ICED13
INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED13
19-22 AUGUST 2013, SUNGKYUNKWAN UNIVERSITY, SEOUL, KOREA

INTERPLAY BETWEEN OFFERING, PROVIDER AND CUSTOMER IN PRODUCT-SERVICE SYSTEMS DESIGN

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ABSTRACT

Customer value creation is pivotal for a company in order to be able to create value for their shareholders. Product-service systems (PSS) offer new ways for creating added value in comparison to selling traditional products with added services. The goal in this article is to study a product-service system design project and identify different interactions in the three dimensions of product-service systems – the offering, the provider, and the user/customer. Being able to identify interactions between the design elements in the three PSS dimensions would advance our understanding about PSS development in general and facilitate designing higher-value product-service systems. The research utilizes first-hand data of an availability-oriented reverse vending machine design project undergone in the research group during 2011-2012. The research resulted in identifying concrete interactions with potentially complex dynamics between the elements from the three dimensions. The interactions between the dimensions play an important role in PSS development, they may provide interesting openings for value creation, and they definitely deserve more attention and further research in the domain.

Keywords: product-service systems, design engineering, value

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1 INTRODUCTION

Consider a service that creates value through use for both, its users and the provider of the service. If providing the service requires the use of an *instrument*, a physical system, the ability to create value *for both parties* is restricted by any downtime of that instrument.

Reverse vending machines (RVM) are such instruments, providing automated recycling services in *deposit-refund* recycling schemes used in many countries. Efforts to decrease the downtime, or inversely, increase the availability of these machines can then directly contribute to creating higher value for both, the users and the providers of the service.

For a company to succeed in the long run, it must create value to its customers (Khalifa 2004, Higgins 1998, Kordupleski, Laitamaki 1997, Milgrom, Roberts 1995, Porter 1996, Woodruff 1997, Wyner 1996). Value can be created for also other stakeholders in the value network, but creating customer value is the source of the ability to create also other values (Khalifa 2004, Treacy, Wiersema 1995, Hammer 1996, Heskett et al. 2008, Lemon et al. 2001). Therefore, the offering of a company should be optimized based on the value created for, primarily, the customer.

However, in a value network consisting of a collection of companies that create value for the customer, the participating companies act based on the incentive systems they have built into their business models. Although being able to create value for the customer allows each company to create value for its shareholders, the internal incentive system of a company might not in fact be aimed to maximize the customer value.

In this article, we examine a design project, where the goal was to increase the availability of a reverse vending machine and the quality of the recycling service through not only technical improvements, but also modifying the logic of business model of the RVM provider. In practice, this goal resulted in moving from selling products and added services to designing an integrated *product-service system* (PSS).

Product-service systems are integrated product and service offerings that deliver value in use to the customer (Baines et al. 2007). By utilizing the three dimensions of product-service systems defined by Sakao *et al.* (Sakao et al. 2009b) – that is, *the offering, the provider, and the user/customer* – the goal in this article is to advance the understanding of the ways moving from products to product-service systems may affect the design of the offering, the provider and its organization, and the user or customer, the use of the system, and the added customer value. Thus, the research question addressed in this article is:

"How do the three dimensions of product-service systems – the offering, the provider, and the user/customer – interact and affect each other in PSS design?"

Moving towards product-service systems approaches has been shown to have potential for positive economic and environmental impacts (Sakao et al. 2009b, Pawar et al. 2009). In order to create higher-value, truly *integrated* product-service systems, instead of merely selling existing products with an added service, it is important to understand the interactions inside the offering, between the offering, the provider, and its business model, and the between the offering, the provider and the user/customer. Advancing the understanding of the implications that the shift from products to product-service systems may bring can facilitate designing higher value and more sustainable offerings for the increasingly competed global markets.

1.1 Contribution

Despite the rather short history of product-service systems research, significant efforts have been made in the PSS design methodology domain as well as practical case studies of realized product-service systems. However, more research is still welcome on the practical implications of moving from the more traditional, product-centric approaches towards product-service systems, and the effects that this shift induces to specific elements such as the physical system design and customer value. For its part, this article aims to advance filling this gap by presenting findings from a concrete PSS design case study.

2 BACKGROUND

This section provides relevant theoretical background related to the research question, and briefly introduces reverse vending machines and their use.

2.1 Product-service systems

Product-service systems (PSS) are integrated offerings of products and services that deliver value in use to the customer (Baines et al. 2007). The distinctive difference of product-service systems to traditional product sales is that the design of the product, the service, the delivery, and the system lifecycle can be designed in an integrative manner and e.g. optimized according to given criteria. Therefore, product-service system allow optimizing the value network to collaborate more effectively in maximizing the value created, instead of local optimization of the activities of each player in the network. Product-service systems mark a shift away from discrete optimization of resources and toward utility-based system resource optimization (Manzini, Vezzoli 2002).

Meier *et al.* (Meier et al. 2010) have identified three main motivations for the use of product-service systems; namely *ecological, technical, and economical* motivations. The ecological motivations refer to possibilities of reducing resource consumption with the increased efficiency introduced by the use of product-service systems. The technical motivations means that focusing on the integrated design of the product and the related service enables innovating on a new level and delivering superior value to the customer. The economical motivation is realized through higher profits due to delivery of services. In addition to these, another main economic benefit of product-service systems *for the supplier* is increased revenues and higher effectiveness due to possibility to *transfer the risks* (both, *risk of failure* and *market risk* (Meier, Bosslau 2012)) from the customer to the supplier. This is a beneficial possibility from the perspectives of both, the customer and the supplier, for two reasons. Firstly, the supplier has more means to tackle the risk-related issues already beginning from the design phases, where the whole system is defined. Secondly, also the customer naturally benefits from reduced risks, is likely to be willing to pay for it as long as the potential risks have possible financial consequences.

One way to characterize different kinds of product-service systems is to classify them into three distinct groups; *function-oriented, availability-oriented,* and *result-oriented product service systems* (Tucker, Tischner 2005). The function-oriented PSS guarantees functionality of a system over a certain period of time for instance by providing maintenance services. The availability-oriented PSS guarantees also the availability and usability of e.g. production capacity and thus larger responsibilities and risks are transferred to the supplier. In the result-oriented PSS, the customer pays only for the agreed upon number of flawless results (e.g. produced items), thus transferring the risks nearly completely to the supplier. Hence, the distribution of risks and responsibilities between the supplier and the customer is the main variable changing in this classification of product-service systems. Further, developing a business model closer to the result-oriented PSS imposes growing technical, organizational, qualification, and financial demands for the company (Meier et al. 2010) .

This article utilizes the three dimensions of product-service systems defined by Sakao *et al.* (Sakao et al. 2009b). As briefly presented in the in section 1, the dimensions are *the offering, the provider, and the user/customer*. As Sakao *et al.* state, the three dimensions are crucial for PSS development. They allow analyzing the system from also other perspectives than the product and the service – i.e. the offering – alone, and facilitate mapping the interactions between the dimensions in the design phase. Further, including the user/customer in the analysis allows examining the value created to the user with the designed product-service system.

2.2 Customer value

Creating value for the customer is the lifeblood of every company. Creating superior customer value can give competitive advantage in the market and result in being able to create value also to the shareholders of the company. Customer value is a complex concept; an offering that *creates value* should conform to some *values* of a customer, but the *values* per se are inherently abstract and complex (Zeithaml 1988).

In this article, we use the conceptual definition of value from Zeithaml, according to which value is the *utility* of an offering based on perceptions of the related benefits and sacrifices – what is received and what is given. That is, the definition provides two ways of increasing customer value – increasing benefits or decreasing sacrifices related to the offering or its consumption. The sacrifices can naturally be either monetary (such as price of an offering) or non-monetary (such as time spent searching for an offering). In addition, Zeithaml's definition guides to consider two ways to affect the benefits and sacrifices; affecting the benefits/sacrifices themselves, or the *perceptions* the customer has about them. (Zeithaml 1988)

Smith & Colgate (Smith, Colgate 2007) define a more elaborate framework for customer value creation. According to the authors, the framework is especially designed to "*assist in efforts to create customer value*". Briefly put, the framework divides value in four different *types*, while also describing five different generic *sources* of value. This can be illustrated as a tabular framework, shown in Table 1. The framework is rather intuitive and practice-oriented; the authors propose applying it in describing marketing strategies, improving product concepts, identifying value creation opportunities, and developing customer value metrics (Smith, Colgate 2007).

Table 1 Customer value framework by Smith & Colgate (Smith & Colgate, 2007)

Sources of value	Types of value: A. Functional/ Instrumental	B. Experiental/ Hedonic	C. Symbolic/ Expressive	D. Cost/ Sacrifice
1. Information	1/A	1/B	1/C	1/D
2. Products	2/A	2/B	2/C	2/D
3. Interactions	3/A	3/B	3/C	3/D
4. Environment	4/A	4/B	4/C	4/D
5. Ownership	5/A	5/B	5/C	5/D

Due to the inherent service-orientation in product-service systems, a PSS is not merely sold to the customer at one point in time; it often allows creating value throughout the life cycle of the system. For this reason, design of product-service systems is an especially interesting research field for value-related design research.

Several works have also studied value creation in the context of product-service systems. For instance Hara *et al.* (Hara et al. 2007) emphasize the importance of transparently integrated service and product design to create optimal value; Kowalkowski & Kindström (Kowalkowski, Kindström 2009) propose a strategy for communicating the value of a product-service system offering; and Sakao & Lindahl (Sakao, Lindahl 2012) present a value-based evaluation method linked to a PSS design method, proposed in an earlier work (Sakao et al. 2009a).

2.3 Reverse vending machines

Reverse vending machines (RVM) are devices that are designed to facilitate returning and recycling different artifacts. They accept recyclable items and reward the user based on the amount of items accepted for recycling. Most often the term reverse vending machine refers to the recycling of empty beverage containers, mainly plastic and glass bottles and aluminum cans, but RVMs have been developed also for batteries, light bulbs, and e.g. used cellphones (Tanskanen, Takala 2003).

RVMs accept recyclable items and reward the user based on the amount of items accepted for recycling. *Deposit-refund systems* are among the best incentives for consumers to recycle solid waste (Calcott, Walls 2005), and reverse vending machines are the main enablers of a deposit-refund system. RVMs are used in many European countries and also e.g. in some states in the USA, and they are often located in grocery stores or recycling centers. Due to the legislation promoting recycling, RVMs are practically a necessity for any grocery store for instance in Finland. Accepting and recycling the empty containers is a service provided by the grocery store to its customers and a providing a high-quality service enables attracting more customers to the store.

The RVMs operate in demanding conditions, and according to the service provider and personnel interviews made for the design project, reliability of the RVMs is considered a problem. Downtime and unavailability of the systems cause direct and indirect losses of earnings for the service provider.

The research was done in Finland, a country with one of the highest rate of recycled containers in the world; the recycle rate for refillable glass bottles is ca. 100%, for aluminum cans 96%, and for PET bottles 94% (Palpa 2012). Due to the high recycling rates of beverage containers and resulting demanding operational environment for RVMs, Finland provides an interesting ground for research related to reverse vending machines.

2.4 Research methodology

The research presented in this article consists of findings from a case study of a concrete product-service system design project conducted in the research group during 2011-2012. The outcome of the design project was a full-scale proof-of-concept prototype of an availability- and maintainability-oriented reverse vending machine. In addition to the system design, the project consisted of designing a preliminary business model for the availability-oriented reverse vending machine. The goal in the design project was to solve an *improvement problem* (Simon 1981, van Aken 2004) whereas the research presented in this article utilizes the material gathered during this solving process to analyze the impacts of PSS business model to the system design and vice versa. The data analyzed was mostly qualitative data from the design team concerning the design process and the intermediate results. More specifically, the data included customer and user interview transcripts and recordings, requirements, design notes, intermediate design concepts, preliminary embodiment designs, CAD models, business model sketches and spreadsheets, etc.

3 REVERSE VENDING MACHINE DESIGN PROJECT

This section presents an overview of the reverse vending machine design project. Details about the technical solutions are omitted from this article; they will be published separately in a more extensive case study after the potential IPR protection efforts.

The goal in the design project was to increase the customer value through decreasing the downtime of the RVMs; in the pre-design customer and user interviews, the unreliability of the otherwise high-end mechatronic machines proved to be the most significant element causing dissatisfaction and frustration. In practice, during the system operation the mechanics of the systems often failed or needed maintenance. Further analysis showed that the business models of the current RVM providers in fact did not include incentives for the providers to improve the quality of the mechanics. Maintenance seemed to be a major income source for the RVM providers, which naturally resulted in *negative incentives* for improving the availability of the systems; in case the systems would not demand regular maintenance attention, the substantial maintenance contracts would not be justified.

Despite the demanding usage environment of RVMs, mechanically the system remains relatively simple; the mechanics include mostly a selection of conveyors and manipulators, technologies used in an extremely wide array of industries. Therefore, the underlying conclusion in the design project was that the business model and the incentives embedded in the earnings logic of the RVM provider have to be redefined. The solution chosen in the design process was to design the RVM and the related services in an integrated manner in order to be able to increase the customer value created – i.e. to design a product-service system.

The design of the physical machine prototype, illustrated in Figure 1, targeted maximizing the availability of the system through increasing maintainability; the ease of maintenance and cleaning, and the ergonomics and usability for the machine operators. The justification for this effort is based on a continuous improvement practice called *total productive maintenance* (TPM). TPM aims to improve the availability and thus productivity of a system by replacing *reactive maintenance* with *preventive, planned maintenance* and *autonomous maintenance*. Simpler maintenance task are allocated for system operators, freeing the more skilled, higher-paid technicians to concentrate on the more demanding maintenance tasks. The simpler maintenance tasks include e.g. routine cleaning and inspecting of the system and its deterioration. The goal of the methodology is *zero defects*, and there are several e.g. procedural means to increase the availability. (Borris 2006)

In a traditional combination of a product and a service, the customer buys the machine with a non-recurrent payment and, in case he/she chooses, the maintenance service with e.g. a monthly payment. Here, the system is designed as an *availability-oriented product-service system* (Tucker, Tischner 2005), where the distinction between the machine and the added service is not made on the offering level, and instead of buying the machine and added services, *the customer pays for the availability of the system*. The ownership of the machine is not transferred to the customer in this case. Thus, the provider bears the risk of potential unavailability and the amount of maintenance work needed. Although the provider must in this case increase its share of the risks involved, the provider is also the one who has means to affect the reliability of the systems through its design and improvement efforts. Thus the business model imposes an incentive for the provider to continuously improve the design. Further, in case the provider bears the costs of unscheduled maintenance, it provides an avenue for it to save money through minimizing the need for maintenance in the design.

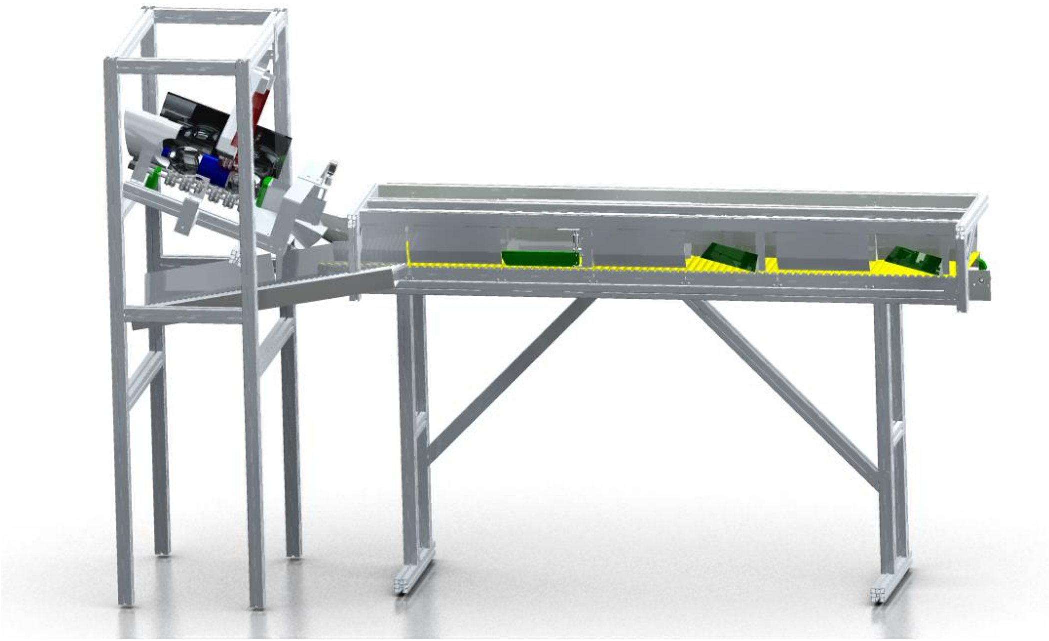

Figure 1. A simplified illustration of the first proof-of-concept prototype built in the design project

4 RESULTS

The RVM design project resulted in a thorough understanding about the domain and its peculiarities as well as plenty of data about the design process itself. The goal in this section is to present the findings from the case study; specifically, the implications caused by the shift from product-centered approach to integrated product-service systems to the three dimensions of product-service systems, i.e.

a) the offering,
b) the provider,
c) the user/customer.

In general, the following sub-sections present the found changes from the perspective of the given dimension. The elements identified in the analysis should also convey the potential value-adding elements to the important, central stakeholders in the value network – mainly, the RVM provider, service provider, RVM operators, and especially the user.

4.1 Offering dimension

The most relevant change in the offering, i.e. the physical system and the integrated services, is the increased availability of the system through design changes in comparison to the current RVM designs.

Increasing the availability of the system – the *primus motor* of the design project – results firstly in designing more robust and reliable subsystems, and secondly in increasing the maintainability of the system in order to allow the operators to maintain the system and thus decrease the mean time to recovery. In addition, increasing the maintainability of the machine and simplifying the mechanics with certain physical design changes leads to slightly modified way of using the machine. All these changes have an effect to the *user dimension*, and at least one of them, the *modified way of using the machine*, has an impact back to the *offering dimension* via the need for e.g. illustrational graphics to the user interface.

Further, remote condition monitoring of the machine and increasing the intelligence of the physical system with fault diagnosis become necessary in order to minimize the need for on-location maintenance.

Increasing the availability of the system affects greatly the *provider dimension*, which redefines the risk and responsibility distribution. The increased operator involvement demands also increased usability and ergonomics for the operator side of the RVMs. The usability for the RVM users has been high also in the past, but significant improvements are possible in the operator side.

The imposed changes towards a product-service system approach in the *provider dimension* further cause changes in the physical design; in order to be economically sustainable, the machine has to be *upgradeable*, allow *re-manufacturing*, and *recycling*. The upgradeability and re-manufacturability induce a need for more modular system, whereas the recyclability prevents the design team from using components that are difficult or costly to recycle.

4.2 Provider dimension

As also Sakao *et al.* (Sakao et al. 2009b) state, moving from products towards availability-oriented product-service systems has significant implications to the provider; it has to adapt its organization to be a product-service system provider instead of a machine manufacturer. In practice, less maintenance work leads to decreasing the size of the needed maintenance organization. This enables the provider to cut organizational costs, since although the maintenance activities were a significant source of income previously, the large localized maintenance organizations also caused significant costs. Due to the reallocated more trivial maintenance tasks, the support function of the provider will increase in size and demand also improvements in the level of expertise. In total, the center of mass in the organization will shift from maintenance to design and support due to the design and business model changes. These changes may induce needs for recruitments, layoffs and other organizational changes, but it also allows a more centralized organization for the provider.

As stated above, the shift towards the availability-oriented product-service system approach causes reallocation of risks and responsibilities, which causes further changes in the *offering dimension*; mainly the usability, upgradeability, re-manufacturability, and recyclability. These in turn force the provider to introduce a more complex design and manufacturing processes able to possibly upgrade existing systems and utilize the re-manufactured and recycled hardware.

4.3 User/customer dimension

Like the name suggests, the user/customer dimension encompasses both, the user and the customer – separate entities in this particular case. The user refers here to the person using the RVM to recycle, whereas the customer refers to the service provider, the party that operates and is responsible for the RVM. As stated above, the usability for the *user* of the RVMs is currently on a high level, and the goal of the design project was to primarily affect the usage only through removing limitations for the use of the machine. In other words, the goal was to get rid of the downtime currently plaguing many RVMs in use.

However, the simplified mechanics lead to a slightly modified way of using the machine that differs from the dominant design. This might require feedback back to the *offering dimension* as minor changes to the user interface, as stated also above.

For the *customer*, the increased availability results in decreased life-cycle costs. Although also the needed skill level of the RVM operator personnel and attention required by the system increases, it is likely to be smaller than the costs caused by frequent, unscheduled visits of authorized maintenance personnel. Also the *user* satisfaction is likely to increase due to the increase availability, which is naturally valuable for the service provider (i.e. the *customer*) given that providing the recycling service is a source of income for them.

As stated, availability-oriented PSSs are a specific instance of product-service systems (Tucker, Tischner 2005). In an availability-oriented product-service system the supplier guarantees a certain level of system availability, and thus also adopts part of the risk. Providing such availability-oriented RVMs would therefore partly alter the mechanics of value creation in the value network. Table 2 shows main projected positive and negative potential value impacts of implementing an availability-oriented RVM for the RVM provider and its two levels of customers – the service provider and the user.

5 DISCUSSION AND FUTURE RESEARCH

The findings from the reverse vending machine design project suggest also that by modifying the incentive system through introducing a product-service system approach it might be possible to bring the values of the important stakeholders, namely the RVM provider and the customer, closer to each other. That is, align previously conflicting interests between the customer and the provider, or remove incentives from one party that may cause negative implication to the other party. In this example, introducing the availability-oriented PSS approach provides both parties an incentive to maximize the availability of the system, whereas the incentives for the availability previously conflicted among the two parties. Similarly, the take-back of the system is valuable in the PSS scheme for both, the customer as well as the provider, especially if the design of the machine allows upgrading and remanufacturing, as stated in section 4.1. In addition, maintaining the machine in a good condition can be designed to be valuable for both parties; along the principles of TPM, referred to in section 3, the autonomous maintenance and cleaning the system increases the availability of the system. The availability of the system again increases user satisfaction, and a more carefully maintained RVM provides more possibilities for re-manufacturing and recycling in the take-back phase.

Table 2 Potential value impacts of introducing an availability-oriented RVM

	Negative value impacts	Positive value impacts
User	-	Increased service availability Increased convenience of use due to cleaner RVMs
Service provider	Added cost of cleaning & inspecting the RVM Added cost of training the RVM operators	Increased machine availability Lower RVM life-cycle costs Higher customer satisfaction
RVM supplier	Lack of maintenance revenues Added product-development costs	No need for large, local maintenance organization Positive incentive to develop reliable systems Higher customer satisfaction

Our hypothesis is that this kind of *value convergence* might be possible to design into value networks by modifying the incentive systems of the value network participants through introducing product-service systems. Value convergence in product-service systems seems to be present at least when moving from *product + maintenance service* business model towards selling system availability as a service. However, this topic demands further research with a wider sampling of case studies concerning a change from selling products towards product-service systems.

Moving from products towards services introduces also several potential challenges. The change may have great influence to the organizational structure of the company, as in the above example, and require dramatic restructuring of the responsibilities. Other than this, for instance the concept of *ownership* may play an important role in the decision-making of customers. The issues may be partly related to conventions of owning e.g. production machinery or certain product's role as *status symbols*, or partly to distribution of risks, responsibilities, and power between the provider and the customer. In case the customers *own* the machinery, they have the power to e.g. modify the systems according their will; service or leasing contracts may prohibit this kind of freedom.

Environmental aspects are one of the main reasons for the growing interest towards product-service systems during the last decade or so. Several authors (for instance (Manzini, Vezzoli 2002, Tukker 2004, MacAloone, Andreasen 2004, Meier et al. 2010)) have studied the potential effects of product-service systems on sustainable development and decoupling economic growth from raw material consumption. These aspects have been, however, omitted from this article due to limiting the scope; including the analysis of the potential environmental impacts of the case study might provide interesting grounds for further research.

The interplay between the three dimensions of product-service systems could be perhaps utilized in communicating the potential for value creation in a given field during the early design process. In the later stages of the design process, where quantitative cost and price information is available, for instance the method proposed by Sakao & Lindahl (Sakao, Lindahl 2012) may prove to be highly useful, but in thus far the field lacks practical *proof-of-value* methods to early design phases for conveying the potential value added with given PSS concepts.

6 CONCLUSION

Product-service systems provide new ways for creating added value for customers in comparison to the traditional product sales. In this article we studied a design case study gone through in the research group in order to advance the understanding of the interactions between the different dimensions of product-service systems during the design process. The PSS dimensions used in the work include the offering, the provider, and the user/customer (Sakao et al. 2009b), and they allow a more complete view of the system in comparison to analyzing the designed offering alone. Further, for instance the design aspects related to customer value creation are more evident when the user/customer dimension is explicitly included in the analysis. The case study used in the work is a design project of an availability-oriented reverse vending machine (RVM).

The work resulted in identifying several interrelated elements from the three dimensions. For instance the goal of increasing the availability of the RVM resulted naturally in several concrete design changes in the offering dimension. These changes affected the provider dimension, i.e. the business and earnings logic of the provider, which imposed changes to the business model – mainly, moving from products to product-service systems – which, again, affected the offering dimension. In addition, the incentive system of the provider was changed due to the product-service system approach, which seemed to remove some contradicting values between the provider and the customer, in other words bring their values closer to each other.

This article presents concrete findings based on first-hand data from a product-service system design project. However, more practical research is needed to further study and especially generalize the findings; for instance similar studies about design cases of the different kinds of PSSs, such as function-oriented, availability-oriented, and result-oriented product-service systems.

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