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**Sources of user knowledge in
B2B manufacturing of complex products**

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Working Paper

Chair: Prof. Dr. Walter Brenner

Version: 1.0

Date: January 15, 2016

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Abstract

Users in innovation of complex products and services (CoPS) are an emerging field of research that focuses on business-to-business (B2B) customers and their demands but seldom on the individual users of CoPS. This study sheds light on the sources of user knowledge that are relevant to innovation in the CoPS context of B2B manufacturing. A secondary analysis of thirty interviews from three B2B manufacturing companies led to a classification of sources of user knowledge in this context into engineering peers, embedded users, field services, primary users, secondary users, and consumers. By making the sources of user knowledge explicit, this study helps future studies in their research on the role of each kind of user in CoPS innovation.

Introduction

User involvement brings many benefits to product development, such as improved product development performance, improved quality of requirements in respect to their usability and fit with users' needs (Kujala 2003). However, involving users can be a demanding task for developers (ibid). In particular, complex, engineering-intense products and systems (CoPS) (Miller et al. 1995; Hobday 1998) like production plants, ships, aircraft, and medical devices with many interconnected and often customised sub-systems continuously evolve through user feedback (Hobday & Rush 1999). CoPS have large numbers of sub-systems and components, are typically produced in small batches or projects (Miller et al. 1995; Hobday 1998), and are high-cost, capital goods (Hobday & Rush 1999). This class of products differs from mass-produced consumer goods, and the small batches or projects in which CoPS are produced facilitate the direct involvement of users in innovation (Hobday & Rush 1999). The literature on CoPS acknowledges that users are important in CoPS innovation (Hobday 1998; 2000; Hobday & Rush 1999; Chen et al. 2007; Baraldi 2009), but because of the high number of sub-systems and components in CoPS, CoPS innovation is dependent on larger innovation networks in which users are one element (Chen et al. 2007; Ngai et al. 2008; Dedehayir et al. 2014). While users' contribution to innovation is acknowledged, the way the term "user" is used lacks accuracy.

Different users offer different kinds of knowledge to developers and use different aspects of CoPS, and their knowledge can be used for different purposes, so a critical factor in development success is selecting the right users based on which sources of user knowledge the developers need (Kujala & Kauppinen 2004). However, the literature on users in innovation in general and CoPS in particular addresses this issue only partially. One aspect of the literature is the confusion in the terms ‘customer’ and ‘user’, which are often used interchangeably (e.g., Hobday 1998; Kaulio 1998; Veryzer 1998; Witell et al. 2011). Users’ knowledge differs from that of customers, as users use aspects of the product, while customers make the purchasing decisions (Abrell et al. 2016). Abrell et al. (2016) acknowledge this distinction between user knowledge and customer knowledge and that user knowledge is particularly useful in guiding digital innovation.

CoPS have only a relatively few customers and a high amount of customisation, and manufacturers often collaborate closely with customer organisations (Hobday 1998). Customers often rely on complex products to manufacture their own products and deliver their own services to consumers, so they have a strong interest in the outcomes of development projects (Hobday 1998; 2000; Hobday & Rush 1999). However, studies on CoPS mention users like “business users” (Hobday & Rush 1999, p. 621) or “using organisation” (Baraldi 2009, p. 19), and Hobday (1998) reports that users tend to be large organisations that frequently collaborate with others, such as maintenance suppliers. These descriptions fit the definition of a *customer* who purchases the complex product, rather than users who use aspects of the product. In order to shed light on the layered multiuser context that characterises CoPS innovation (Baraldi 2009) and deepen the discussion on the role of users in CoPS innovation, this study seeks to identify the kinds of users of CoPS and the kinds of knowledge they offer to the innovation process. In particular, this study aims to answer the following research question:

What sources of user knowledge are used for innovation in B2B manufacturing of complex products?

This study is organised as follows: first, fundamental theoretical concepts are introduced, followed by the research methodology used to derive the findings. Then

the findings are outlined, followed by the discussion and conclusion, which includes future research opportunities.

Theoretical Background

This study takes place in the CoPS industry, which differs from mass-produced commodity goods in that CoPS are typically produced in projects or small batches and are high-cost, capital goods with a high amount of customisation (Hobday 1998; Hobday & Rush 1999). Innovation in CoPS is described as delivery of a product or system with the functionalities required by the user (Chen et al. 2007). Users' dynamics are also likely to differ from those of users of mass produced commodity goods, as there are fewer users and they are more involved (Hobday 1998). Studies have been conducted on innovative users in consumer goods (Lüthje 2004; Lüthje et al. 2005), the field of medical equipment (Lettl et al. 2006; Hinsch et al. 2014), low-tech B2B environments (Herstatt & von Hippel 1992), library information systems (Morrison et al. 2000), CAD software (Urban & von Hippel 1988), and scientific instruments (Rothwell et al. 1974; von Hippel 1976). While some of these are arguably B2B environments, most of the products developed did not have the complex interdependencies and layered multiuser context that are attributed to CoPS (Hobday & Rush 1999; Baraldi 2009).

Insights concerning the various sources of user knowledge are limited not only in CoPS but also in the wider discourse on users in innovation. The literature on users in innovation is divided into two streams: users as innovators (e.g., Lüthje et al. 2005; Hyysalo 2009; Hinsch et al. 2014) and users who give input to innovation processes (e.g., De Moor et al. 2010; Sandmeier et al. 2010; Bosch-Sijtsema & Bosch 2015). While the traits of innovative users are discussed in the first stream, innovation of complex products is likely to be influenced by the second stream of research because of the products' complexity and the breadth of skills required for new product development (Hobday 1998). However, while the literature outlines types of users, such as intermediate users (Bogers et al. 2010), the sources of user knowledge that exist in CoPS development remain unclear.

Moreover, the terms ‘users’ and ‘customers’ are often used interchangeably (e.g., Kaulio 1998; Veryzer 1998; Gruner & Homburg 2000; Witell et al. 2011) in the CoPS context (Hobday 1998; 2000), where a user is described as “a large organisation with a considerable interest in the outcome of each project” (Hobday 1998, p. 705). However, a distinction must be made between customers and users (Abrell et al. 2016; Abrell & Durstewitz 2016). In this study, the term ‘user’ refers to individuals who use some aspect of and benefit from a B2B manufacturer’s CoPS (von Hippel 2005; Baldwin & von Hippel 2011), while the term ‘customer’ refers to an organisation that purchases the product, rather than in directly using it (Abrell et al. 2016). Table 1 provides an overview of the definitions of ‘user’ used in literature.

Study	Description
Baldwin & von Hippel 2011	Firms or individual consumers who expect to benefit from using a product or service
Hobday 1998	a large organisation with a considerable interest in the outcome of a project
Hobday 2000	user as owner-operator
Dedehayir et al. 2014	user as purchaser of a CoPS
Bogers et al. 2010	Firms as intermediary users
Magnusson 2003	Those who use the product

Table 1: Descriptions of users in the B2B context

In CoPS, particularly B2B manufacturing of complex products, various users interact with the complex product in one way or another. While Hobday (1998) describes the customer organisation as a user, there is no attempt to categorise users, although doing so is necessary in order to advance the discussion of user involvement in B2B manufacturing of CoPS.

Methodology

A secondary analysis of data was conducted for the study that takes into account research conducted over the course of two years. Secondary analysis is an investigation strategy that uses data that already exists (Heaton 2004) to answer new or extended questions (Thome 1998). The present study draws on a combination of amplified and supplementary secondary analyses (Heaton 2004). It was possible to identify two data sets to serve as the empirical foundation of the present study (amplified secondary analysis). In the previous studies based on these data sets, the investigation of users in B2B manufacturing was only partly addressed, and it became apparent that the various kinds of users in B2B manufacturing warranted

further research, as the roles of users and customers differed in this context (supplementary secondary analysis).

Following Heaton (2008), the study reuses existing qualitative data to investigate new questions. However, in line with studies that reflect upon secondary analysis (Szabo & Strang 1997; Mauthner et al. 1998), the data set for this study is limited to data that the author has personally collected. This 'personal' secondary analysis ensures that the researcher knows how the data was collected (Heaton 2004). In sorting the data, the author focused on transcribed interviews, which are particularly suitable for secondary analysis (Heaton 2004), and omitted data that other researchers had collected. The data was re-coded from scratch, as has been suggested for amplified analysis (Heaton 2004).

This study uses thirty interviews from two data sets. All case companies are large B2B manufacturing companies of CoPS that are based in Finland or Germany, that have long development cycles, and that involve users in their innovation projects. The interviewees were managers concerned with innovation in the companies, R&D managers, innovation managers, marketing managers, and IT managers. User experts who were responsible for incorporating the user's perspective into innovation were also included. Table 2 provides an overview of the data used for this study. The interviews were analysed using NVivo, which helped in the coding process and in structuring the data (Richards 1999). Using NVivo supported a systematic approach to the analysis that reduced coding errors and increased validity and rigor (Wolfe et al. 1993).

	Data Set A		Data Set B
<i>Year of Data Collection</i>	2014		2015
<i>Company</i>	Company 1	Company 2	Company 3
<i>Location of the unit interviewed</i>	Germany	Finland	Germany
<i>Industry</i>	Aircraft manufacturing	Medical device manufacturing	Plant and component technologies
<i>Products</i>	Aircraft	Magnetic Resonance Imaging Devices	Manufacturing plants, ships, car components
<i>Number of Interviews</i>	10	11	9
<i>Interviewees</i>	Innovation Manager (2), Senior Innovation Manager (4), R&D Manager, User Expert (2), Senior User Expert	R&D Manager (3), Senior R&D Manager (2), Marketing Manager, Senior Marketing Manager, User Expert (3), Senior User Expert	R&D Manager (3), Innovation Manager (2), IT Managers (4)

Table 2: Overview of the data sets

The analysis used emergent coding of the interviews. Each interview was coded with codes for “types of users”, “user contact”, and “customers” in order to get an overview of the interviewees’ understanding of users and customers and their accessibility to R&D engineers, which is important for direct involvement. While “types of users” and “customers” were used to mark specific users and customers mentioned in the interviews, “user contact” was used to highlight emergent findings concerning the use of users’ knowledge.

The outcomes of the coding were transferred to sticky notes, many of which had specific users on them. For example, “cabin crew” and “passengers” or “operators” were clustered according to the organisation to which they belonged. This first categorisation distinguished users within the manufacturer organisation, within the customer organisation, and consumers. In the next step, the granularity of the categorisation was improved by identifying similarities among users based on their tasks in relation to the CoPS. In this step the focus was altered from users to “sources of user knowledge”, as it became apparent that engineering peers and human-factors specialists were used as sources for user knowledge, although they are not users as such. Next, the concrete examples were abstracted, and the dimensions “user knowledge sought” and “accessibility for R&D engineers” were

added using the findings from the “user contact” code. In the following section, each source of user knowledge is introduced, and the findings are summarised in Table 3.

Findings

General findings: Users, customers, and consumers in CoPS

In CoPS many users use aspects of the product or system collaboratively. While all are users with their own perspectives, the CoPS is the object that brings them together. One interviewee reported on users of complex medical devices:

I think we have many users: We have the actual operator who operates the device—in the USA they typically call them technicians, but they might also be called nurses—and then, of course, one user is the doctor, and different kinds of medical doctors can be recognised there. Hospital physicists might also be users, and service engineers might be users. – R&D Manager, Company 2

In line with the definition of users provided for the purposes of the present study, the interviewees distinguished between ‘customers’ and ‘users’, and ‘customers’ also included potential customers:

A user is the person who uses the equipment itself, who will read the instructions for use, who will receive training. The customer is the buyer, the one who pays the bill, who will expect to see the clinical benefit out of it. – Senior User Expert, Company 2

Users and customers are closely connected, and a B2B customer is often between the manufacturer and the consumers. Both perspectives need to be taken into account for CoPS innovation, as the customer’s success has an impact on the manufacturer:

We innovate new products for our customers, but they use them inside their products, which are in turn used by the end user. That means, on one hand, we need to innovate according to the specifications of our customers, such as automotive OEMs. On the other hand, we need to anticipate which end user trends exist, how the end user will use the product, and how much he will like the product. – Innovation Manager, Company 3

Table 3 provides an overview of the sources of user knowledge.

Organisation	Manufacturer				Customer			Consumers
	Engineering Peers	Embedded Users	Field Services	Primary users	Secondary users			
<i>Aircraft manufacturing</i>	R&D managers	Human factors specialists	Maintenance engineers	Cabin crew, cleaners, maintenance workers Pilots	Airlines, leasing companies		Passengers	
<i>Medical device manufacturing</i>	R&D managers	User representatives, trainers	Maintenance engineers	Nurses, maintenance workers Operators, doctors	Hospitals		Patients	
<i>Plant and component technologies</i>	R&D managers	Test crews	Maintenance engineers	Workers in a factory, ship crews Operators	Governments		-	
<i>Task</i>	develop complex products	give user feedback to engineering	provide services to customers	operate aspects of the complex product	gain economic benefit from the product		consume the product or service	
<i>User knowledge sought</i>	Peer feedback	Users' and R&D's perspective	Users' knowledge about competitors and issues in operations	Knowledge about aspects of operation	Knowledge about administration and commercial viability, knowledge about operational trends and competitors		Knowledge about aspects of operation, commercial desirability of B2B customers' offering	
<i>Accessibility for R&D engineers</i>	very high	high	medium	very low	low		very low	

Table 3: Sources of user knowledge of complex products and systems from the manufacturer's point of view

Manufacturer Organisation

Inside the manufacturer are three groups that are particularly important sources of user knowledge: engineering peers, embedded users, and field services.

Engineering Peers

Engineering peers, such as R&D managers, have the task of developing the CoPS, and R&D engineers often ask these peers to provide feedback. The peers' perspective is taken into account either exclusively or combined with the perspectives of users, such as embedded users:

In the earliest phase, when we build the first prototypes, we usually give them to our product applications people so they can test them, and we typically get the first feedback from them. [...] Then we try to get their feedback into the design. In the development phase we try to use [the product] in the engineering department widely as well and give it to other mechanical designers or other electrical designers to see how they use it, which is a different view. – R&D Manager, Company 2

User knowledge is typically an opinion of how users might use the product. Engineers' accessibility to other R&D managers is high, as they are direct peers.

Embedded Users

The organisations interviewed employed embedded users like human-factors specialists, user representatives, test crews, and trainers—users who have the task of contributing to CoPS development, testing products, or training users before delivery of the CoPS:

The quickest way to get immediate feedback is from our own shipyards crews. We have crews who do the tests and trials with the ships before they are delivered to the customers. Of course, they give us direct feedback. – R&D Manager, Company 3

One particularly valuable point of view is that these embedded users are looking at the complete use situation:

We are not looking at systems that are broken down into chapters but into the operation of the user's entire environment. – User Expert, Company 1

These embedded users have a user background, although their knowledge as users might change over time because of their continuous involvement in R&D projects:

When you are in a hospital, you are the customer, and when you are working in the company, the hospital's people are your customers, so that is completely different. [...] In a hospital we are taking care of the patients; in a company we are taking care of the patients and the customer. – User Expert, Company 2

I no longer see myself as a normal hospital user because I'm not—I have too much information—but I do understand very well how they are doing because we are visiting hospitals, and we know what is hospital work. What are sick people's demands? It hasn't changed. I see still that the hospital is busy and that the people are sick. – User Expert, Company 2

The embedded users have a user's knowledge but also a developer's viewpoint. Engineers' accessibility to these embedded users, particularly when they are employed to give user feedback, is typically high.

Field services

Field services, such as maintenance engineers, who have the task of providing maintenance services to customers, are also important sources of user knowledge:

We also learn a lot from field service engineers. The people on the ground who are either servicing or supporting—those are the people who know the most.— Marketing Manager, Company 2

User knowledge from field services refers primarily to issues in operations that occur often, as well as to competitors' products that might be in operation. However, as manufacturing organisations are large, the link to development teams is not always established, so engineers' accessibility to field services is not always a given:

Customer services, who take care of the customers, are relatively far away from engineering, where we are located. I would say that we have room for improvement there. – Senior User Expert, Company 1

Customer Organisation

Within the customer organisation are two main user groups: primary users and secondary users. Primary users are directly involved in operating or using parts of the CoPS, while secondary users gain economic benefits from the use of the product:

The end user is the one using the device. In some cases, it's a doctor or a physicist or in some hospital it's the nurses that are using the actual device. Of course, even if doctors don't use the device, they are still the users because they're using some part of the information. And, of course, there are other kind of secondary end users: the IT administration at the hospitals and whatever maintenance they have at the hospital. – Senior R&D Manager, Company 2

Primary users

Primary users operate aspects of the complex product. In this group are highly skilled professionals like pilots, doctors, and operators, and staff like cabin crew, cleaners, maintenance, factory workers, nurses, and ship crews. The differentiating factor within this group may lie in the amount of formal training and responsibility for operating the CoPS. Both groups are often in close collaboration, as in the example of device operators and medical doctors who are making a diagnosis:

The operator is someone who is physically most exposed to the device, but I also consider the physician as a user. He or she is the one who is getting the end product, which is helping the analysis or treatment. – Senior R&D Manager, Company 2

The task of primary users is to operate some part of the CoPS to produce another product or deliver a service. R&D engineers' accessibility to primary users is typically low, as these users provide value-adding activities in the customer organisation and are not readily available to engineers:

The doctors and the end users are usually doing something productive, and we need to get their involvement in order to get them to give us feedback. They need to be able to see that their involvement is productive, whether we pay for them for it or they see that, the next version is definitely better because of their involvement. But we are not there. – Senior R&D Manager, Company 2

Secondary users

Secondary users are those who gain an economic benefit from the product. They are often referred to as the customer and can be governments, airlines, leasing companies, producers, and others. They can be actual or potential customers and often involve multiple professions:

Before the actual purchase takes place, we receive customers here and we visit customer sites together with prospects. Customers who are considering buying the products [...], the buyers, are the people who make the final [purchasing] decisions, [while those who make] clinical decisions and the operators are users. It's very rare that customers trust their own judgement; they want the users, the operators, to be involved and have their say. – Senior User Expert, Company 2

Customers rarely decide on their own; instead, the viewpoints of all users are taken into account:

The customer of the cabin [we manufacture] is the airline, so they are always a user. On the next level are two main segments, the passengers and then the cabin crew, who need to work with the equipment on board. We have to consider all three users in one way or the other. – Innovation Manager, Company 1

Nevertheless, secondary users are often perceived to focus on certain aspects of the CoPS, such as cost:

Airlines are big organisations. The people who are buying the aircraft look at the cost figures, which is reasonable in that competitive environment. And they look at how they can best sell to the passenger. But they sometimes neglect the needs of the cabin crew a bit. – User Expert, Company 1

Secondary users can provide knowledge about administration and commercial viability, operational trends, and competitor information, as the customer may also operate complex products from competitors. R&D engineers' accessibility to secondary users is low; although secondary users have established links to the manufacturer, they are often to marketing and sales departments, rather than R&D engineers.

Consumers

In business-to-business-to-consumer (B2B2C) markets, consumers consume the products manufactured by the B2B customer use parts of the complex product, or use a service delivered by using complex products. Examples are airline passengers, drivers, and hospital patients. These users may judge the service of the B2B customer based on aspects of the complex product that is close to them, such as the cabin of an aircraft, or a medical device. Knowledge about these end users might enable B2B manufacturers to design solutions for their customers proactively:

The idea was that our passenger expertise enables us to speak with our customers as equals. But now I would say that we probably know more about the passengers than the airlines do. – Innovation Manager, Company 1

Although some departments may have involved consumers, R&D engineers had challenges involving these users, so engineers' accessibility to consumers is low. As consumers in B2B2C markets pay the customers of the CoPS, these user groups may not be taken equally into account:

When we are dealing with more complex environments, we may see contradictory requirements of different users, as it could be that the cabin crew has other requirements than a passenger has. Then the question is who pays, and it's a compromise then. – User Expert, Company 1

Consumers have knowledge about aspects of operation, as well as the commercial desirability of the B2B customers' offering. R&D engineers' accessibility to these consumers is typically low, as these users are not necessarily part of the organisation or the customer's organisation, so they are difficult to find and approach.

Discussion and Conclusion

Building on Baraldi (2009), who describes the CoPS environment as a layered multiuser context, this study sheds light on another dimension of complexity within the CoPS environment: the various users and sources of user knowledge. As user involvement is central to the development of CoPS (Hobday 1998; 2000), and the goal of CoPS innovation is to deliver the product or system with the functionalities that the user requires (Chen et al. 2007), understand which sources of user

knowledge exist in this context is important. To date, users have been discussed in CoPS as part of knowledge networks (Chen et al. 2007; Ngai et al. 2008; Dedehayir et al. 2014) and have been described as large organisations themselves (Hobday 1998; 2000). The present research argues that users are individuals and that customer organisations encompass both primary and secondary users, where primary users are those who operate aspects of a complex product, such as pilots of an aircraft, and secondary users are those that gain an economic benefit from using the product, such as an airline. Different users offer different insights about the use of parts of a complex product. These perspectives are sometimes treated in isolation, but often the combination of involving different users' knowledge yields potential for innovation. Therefore, this research contributes to the literature on CoPS innovation by identifying the various sources of user knowledge, thereby facilitating more differentiated future research on the role of users in CoPS innovation.

Accessibility is a central theme in the effort to make use of the different sources of user knowledge, but each user group may be differently accessible to manufacturers and R&D engineers. Since access to users is a central problem for R&D engineers in manufacturer organisations, the most accessible users are usually those who are taken most into consideration. The manufacturers interviewed for this research reacted to this issue by employing embedded users as a source of user knowledge, an approach that was introduced in recent research in the context of sporting equipment (Schweisfurth & Herstatt 2015; 2016; Schweisfurth & Raasch 2015). However, unlike the CoPS context, these studies report on embedded users as employees who also use these products, such as mountain bikes, in their leisure time, so they offer user knowledge while also drawing on their knowledge of corporate structures (Schweisfurth & Raasch 2015). While the argument that embedded users draw on corporate and user knowledge structures also holds in the CoPS context, the embedded users of CoPS must be hired specifically for their user knowledge. Embedded users have a central role in offering user knowledge to R&D engineers of CoPS, as other channels, such as field services, primary and secondary users inside a customer organisation, and consumers, are largely inaccessible.

Future research is warranted on the role of sources of user knowledge. The sources of user knowledge outlined here could be further researched in terms of their task

complexity, levels of training, motivation to participate in innovation projects, and the methods used to involve them, leading to a taxonomy of users in B2B manufacturing of CoPS. While the present research sheds light on the complexity around the sources of user knowledge in CoPS innovation, a promising research avenue concerns the kinds of user knowledge that can be obtained from the various user groups and how developers in manufacturing companies can use this knowledge.

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