviewees mentioned the challenge that engineering specifications may overrule insights based on user knowledge:

> *At least we try to mitigate all the risks, or the potential hazards need to be redesigned such a way that they are not hazards anymore. I think that's the most critical one. Then we try to improve the usage, and sometimes there are compromises between the engineering specs and usage.* – R&D Manager, Company B

Another challenge that CoPS manufacturers face is determining the value of user knowledge, as it is difficult to measure. The practice of endorsing the value of user knowledge was proposed as a solution to ensure that user knowledge is fully utilised. Endorsing the value of user knowledge to the developers and decision-makers involved in the innovation process increases their awareness of the people for whom they develop products, which enhances their ability to make decisions that reflect users' needs consciously throughout the development phases. This understanding of users' needs helps them avoid over-engineered and complex solutions that do not meet users' needs:

> *Sometimes the product is over-engineered. It has too many features. We get that feedback and we also provide that feedback to the design office. Let's say we have an interface providing 150 features, and the users say "I just need*

five. And if I have these five available, then I have no problem with the navigation structure anymore." – User expert, Company A

4.2. Understanding the users' problems

We found that managers require a good understanding of their products' users and their 'real needs' early in the innovation process. Especially before the actual development starts, managers recognised the importance to establish a base of user knowledge that can help them evaluate what ideas and concepts should be developed:

> *If you don't know the problem, then you start innovating only on the technology, and we easily make complex or expensive solutions where there is no real need.* - Senior R&D manager, Company B

Methods such as observation of the users in their natural context, self-documentation toolkits, scenario-building workshops with users, and experiments were mentioned as ways to improve understanding of users' problems, which helps the developers to think about solutions from the users' perspective and helps to sensitise them to the system's overall context of use:

> *The users reflect a picture to our R&D people that they do not know or problems that they do not perceive any more after twenty years in the company. It helps them to get a change of perspective.* - Innovation manager, Company A

4.3. Enabling continuous access to users

Users were considered a source of innovation from which to elicit requirements at the beginning of a new development process and as validators of the final system at the end of the process. However, the interviewees recognised that there is a need for continuous access to the users' perspective in order to avoid undesirable outcomes:

> *Early on you probably had the user on board, but when the development started, then the user vanished out of the development; and at the end, as the development was finished, a user came and said that this is not what we wanted.* - Innovation manager, Company A

The case companies considered keeping the user continuously in mind to be important, especially in the context of long development cycles. Users' needs and requirements can change during a long process, and complex product development requires iterative approaches:

> *The requirements change inevitably during the course of the development. [...] Everything that exceeds a certain degree of complexity will have an iterative development process. This alone requires that one talks with the user during the whole course of the development.* - Senior innovation manager, Company A

Albeit the interviewees recognised this practice, it was not in widespread use in the case companies. This was explained by the organisational complexity of CoPS manufacturers. Even when one entity in the company has the required knowledge from users, that knowledge is not necessarily available to the developers and decision-makers on the 'doing' level. Since developers make design choices constantly, ensuring that they have a firm understanding of the users' requirements enables them to make design choices in favour of the user and to avoid undesirable solutions.

4.4. Selecting suitable user profiles

Another finding refers to the importance of selecting the right user profiles, which helps developers to set priorities and design with the most important groups of users in mind:

> *Typically, you try to get a good spread of users. For instance, if you're targeting radiologists and technologists, you need to ask them both. You make a pre-selection [of users] based on what you think is the most relevant market and the most relevant customer segment [to the product you're designing].* - Senior marketing manager, Company B

It is necessary that designers are aware of all of the user groups that will interact with the system since these groups' needs and expectations may differ:

> *If we are dealing with more complex environments, maybe with the contradictory requirements of different users—it could be that the cabin crew has other requirements than a passenger—then the question is who pays and it's a compromise then.* – User expert, Company A

Focusing on one primary user group may lead to a final system that has features that have little relevance to other user groups or that do not match their capabilities. For example, there is a difference between users who use medical devices primarily for research purposes and who need to be able to adjust parameters and have full access to the devices' settings, and commercial users whose priority is to have safe and efficient patient throughput. While the interviewees stressed the importance of selecting suitable user profiles, practical considerations of accessibility of certain users were often mentioned to influence the choice of the users.

Selecting particular user profiles whose needs drive the development process can be challenging. In a B2B manufacturing context, selecting and involving users is often a matter of their availability and motivation:

> *They would need to be able to see that their involvement in development is productive, whether we pay for them or they see that, by involving them, the next version is definitely better.* – Senior R&D manager, Company B

4.5. Matching types of user knowledge and project phases

CoPS have long development times, ranging from three to twelve years in medical devices and aircraft development. The types of user knowledge were considered to differ depending on the stage of the innovation process. We identified a funnel of information needs, starting from general information about the users, their needs, and expectations and on to specific feedback and users' opinions about the product under development. General information about users' needs is required early in the innovation process in order to derive first, high-level requirements when the project scope is still ambiguous. Therefore, at the beginning of a new development project, user experts are heavily involved in generating the general requirements that are suitable for creating first concepts, and these requirements are then iterated with users to add more detailed information during the development process:

> *When we have a brand-new product, no one actually knows what the requirements should be, so I try to think in terms of very basic-level requirements and then proceed to more and more technical sort of requirements.* - User expert, Company B

Discussions with users in the early phases of a project tend to be on an abstract level in order to obtain input about the main direction of the project based on initial ideas and design concepts related to the whole system. As the project begins to materialise and first prototypes are developed, users' input on specific sub-systems is needed, which often entails more detailed input on designs and product features.

4.6. Translating user knowledge into specifications

User knowledge must be translated into design specifications if the knowledge is to be used in the development process. During this translation process, both case companies prefer to prioritise users' needs according to their importance. The interviewees mentioned that, in the context complex products, it is necessary to translate users' needs into a format that is compatible with other design specifications. If the needs are not translated into requirements, they risk being neglected in favour of engineering specifications:

> *That is always the danger since there are exact requirements for weight, cost and approvability, but for those [user-related] soft factors, these requirements do not exist. Then those soft factors risk being dropped because, in the end, the engineering is measured. Whether the target group or user likes it or not is the next question.* - User expert, Company A

Therefore, diffusing user knowledge throughout the organisation was considered critical in a CoPS environment. Employees who have such knowledge, through either previous experience or contact with users, should be aware of the form in which designers and engineers require information. In order to make the users' insights available in a way that is relevant to and makes sense to the various disciplines at later stages of the process, designers and developers must thoroughly understand the users' needs. Hence, documenting users' needs and making them available to the various disciplines during the development stages was suggested to promote the systematic consideration of user knowledge:

> *When the project starts, it is crucial to make sure that the user requirements make sense so we don't require too much and the developers can make the product. On the other hand, we make testable requirements, which we can later validate and from which the developers can derive system requirements that they can verify.* - Senior user expert, Company B

4.7. Validating design choices through timely feedback from users

According to the interviews, users' feedback is beneficial at multiple phases during the development process. The findings suggest that conducting user evaluations at various design iterations helps decision-makers make informed decisions that include the users' perspective:

> *First, you implement it technically, encounter certain difficulties that require making technical changes, and then ask the user again if that is still attractive or not. Can I abandon one or another functionality because I cannot implement it*? - Senior innovation manager, Company A

While the interviewees mentioned the need for timely feedback for validating design choices, they often struggled with accessing users on such a regular basis. Therefore, this practice was deemed beneficial by the interviewees, but not put entirely into practice.

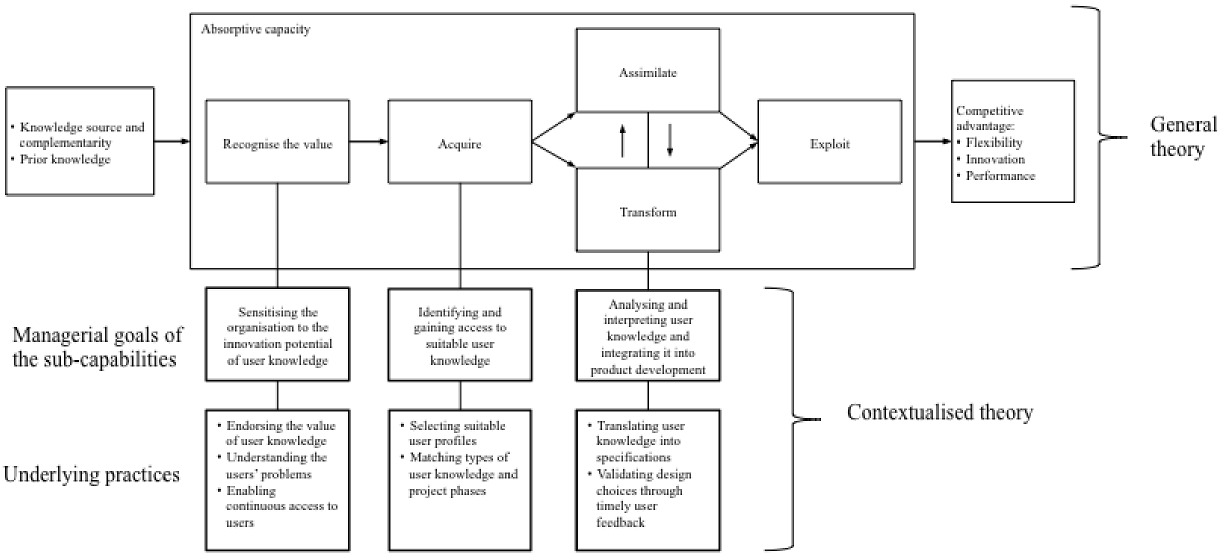
It became evident that in a CoPS development environment the time frame for timely evaluations from users differs between module development and full system evaluation. While module development teams need more frequent validation, the evaluation of a complete product design can be as infrequent as once in a year. Therefore, the frequency with which users are involved for specific concept evaluations depends on the development progress of the overall system and its components. Timely evaluations are considered beneficial when there is something tangible that requires evaluative feedback to provide relevant input for the developers and the next design iteration.

5. Discussion

5.1 Theoretical implications

In this study, we have investigated two B2B companies who utilise user knowledge in their CoPS innovation processes. We identify managerial practices for doing so and use these insights to elaborate the general absorptive capacity theory by contextualising three of its sub-capabilities – recognition of the value, acquisition, and assimilation/transformation – with respect to users and CoPS (Figure 2).

Figure 2: Elaboration of the absorptive capacity theory.



User knowledge is central to developing solutions that are desirable and usable, especially when it comes to highly innovative, technical products (Callahan & Lasry, 2004). We identified seven practices that facilitate user knowledge utilisation in CoPS user innovation. This provides new insights as to how CoPS manufacturing companies can apply an open innovation framework from a user perspective (Gassmann, Enkel, & Chesbrough, 2010). The practices derived from CoPS specific challenges in user innovation reveal the potential for CoPS manufacturing companies to alleviate organisational barriers in adopting an open user innovation framework (cf.

Chesbrough & Crowther, 2006; Katz & Allen, 1982; van de Vrande et al., 2009). We extend the vast literature on B2B companies and open innovation from a technological perspective (Chesbrough, 2003) by identifying and describing capabilities necessary for integrating user needs and external knowledge into the CoPS innovation process (Lichtenthaler, 2011).

The seven practices and respective capabilities highlight the necessity for integrating the user perspective into the innovation process more systematically (Bogers et al., 2010; Ives & Olson, 1984; Kujala, 2003). The CoPS characteristics –long development cycles, parallel projects for parts and sub-system development, engineering-intensiveness– reveal specific challenges for utilising user knowledge inside the firm. Whereas frequent user interaction reduces project uncertainty and has a positive effect on innovation project success (Gales & Cole, 1995), we show that translating the knowledge obtained from those interactions into existing development processes requires developers to have access to and understand the user perspective in their decision-making process. Sensitising employees for the users' perspective enables developers consider both, the technical feasibility as well as the usability of the system under development.

Besides the timing and selection of users is critical in development processes (Gruner & Homburg, 2000), we found that the type of information a company gives to users in order to receive feedback as well as the input needed at certain stages of the development process is substantial for the recognition and consideration of user knowledge at specific development stages. Internal user experts mediate the discrepancy between external need-knowledge and internal solution-knowledge as boundary spanners (Schweisfurth & Herstatt, 2016). However, translating user needs into common engineering-like specifications is required to bring the user perspective to the decision-making and implementing level. Further research could investigate the process of turning tacit user knowledge into explicit information and its effects on the innovation process.

The study also contributes to the absorptive capacity literature by elaborating the general theory in the context of users and CoPS. In theory elaboration, the logic of the general theory is modified by investigating it in a specific empirical context (Ketokivi & Choi, 2014). Here, the general theory of absorptive capacity and its sub-capabilities is adopted and the empirical findings are used to propose what the capabilities could consist of in the context of users and CoPS. The elaboration includes two elements: managerial goals and practices. The relationship between the elaborated elements and the general theory are illustrated in Figure 2. The managerial goals describe the purposes of the capabilities, a defining element of organisational capabilities (Dosi, Nelson, & Winter, 2000). The practices address capability microfoundations (Felin et al., 2012; Lewin et al., 2010; Teece, 2007), and provide understanding on the underlying factors which give rise to capabilities. Previous studies have concluded that the empirical context may influence the ways companies are able to absorb external knowledge (Volberda et al., 2010; Apriliyanti & Alon, 2017). Research which addresses the micro-level antecedents of absorptive capacity is, however, scarce (Easterby-Smith et al., 2008; Martinkenaite & Breunig, 2016; Volberda et al., 2010). The value of proposing managerial goals and practices associated with the capabilities is that they illustrate what the capabilities may really be in terms of their constituent components, which may help in understanding differences between the absorptive capacities between companies (Felin et al., 2012).

5.2 Managerial implications

Our findings suggest that user involvement is valuable for CoPS development but difficult to implement. Before knowledge of user needs and preferences can be integrated in new products, three important hurdles need to be overcome. First, the organisation needs to be sensitised to comprehend the value of users to innovation. Second, practices need to be implemented to find suitable users for the issues at hand. Finally, the users' input must be formatted so that the developers may easily use it and the resulting specifications should be systematically integrated in the development process. If any of these capabilities is missing, the users' contributions are likely to have only modest impacts. In the context of CoPS, development is typically lengthy, highly technology-driven, and includes multiple sub-processes. Therefore, special attention should be paid to choose the right users, determine the right moment to involve them, and ensure that the organisation is receptive to their inputs.

5.3 Limitations

Our study it is subject to certain limitations that should be acknowledged. The study is based on case study research and a qualitative research approach. The two cases were selected using theoretical sampling (Eisenhardt & Graebner, 2007) and are situated in the context of B2B manufacturing with long development cycles and complex products and systems. Many of the difficulties the companies faced were associated with characteristics that are specific to CoPS development. It is likely that, for example, sensitising the organisation to the innovation potential of users would be easier in B2C contexts where product design is more user-centric to start with. Hence, we recommend that future research explores the managerial goals' and practices' relevance to other contexts. A natural extension considering the scope of our analysis would be to study the exploitation capability and the commercialisation of CoPS with strong user involvement (Shaw et al., 1989). Focusing on specific innovation projects would also be beneficial in comparing the findings with the new-product development project phases and project management systems. Another limitation is that all of the proposed practices were not yet fully in use in the case companies at the time of the data collection. They are formulated by combining actual experiences as reported by the interviewees and their views of what they should do to improve their operations. While the interviewees are expert informants, the lack of direct experiences in some instances may reduce the validity of the findings. Furthermore, due to the confidential nature of innovation projects, it was not possible to depict specific examples of projects, in which the practices were applied.

6. Conclusion

To conclude, CoPS manufacturers recognise the importance to value user knowledge, however have issues in utilising user knowledge in practice. Understanding users and their needs is critical for the development of CoPS that are both relevant to and desirable for their customers. However, there is limited understanding how users' knowledge is acquired and integrated into manufacturing companies' innovation processes. One interviewee said, "We try to listen to users, but whether we understand them is the more difficult question." This comment illustrates that although user knowledge is deemed important, the understanding of how to leverage it in practice is in its infancy, as it might be difficult to gain understanding of the tacit needs of the users.

In this study, we investigate the absorptive capacity construct and its sub-capabilities—recognition of the value, acquisition, and assimilation/transformation—which enable the utilisation of user knowledge in the form of beneficial innovation outputs. By examining two manufacturers of CoPS, we identify managerial goals and related practices that reveal how the stages of the absorption process can be implemented. Based on our findings, we argue that both cultural and procedural aspects of the absorption process must be acknowledged when involving users. We also point out that, in the context of CoPS, because of the long development processes, it is critical to involve users continuously throughout the project, rather than only at the beginning and the end. Managers should also pay close attention to the knowledge-acquisition stage since there are many kinds of users, each of whom possesses its own type of knowledge. Both of these aspects should be matched with current project stages accordingly.

References

Abrell, T., 2017. Sources of user knowledge in B2B manufacturing of complex products, online: https://www.alexandria.unisg.ch/250214/ [accessed: 06.04.2017].

Abrell, T., Pihlajamaa, M., Kanto, L., Brocke, vom, J. and Uebernickel, F., 2016. The role of users and customers in digital innovation: Insigths from B2B manufacturing firms. *Information & Management*, 53(3), pp.324–335.

Ackert, S. 2013. Commercial Aspects of Aircraft Customization, online: http://www.aircraftmonitor.com/uploads/1/5/9/9/15993320/commercial_aspects_of_aircraft_customization___v1.pdf [accessed: 21.09.2017].

Alavi, M. and Leidner, D.E., 2001. Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly*, 25(1), pp.107–136.

Apriliyanti, I.D., Alon, I., 2017. Bibliometric Analysis of Absorptive Capacity. *International Business Review*, (in press), doi: 10.1016/j.ibusrev.2017.02.007.

Baldwin, C. and von Hippel, E., 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science*, 22(6), pp.1399–1417.

Baraldi, E., 2009. User-related complexity dimensions of complex products and systems (CoPS): A case of implementing an ERP system. *International Journal of Innovation Management*, 13(01), pp.19–45.

Bianchi, M., Croce, A., Dell'Era, C., Di Benedetto, C.A. and Frattini, F., 2015. Organizing for inbound open innovation: How external consultants and a dedicated R&D unit influence product innovation performance. *Journal of Product Innovation Management*, 33(4), pp.492-510.

Block, J.H., Henkel, J., Schweisfurth, T.G., Stiegler, A., 2016. Commercializing User Innovations by Vertical Diversification: The User-Manufacturer Innovator. *Research policy* 45(1), pp.244–259.

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

Boon, W.P.C., Moors, E.H.M., Kuhlmann, S. and Smits, R.E.H.M., 2011. Demand articulation in emerging technologies: Intermediary user organisations as co-producers? *Research Policy*, 40(2), pp.242–252.

Bosch-Sijtsema, P. and Bosch, J., 2015. User Involvement throughout the Innovation Process in High-Tech Industries. *Journal of Product Innovation Management*, 32(5), pp.793-807.

Callahan, J. and Lasry, E., 2004. The importance of customer input in the development of very new products. *R&D Management*, 34(2), pp.107–120.

Chen, J., Tong, L. and Ngai, E.W., 2007. Inter-organizational knowledge management in complex products and systems: Challenges and an exploratory framework. *Journal of Technology Management in China*, 2(2), pp.134–144.

Cheng, C.C. and Huizingh, E.K., 2014. When is open innovation beneficial? The role of strategic orientation. *Journal of Product Innovation Management*, 31(6), pp.1235–1253.

Chesbrough, H.W., 2003. *Open innovation: The new imperative for creating and profiting from technology*. Boston, Massachusetts: Harvard Business School Publishing Corporation.

Chesbrough, H., & Crowther, A. K., 2006. Beyond high tech: early adopters of open innovation in other industries. *R&D Management,* 36(3), pp.229-236.

Christensen, J.F., Olesen, M.H. and Kjær, J.S., 2005. The industrial dynamics of Open Innovation—Evidence from the transformation of consumer electronics. *Research Policy*, 34(10), pp.1533–1549.

Cohen, W.M. and Levinthal, D.A., 1989. Innovation and learning: the two faces of R & D. *The economic journal*, 99(397), pp.569–596.

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

Coviello, N., 2014. How to Publish Qualitative Entrepreneurship Research in Top Journals. In: A. Fayolle and M. Wright, eds., *How to Get Published in the Best Entrepreneurship Journals: A Guide to Steer Your Academic Career*. Cheltenham: Edward Elgar, pp.167–182.

da Mota Pedrosa, A., 2012. Customer integration during innovation development: An exploratory study in the logistics service industry. *Creativity and Innovation Management*, 21(3), pp.263-276.

Dahlander, L. and Frederiksen, L., 2012. The core and cosmopolitans: A relational view of innovation in user communities. *Organization Science*, 23(4), pp.988–1007.

Dahlander, L. and Gann, D.M., 2010. How open is innovation? *Research Policy*, 39(6), pp.699–709.

Dedehayir, O., Nokelainen, T. and Mäkinen, S.J., 2014. Disruptive innovations in complex product systems industries: A case study. *Journal of Engineering and Technology Management*, 33, pp.174–192.

Di Gangi, P.M., Wasko, M., 2009. Steal My Idea! Organizational Adoption of User Innovations from a User Innovation Community: A Case Study of Dell IdeaStorm. *Decision Support Systems*, 48, pp.303–312.

Dosi, G., Nelson, R.R., Winter, S.G., 2000. Introduction: The Nature and Dynamics of Organizational Capabilities. In *The Nature and Dynamics of Organizational Capabilities*. Oxford University Press, Oxford, pp.1–22.

Du, J., Leten, B. and Vanhaverbeke, W., 2014. Managing open innovation projects with science-based and market-based partners. *Research Policy*, 43(5), pp.828–840.

Dubois, A. and Gadde, L.-E., 2002. Systematic combining: an abductive approach to case research. *Journal of Business Research*, 55, pp.553–560.

Dubois, A. and Gadde, L.-E., 2014. ‘Systematic combining’—A decade later. *Journal of Business Research*, 67(6), pp.1277–1284.

Easterby-Smith, M., Graça, M., Antonacopoulou, E. and Ferdinand, J., 2008. Absorptive capacity: A process perspective. *Management Learning*, 39(5), pp.483–501.

Eisenhardt, K.M. and Graebner, M.E., 2007. Theory Building From Cases: Opportunities and Challenges. *Academy of Management Journal*, 50(1), pp.25–32.

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *Academy of Management review*, 14(4), pp.532–550.

Enkel, E., Gassmann, O. and Chesbrough, H., 2009. Open R&D and open innovation: exploring the phenomenon. *R&D Management*, 39(4), pp.311–316.

Enkel, E., Perez-Freije, J. and Gassmann, O., 2005. Minimizing Market Risks Through Customer Integration in New Product Development: Learning from Bad Practice. *Creativity and Innovation Management*, 14(4), pp.425–437.

Faems, D., Van Looy, B. and Debackere, K., 2005. Interorganizational collaboration and innovation: toward a portfolio approach. *Journal of Product Innovation Management*, 22(3), pp.238–250.

Felin, T., Foss, N.J., Heimeriks, K.H., Madsen, T.L., 2012. Microfoundations of Routines and Capabilities: Individuals, Processes, and Structure. *Journal of Management Studies*, 49, pp.1351–1374.

Flick, U., 2009. *An Introduction to Qualitative Research*. 4 ed. London, Thousand Oaks, New Delhi: Sage Publications.

Forés, B. and Camisón, C., 2016. Does incremental and radical innovation performance depend on different types of knowledge accumulation capabilities and organizational size? *Journal of Business Research*, 69(2), pp.831–848.

Franke, N. and Shah, S., 2003. How communities support innovative activities: an exploration of assistance and sharing among end-users. *Research Policy*, 32(1), pp.157–178.

Gales, L., Mansour-Cole, D., 1995. User Involvement in Innovation Projects: Toward an Information Processing Model. *Journal of Engineering and Technology Management*, 12, pp.77–109.

Gassmann, O., Enkel, E. and Chesbrough, H., 2010. The future of open innovation. *R&D Management*, 40(3), pp.213–221.

Glaser, B.G., 1978. *Theoretical sensitivity: Advances in the methodology of grounded theory*. Mill Valley: Sociology Press.

Glaser, R., 1999. Expert knowledge and process of thinking. In R. McCormick & C. Paechter, eds. *Learning and knowledge*, London: Paul Chapman.

Griffin, A. and Belliveau, P., 1997. *Drivers of NPD success: The 1997 PDMA report*. PDMA.

Griffin, A. and Hauser, J.R., 1993. The voice of the customer. *Marketing science*, 12(1), pp.1–27.

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

Haefliger, S., Jäger, P. and von Krogh, G., 2010. Under the radar: Industry entry by user entrepreneurs. *Research Policy*, 39(9), pp.1198–1213.

Hobday, M. and Rush, H., 1999. Technology management in complex product systems (CoPS) – ten questions answered. *Int. J. Technology Management*, 17(6), pp.618–639.

Hobday, M., 1998. Product complexity, innovation and industrial organisation. *Research Policy*, 26(6), pp.689–710.

Hobday, M., 2000. The project-based organisation: an ideal form for managing complex products and systems? *Research Policy*, 29(7), pp.871–893.

Holt, K., 1988. Market-oriented product innovation at Høyang Polaris and Jøtul. *Technovation*, 8(4), pp.249–254.

Huang, Y., Vir Singh, P. and Srinivasan, K., 2014. Crowdsourcing new product ideas under consumer learning. *Management science*, 60(9), pp.2138–2159.

Hyysalo, S., 2009. User Innovation and Everyday Practices: Micro-Innovation in Sports Industry Development. *R&D Management*, 39, pp.247–258.

Ives, B., Olson, M.H., 1984. User Involvement and MIS Success: A Review of Research. *Management Science*, 30, pp.586–603.

Katz, R., Allen, T.J., 1982. Investigating the Not Invented Here (NIH) Syndrome: A Look at the Performance, Tenure, and Communication Patterns of 50 R & D Project Groups. *R&D Management*, 12, pp.7–20.

Kaulio, M.A., 1998. Customer, consumer and user involvement in product development: A framework and a review of selected methods. *Total Quality Management*, 9(1), pp.141–149.

Kärkkäinen, H., Piippo, P. and Tuominen, M., 2001. Ten tools for customer-driven product development in industrial companies. *International Journal of Production Economics*, 69(2), pp.161–176.

Ketokivi, M., Choi, T., 2014. Renaissance of Case Research as a Scientific Method. *Journal of Operations Management*, 32, pp.232–240.

Khodakarami, F. and Chan, Y.E., 2014. Exploring the role of customer relationship management (CRM) systems in customer knowledge creation. *Information & Management*, 51(1), pp.27–42.

Klein, K. J., & Sorra, J. S., 1996. The challenge of innovation implementation. *Academy of Management review*, 21(4), 1055-1080.

Kristensson, P., Gustafsson, A., & Archer, T., 2004. Harnessing the creative potential among users. *Journal of Product Innovation Management*, 21(1), 4-14.

Kujala, S., 2003. User involvement: A review of the benefits and challenges. *Behaviour & Information Technology*, 22(1), pp.1–16.

Lakemond, N., Bengtsson, L., Laursen, K. and Tell, F., 2016. Match and manage: the use of knowledge matching and project management to integrate knowledge in collaborative inbound open innovation. *Industrial and Corporate Change*, 25(2), pp.333–352.

Lane, P.J., Koka, B.R. and Pathak, S., 2006. The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of Management review*, 31(4), pp.833–863.

Leimeister, J.M., Huber, M., Bretschneider, U. and Krcmar, H., 2009. Leveraging crowdsourcing: activation-supporting components for IT-based ideas competition. *Journal of Management Information Systems*, 26(1), pp.197–224.

Lettl, C., Herstatt, C. and Gemuenden, H.G., 2006. Users' contributions to radical innovation: evidence from four cases in the field of medical equipment technology. *R&D Management*, 36(3), pp.251–272.

Lewin, A.Y., Massini, S., Peeters, C., 2010. Microfoundations of Internal and External Absorptive Capacity Routines. *Organization Science*, 22, pp.81–98.

Liamputtong, P., 2011. *Focus Group Methodology - Principles and Practice*. Thousand Oaks, California: SAGE Publications Inc.

Lichtenthaler, U. and Lichtenthaler, E., 2009. A Capability-Based Framework for Open Innovation: Complementing Absorptive Capacity. *Journal of Management Studies*, 46(8), pp.1315–1338.

Lichtenthaler, U., 2011. Open innovation: Past research, current debates, and future directions. *The Academy of Management Executive*, 25(1), pp.75–93.

Lüthje, C., 2004. Characteristics of innovating users in a consumer goods field: An empirical study of sport-related product consumers. *Technovation*, 24(9), pp.683–695.

Magnusson, P. R., Matthing, J., & Kristensson, P., 2003. Managing user involvement in service innovation: Experiments with innovating end users. *Journal of Service Research*, 6(2), 111-124.

Magnusson, P.R., 2009. Exploring the Contributions of Involving Ordinary Users in Ideation of Technology-Based Services*. *Journal of Product Innovation Management*, 26(5), pp.578–593.

Marchi, G., Giachetti, C. and de Gennaro, P., 2011. Extending lead-user theory to online brand communities: The case of the community Ducati. *Technovation*, 31(8), pp.350–361.

Martinkenaite, I. and Breunig, K.J., 2016. Journal of Business Research. *Journal of Business Research*, 69(2), pp.700–708.

Miles, M.B. and Huberman, A.M., 1994. *Qualitative data analysis: An expanded sourcebook*. 2nd ed. Thousand Oaks: Sage Publications, Inc.

Miller, R., Hobday, M., Leroux-Demers, T. and Olleros, X., 1995. Innovation in complex systems industries: the case of flight simulation. *Industrial and Corporate Change*, 4(2), pp.363–400.

Morgan, D.L., 1997. *Focus Groups as Qualitative Research*. 2nd ed. Thousand Oaks, California: SAGE Publications, Inc.

Morrison, P.D., Roberts, J.H. and Midgley, D.F., 2004. The nature of lead users and measurement of leading edge status. *Research Policy*, 33(2), pp.351–362.

Mowery, D.C. and Rosenberg, N., 1982. The Commercial Aircraft Industry. In: R.R. Nelson, ed., *Government and Technical Progress - A Cross-Industry Analysis*. New York, Oxford, Toronto, Sydney, Paris, Frankfurt: Pergamon Press, pp.101–161.

Ngai, E.W., Jin, C. and Liang, T., 2008. A qualitative study of inter-organizational knowledge management in complex products and systems development. *R&D Management*, 38(4), pp.421–440.

Noblet, J.-P., Simon, E. and Parent, R., 2011. Absorptive capacity: a proposed operationalization. *Knowledge Management Research & Practice*, 9(4), pp.367–377.

Nonaka, I., 1994. A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), pp.14–37.

Ozer, M., 2009. The roles of product lead-users and product experts in new product evaluation. *Research Policy*, 38(8), pp.1340–1349.

Palacios, M., Martinez-Corral, A., Nisar, A. and Grijalvo, M., 2016. Crowdsourcing and organizational forms: Emerging trends and research implications. *Journal of Business Research*, 69(5), pp.1834–1839.

Patton, M.Q., 2014. *Qualitative Research & Evaluation Methods: Integrating Theory and Practice*. Thousand Oaks, CA: SAGE Publications.

Peirce, C. S., 1931. *Collected papers*, edited by Hartshorne, C. & Weiss, P., Cambridge: Harvard University Press.

Poetz, M. K., & Schreier, M., 2012. The value of crowdsourcing: can users really compete with professionals in generating new product ideas?. *Journal of Product Innovation Management*, 29(2), 245-256.

Polanyi, M., 1966. *The Tacit Dimension*. New York: Doubleday & Company, Inc.

Rajala, R., Westerlund, M., Vuori, M. and Hares, J.-P., 2013. From Idea Crowdsourcing to Managing User Knowledge. *Technology Innovation Management Review*, 3(12), pp.23–31.

Randhawa, K., Wilden, R. and Hohberger, J., 2016. A bibliometric review of open innovation: Setting a research agenda. *Journal of Product Innovation Management*, 33(6), pp. 750-772.

Ridder, H.G., Hoon, C. and McCandless Baluch, A., 2014. Entering a dialogue: Positioning case study findings towards theory. *British Journal of Management*, 25(2), pp.373–387.

Rothwell, R. and Gardiner, P., 1985. Invention, innovation, re-innovation and the role of the user: A case study of British hovercraft development. *Technovation*, 3(3), pp.167–186.

Rothwell, R., Freeman, C., Horlsey, A., Jervis, V., Robertson, AB and Townsend, J., 1974. SAPPHO updated-project SAPPHO phase II. *Research Policy*, 3(3), pp.258–291.

Roy, R., Sarkar, M.B., 2015. Knowledge, firm boundaries, and innovation: Mitigating the incumbent's curse during radical technological change. *Strategic Management Journal* 37(5), pp.835–854.

Schemmann, B., Herrmann, A.M., Chappin, M.M. and Heimeriks, G.J., 2016. Crowdsourcing ideas: Involving ordinary users in the ideation phase of new product development. *Research Policy*, 45(6), pp.1145–1154.

Schweisfurth, T.G. and Herstatt, C., 2016. How internal users contribute to corporate product innovation: the case of embedded users. *R&D Management*, 46(51) pp.107–126.

Schweisfurth, T.G. and Raasch, C., 2015. Embedded lead users—The benefits of employing users for corporate innovation. *Research Policy*, 44(1), pp.168–180.

Shah, S.K. and Tripsas, M., 2007. The accidental entrepreneur: the emergent and collective process of user entrepreneurship. *Strategic Entrepreneurship Journal*, 1(1-2), pp.123–140.

Shaw, J., Giglierano, J. and Kallis, J., 1989. Marketing complex technical products: The importance of intangible attributes. *Industrial Marketing Management*, 18(1), pp.45–53.

Sisodiya, S.R., Johnson, J.L. and Grégoire, Y., 2013. Inbound open innovation for enhanced performance: Enablers and opportunities. *Industrial Marketing Management*, 42(5), pp.836–849.

Smith, S.W. and Shah, S.K., 2013. Do Innovative Users Generate More Useful Insights? An Analysis of Corporate Venture Capital Investments in the Medical Device industry. *Strategic Entrepreneurship Journal*, 7(2), pp.151–167.

Stewart, D.W., Shamdasani, P.N. and Rook, D.W., 2007. *Focus Groups - Theory and Practice*. 2nd ed. Thousand Oaks, California: SAGE Publications Inc.

Teece, D.J., 2007. Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance. *Strategic Management Journal*, 28, pp.1319–1350.

Tether, B.S. and Tajar, A., 2008. Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. *Research Policy*, 37(6), pp.1079–1095.

Todorova, G. and Durisin, B., 2007. Absorptive capacity: Valuing a reconceptualization. *Academy of Management review*, 32(3), pp.774–786.

Urban, G.I. and von Hippel, E., 1988. Lead User Analyses for the Development of New Industrial Products. *Management science*, 34(5), pp.569–582.

Van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W. and de Rochemont, M., 2009. Open innovation in SMEs: Trends, motives and management challenges. *Technovation*, 29(6-7), pp.423–437.

Van den Bosch, F.A.J., Van Wijk, R.A.J.L., Volberda, H.W., 2003, Absorptive Capacity: Antecedents, Models and Outcomes. In: *The Blackwell Handbook of Organizational Learning and Knowledge Management*. Blackwell Publishing Ltd, Malden, MA, USA, pp. 278–301.

Volberda, H.W., Foss, N.J. and Lyles, M.A., 2010. Perspective-absorbing the concept of absorptive capacity: how to realize its potential in the organization field. *Organization Science*, 21(4), pp.931–951.

von Hippel, E., 1976. The dominant role of users in the scientific instrument innovation process. *Research Policy*, 5(3), pp.212–239.

von Hippel, E., 1986. Lead Users: A Source of Novel Product Concepts. *Management science*, 32(7), pp.791–805.

von Hippel, E., 1994. ‘Sticky Information’ and the Locus of Problem Solving: Implications for Innovation. *Management science*, 40(4), pp.429–439.

West, J. and Bogers, M., 2014. Leveraging external sources of innovation: a review of research on open innovation. *Journal of Product Innovation Management*, 31(4), pp.814–831.

Wolfe, R.A., Gephart, R.P. and Johnson, T.E., 1993. Computer-facilitated qualitative data analysis: Potential contributions to management research. *Journal of Management*, 19(3), pp.637–660.

Xu, Y., Yeh, C.-H., 2012. An Integrated Approach to Evaluation and Planning of Best

Practices. *Omega*, 40, pp.65–78.

Yin, R.K., 2003. *Case Study Research Design and Methods*. 3rd ed. London: Sage Publications.

Zahra, S.A. and George, G., 2002. Absorptive Capacity: A Review, Reconceptualization, and Extension. *The Academy of Management Review*, 27(2), pp.185–203.

Zwass, V., 2010. Co-creation: Toward a taxonomy and an integrated research perspective. *International Journal of Electronic Commerce*, 15(1), pp.11–48.