Customer needs and knowledge in product-service systems development

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ABSTRACT
Customer interfaces are often underexploited since the potential inherent in various forms of collaboration and interaction has not yet been fully recognized. In this paper, we consider the need for knowledge at various organizational levels at the early stages of the product and service innovation process. We present a systematic framework for exploiting the potential in the current ways of collaborating and for gathering information to support the front-end of the innovation process.

Keywords: Product-Service System, industrial services, maintenance, customer needs

1. INTRODUCTION
Transformation from goods-dominant logic towards service-dominant logic has continued in many companies and recent years have actually strengthened the motivation to develop new service businesses. However, systematic methods for creating services in close collaboration with customers and for gathering information on customer needs seem to be underexploited. Companies also lack practical tools for converting the information gathered into the requirements of the product and service portfolio.

Despite the lack of customer involvement at the front-end of the innovation process in practice, the service provider would clearly benefit from having a profound knowledge not only of the customer’s current requirements but also of changes in the business environment. The aspects to be considered vary from general trends, such as sustainability and environmental and safety issues, to customer specific issues, such as changes in the production structure and an increased need for networking and knowledge-intensive business services.

Customer interfaces are often underexploited since the potential inherent in various forms of collaboration and interaction has not yet been fully recognized. In this paper, we propose a framework for gathering information for the product-service system innovation process. Knowledge is explored based on a model of the innovation process. As a conclusion, we discuss the weaknesses of the current forms of collaboration and the need for further research.

From the perspective of service and engineering asset management research, our paper specifically addresses the early stages of the innovation process and new customer needs for effective asset management. For practitioners, sound methods for gathering and utilizing the information on customer needs and customer value potential when creating business cases can provide an important advantage. Overall, the purpose of this paper is to explore the possibilities to support the existing practices related to the front end of the innovation process. The paper is restricted to industrial service business development with a special focus on asset management and maintenance services.

2. THE NEED FOR NEW CUSTOMER KNOWLEDGE

2.1 The transition towards customer-centric service business
Product manufacturers are challenged to make transitions to providing systems of products and services which are jointly capable of fulfilling specific client demands (Manzini & Vezzoli, 2003). Provision of product-service systems (PSS) aims to assume a greater role in the customer’s business and therefore calls for a better understanding of how the innovation processes should be structured and provided with adequate information. While acknowledging the customers’ difficulties in defining their exact needs (Ojasalo, 2007), the providers of products and services are still searching for concepts with which to
identify such long-term needs. Customers, on the other hand, should have an active role in service development. Olsen & Sallis (2006) state that access to customer problems and needs is best achieved by being close to the customer. However, application of the traditional principles of goods-dominant logic does not support the creation of such a relationship. The PSS innovation process is supported by gathering as much information of the customers’ processes as is reasonably possible in order to guarantee adequate customer-centricity. While industrial service providers are faced with the need to customize their service offering according to the individual needs of the customer (Panesar & Markeset, 2008), being close to the customer is necessary to gain a sufficient understanding of the customer’s current needs. Even though being close to the customer is a necessity when developing and providing services, close collaboration does not necessarily help when latent needs and long-term solutions need to be identified (Olsen & Sallis, 2006). The challenge for managers is claimed to be to detect the changes and find the appropriate actions to respond to them (Panesar & Markeset, 2008).

Staying close to the customer and creating solutions for the needs specifically articulated by him is based on a reactive market orientation, while a proactive market orientation requires a more sustained focus and new information about the future. Since too strong short-term market orientation may undermine long-term objectives, the innovation process should be in balance regarding the opportunities for new breakthroughs and incremental innovations. Our findings show a wide variation in companies regarding their philosophy on customer involvement in the innovation process. While some companies state that there is very little point in developing and creating anything without the customer, others seem to prefer to exclude the customer from the process until the test phase of the new concept.

Companies therefore vary in their perception of the customer’s role and also in their understanding of the value of their own products and services. The notion that value is embedded in the products, the existing theory on value-in-exchange and the traditional product-centric thinking are challenged by the service logic (Grönroos, 2008) which presents customers as value creators and providers as facilitators. In providing customers with the value foundation required in the customers’ value-creation processes by means of services, the provider is challenged to contemplate the processes to be effected. The transition can be supported by appropriate knowledge.

2.2 Trends related to service business and customer relationships

Ojanen et al. (2008) present the success factors related to new service development (NSD) and describe the NSD process for their success factor analysis through two main stages, namely a search stage and an implementation stage. For the search stage in the NSD process especially, a profound understanding of customers’ production and business processes as well as an efficient needs assessment are crucial for successful development. On the other hand, Ojanen et al. state that a fast reaction to changing client needs is also important in the implementation stage of the NSD process. Technological factors play a major role in the implementation stage, and the ability to network and build trust is important throughout.

For a manufacturer, access to information concerning a wide installed base may constitute an important success factor when providing services (Ahonen et al., 2010). Thus, managing, developing and implementing services can benefit from the information content of the data gathered from the field. However, all these aspects require the development of new capabilities.

We carried out interviews with a variety of Finnish product and service providers and their customers. There were a few common general topics that the customers specifically emphasized. For instance, it was customers’ experience that the willingness to offer performance-based contracts was still rather weak. One of the reasons for this was that providers do not have sufficient information on the use phase of the product and, for instance, the maintainability performance of the product. Thus, taking advantage of the previously mentioned success factor, access to a wide installed base, often necessitates addressing a variety of practical problems. Customers also noted that the debate related to developing services should be on-going at all organizational levels. Knowledge sharing practices at managerial level alone do not ensure an adequate base for service business development. In the frequent absence of adequate information, too many assumptions may be made. Continuous forms of collaboration, such as shared development projects, seem to help in information exchange at a fairly concrete level.

Customers also seem to expect more debate on future requirements and new opportunities, without being too restricted to current solutions. Real break-through innovations may also emerge from customers themselves finding answers to the problems identified. Thus, in certain branches, customers may have a pivotal role in the creation of innovations and, for the benefit of the product manufacturers, the situation presents an opportunity for developing these new ideas further for a wider market.
Customers may assume different roles during the process. For instance, according to Alam & Perry (2002) customer participation at the idea generation stage of the service development process is characterized by the following ways of making a contribution: state needs, problems and their solution, criticize existing service; identify gaps in the market; provide a wish list (service requirements); state new service adoption criteria. According to the companies interviewed in our study, an adequate level of understanding is only achieved through a continuing relationship with the customer. It can be concluded that the transaction-based models with irregular meetings may provide a rather narrow perspective for the process of learning the customer's production so well that it is possible to identify new business opportunities.

Service provision processes can be supported by appropriate knowledge about customers and adequate feedback from the former experiences of service provisions. This systematic support typically aims at only small incremental improvements and new breakthroughs are not specifically supported. However, looking at the same sources of information from new perspectives may yield important benefit for the front-end of the service innovation process. The transition to service-dominant logic and the objective of adding more services to the company's portfolio are challenged by the fact that information needed in the successful provision of products typically does not suffice for creating successful services. While thorough knowledge about the requirements and specifications for the product provided combined with adequate knowledge about the production process is enough for successful product development, the information required by the service development procedures is more complex and the developers need to know more about the customer's business. Involving in the innovation process people from different positions and levels in the company organization, methods for the co-creation and integration of knowledge coming outside from the company have been found to be important when developing services. In industrial services and especially in PSS development processes, we still lack systematic frameworks for gathering useful information and converting this into useful knowledge. In what follows, we discuss the various perspectives to be taken into account and further analyse which specific information is useful from the development process perspective.

We conclude that the literature and the results of our interviews support the assumption that the innovation process should be further supported with new types of knowledge. The front-end of the innovation process is particularly addressed in the following sections.

3. KNOWLEDGE IN THE FRONT-END OF INNOVATION PROCESS

3.1 A practical view on the PSS innovation process

A significant challenge is that the early concept development and design phases of the innovation process are somewhat unstructured and uncontrolled. Even though methods and tools have been created for the management of the fuzzy front-end of the innovation process (e.g. Paasi & Valkokari 2010), there is so far very little experience of systematically providing these early phases with adequate amounts of analysed information. Paasi & Valkokari state that the provision of structure and control helps companies in the management of future uncertainty and the use of specific tools is less important. Thus, regardless of which specific tools are in favour, in this paper we aim to present the important perspectives and levels of information to be considered during the process.

As a baseline for our work, we take the value proposition related to the solution provided as the core of the innovation process. In general, the value proposition can be outlined by integrating the information from weak signals, megatrends, market research and business intelligence. We pay specific attention to the underexploited opportunities to gather and utilize data and knowledge from customers.

According to Paasi & Valkokari (2010), customers may have difficulties in identifying and articulating their needs or they may consider the needs so self-evident that they do not understand their significance from the viewpoint of the innovation process. This statement supports our assumption that service providers should be better able to actively enhance their understanding of the customer's business and further to ascertain which elements of services and products would be successful in the future. However, changes may also entail significant risks. Paasi & Valkokari (2010) note that customers may also resist a new concept because of the learning requirement entailed in such changes, of the need to abandon existing practices and routines, and sometimes to change social aspects and hierarchies at work. This implies that the transition should be made as easy as possible. Information on which solutions customers feel uncomfortable with should be communicated in the early stages of the PSS development process as well. Changes in the business environment and the transition towards collaborative and customer-centric
planning in a networked environment also call for new capabilities (e.g. Salkari et al., 2007; Wise and Bauungartner, 1999; Kumar et al., 2004; Kindström and Kowalkowski, 2009). Firms striving to collaborate with their client in new service development in such an environment should further develop their knowledge processing mechanisms to cope with the different dimensions of customer knowledge. From the customers' perspective, the experiences of being involved in the development may vary depending on the nature of the collaboration. It may be agreed that a customer takes an active role in mediating new information and thus knowledge is created together. Alternatively, the service provider may merely exploit the current collaboration practices by observing the customer more efficiently without the customer even noticing any big difference.

Based on the preceding challenges related to innovation management, in the rest of the section we broadly present a practical product-service system development process and related knowledge flows. Section 3.2 addresses the issues related to the various types of knowledge gathered more specifically.

**FIGURE 1.** A simplified description of the PSS development process with feedback information.

Figure 1 illustrates the process for the product and service innovation process at a low level of detail. The figure specifically addresses the feedback loops of information from customers and required for each stage. The stages included in the process can be briefly described as follows:

- **Front-end processes**: the stage includes gathering relevant information and ideas, for instance from the company's own employees, from the market and especially from customers. As suggested earlier, customers are often unable to articulate their future needs and the PSS provider needs to ensure that an appropriate amount of relevant data is gathered in order to be better able to understand customers' business. The front-end processes are those intended to integrate the gathered data and ideas in order to refine the ideas into promising concepts of products and services. Front-end processes result in concepts ready to be incorporated into the new product or service development processes (R&D stage). The stage is iterative in nature and also includes evaluations of whether ideas will be further developed into concepts, whether they will be rejected or put on hold. The front-end processes and R&D processes are separated by the final decision node, where the decision must be taken regarding each concept, whether it will be selected for further development within a specific new product development (NPD) or new service development (NSD) project.

- **R&D processes**: New product and service development projects are carried out based on the results of the front-end processes and on the screening, which results in the most profitable candidates only to be accepted for further development. Economic evaluations are carried out when selecting the best candidates for the next stage.

- **Portfolio**: Based on information on customer value, business potential, technical feasibility and suitability for the company’s strategy, the best candidates are selected for inclusion in the product and service portfolio of the company.

- **Delivery processes**: This stage is characterized by many specific design tasks aiming at integrating existing product modules and services in the portfolio to compose a combination – a solution – that meets the customer’s requirement. Case-specific tailoring may take place during
the stage and modular design with options for a variety of combinations provides the baseline for customer driven solutions. In the case of physical products, the delivery project is finalized by having the product installed and/or taken into use. In the case of services offered, the delivery processes can be addressed as individual service deliveries (such as specific maintenance tasks) very often in direct interaction with the customer. The delivery processes, however, are often regarded as a continuous flow of interactions.

- **Product use and use support:** The use stage provides an important source of information for all the stages included in the innovation process.

Data and information gathered at the product use stage vary from specific details regarding the installed product to strategic level business information. Therefore the information can have various important uses. The arrows in Figure 1 represent the feedback information from the use stage to each of the stages included in the innovation process. The feedback loops generated by the arrows can be described as follows:

- **Inner loop:** The information concerns specific individual machines or products installed or taken into use. The feedback information primarily concerns the results of decisions made during the delivery projects of the machine. Therefore utilization of the information results in improvements concerning how delivery projects are planned and carried out. Individual customer problems are solved based on the information.

- **Middle loop:** Since the inner loop primarily addresses the experiences gathered regarding an individual product or customer specific service delivery, no attention is paid to problems or challenges that need to be addressed at earlier stages of the process and to procedures which cause changes to the future portfolio. The middle loop considers these issues.

- **Outer loop:** While the loops presented above primarily support the incremental development of an existing product and service offering (portfolio), the outer loop is planned to represent the channel for providing the early idea generation and enrichment activities of the innovation process with useful information. Thus the outer loop consists of information targeted at the creation of radical innovation; however, there are no strict rules for the classification of information. A rule of thumb is that the outer loop embodies significantly more novelty value than the two other loops. However, it should still be born in mind that a piece of information primarily meant to support, for instance, the delivery process development (inner loop) may on other occasions provide a starting point for creating ideas for a completely new product structure or service product.

In the following section we address more precisely the requirements for various types of information in the front-end and thus the outer loop presented in Figure 1.

### 3.2 A knowledge framework for the front-end

Since customers have trouble imagining and giving feedback about something that they have not experienced (Matthing et al., 2004), product and service developers need to assume a more active role in finding the relevant information. Matthing et al. state that involving the customer in the development process of a service helps to learn about the customer's latent needs. On the other hand, identifying the customer's existing strategic needs can be supported by systematic methods for learning about the customer's business; for instance the value chain analysis by Crain & Abraham (2008). In this section, we propose a set of various types of knowledge which requires specific attention in order to learn more about the customer and customer's future needs.

According to the findings of Panesar & Markeset (2008), market needs and customer initiatives and feedback provide the most important drivers for innovations. The most important source of ideas is the employees of the product and service provider. This is explained by the fact that continuous interaction with the customer results in a profound understanding of service content, the delivery process and customer needs. Following this suggestion, the employees should not only have an opportunity to access relevant customer knowledge but also exploit these opportunities fairly efficiently. We still find that many of the forms of interaction lack sufficiently systematic approaches which would help to bring certain pieces of information together in order to create input for the front-end. The findings of Panesar & Markeset (2008) indicate that feedback from the customer and interaction between employees are the
most important means to encourage service innovations. In this section we address the various types of knowledge to be considered in these forms of collaboration.

Customer knowledge can be categorized as follows: knowledge for the customer, knowledge from the customer and knowledge about the customer. We pay special attention to supporting the creation of knowledge about the customer and discuss issues related to knowledge from the customer only briefly. The former type of knowledge is directly related to long-term learning, while the latter type of knowledge (feedback, experiences of products and services) mainly supports the continuous development of the PSS offering. The most critical success factors for developing new customer-centric services require thorough understanding and management of various types of customer knowledge (Edvardsson et al., 2000):

- customers’ needs, priorities, requirements, expectations, and preferences
- customers’ service context (when, how, why and where the service is used)
- customers’ knowledge and capability to use the service
- customers’ experiences, emotions, and behaviors when using the services
- customers’ values and cognitive structures.

Even though these four categories of knowledge can be regarded as something that can be partly obtained from the customer, for a PSS provider it is important to pay attention to identifying the ‘hidden issues’ by learning more about the customer. We focus on ‘knowledge about the customer’ that specifically facilitates understanding the first category presented above, but also the following three list items from selected perspectives. In this paper, however, we do not actually cover issues related to customers’ values and cognitive structures. Since the new channels for gathering information required and described earlier are often difficult to create, we emphasize the need to utilize the existing customer interactions more efficiently in order to gather sufficient knowledge about the customer. In order to be successful, “the frontline” needs to be equipped with appropriate tools and methods to collaborate with the customer, that is, to “observe, seek, discuss and ask”. We propose the following main categories of information to be considered when gathering new customer knowledge for the development of new innovative PSS concepts:

- business environment knowledge
- customer and production environment knowledge.

Figure 2 outlines the role of gathering knowledge when searching for new business opportunities. Thus here we specifically address the outer loop of knowledge presented in Figure 1.
3.2. Business environment knowledge

A profound understanding of customers’ business has been widely argued to be an important success factor for a service or PSS provider. The business environment knowledge part of the framework aims at structuring and enhancing this understanding. The combination of aspects has been considered especially from the perspective of maintenance service provision and thus selection of the appropriate modes of operation. However, considering these aspects is important when developing industrial services in general; they provide a great knowledge base for the early phases of the innovation process. The aspects included in the framework can be characterized in more detail as follows:

- **Business drivers and success factors**: Business drivers may vary from capacity, cost efficiency, and quality to safety and non-failure policies. PSS solutions need to be in line with the customers’ objectives derived from strategy and thus a combination of these business drivers.

- **Life cycles of the customer’s plants**: By considering whether the plant is in the implementation phase, normal production phase, ageing but continuously invested in or ageing with consequences to production efficiency, yields important information on which to base correct solutions.

- **Economic situation - demand and position in the market**: Current economic trend in the industry (for instance, information on significant external disturbances or overheated economies). PSS solutions can be provided in order to enable the customer to focus on the most profitable businesses.

- **Fluctuations in demand and their influence**: The diversity of the product and service offering may be of help when combatting the undesirable consequences of the fluctuations.

- **Maturity of the industry and products**: Naturally, a fast-growing field is a great ground for innovations but at the same time rather challenging, requiring rapid reaction and ample innovativeness with a continuously developing PSS portfolio.

- **Changing customer needs and future challenges**: Current and future market requirements and customer demands are to be covered. Objectives for the PSSs are ultimately derived from the objectives and business goals of the customer’s customer.
3.2.b Customer and production environment knowledge

A framework for gathering information under the abovementioned categories is presented in Figure 2. Customer and production environment knowledge (created on the basis of information on customer specific issues, production processes and the surrounding environment) is presented as a combination of eight different main aspects. These aspects can be characterized in more detail as follows:

- **Criticality and production structure**: The criticality of the equipment considered from the perspective of production efficiency is dependent e.g. on the redundancy and reliability structure of the system in general and the value of the production losses. Furthermore, by addressing the gap between the actual production volume and the theoretical capacity, one can identify the general bottlenecks in the systems. Criticality can be measured by classifying the equipment. Services or new PSS solutions can be focused on the most critical system parts.

- **Maintenance issues**:
  - **Complexity of maintenance**: The complexity of the maintenance activities required depends on the complexity of the equipment, its structure, technology, inherent causes for delay and maintainability. Since complexity may cause significant production losses, new innovative solutions for improvement (such as making the equipment easier to maintain or finding new working methods...) may be valuable.
  - **Needs for preventive and corrective maintenance**: For the purposes of planning maintenance activities, the required level of maintenance, which depends on the customer's objectives, the characteristics of the environment, the stresses caused by the production, and the technology used all need to be known.
  - **Opportunities for carrying out maintenance**: The ‘maintenance windows’ depend on the amount of idle time and the proportion of this which can be used for maintenance, and how much maintenance can be carried out during production and, for instance, grade changes.

- **Risks**: Service provisions require considering risks from various perspectives. Risks caused by failures should be analysed in order to plan appropriate activities for decreasing the failure probability or consequences. On the other hand, the occupational risks need to be identified and managed by appropriate actions. Solutions for managing the risks can be identified by carefully considering these aspects.

- **Demand for knowledge and skills**: The number of special tasks required and the technology to be used are components of the demand for knowledge and skills.

- **Need for investments**: The investment history reveals the extent of past investments. By comparing this information against knowledge of trends in failures and other relevant production performance measures and experiences, the future allocation of investments can be predicted. Other production efficiency improvements can also be initiated, and need for new technological solutions identified.

- **Failure behaviour**: The failure behaviour of production systems is affected by various factors, such as the lifecycle phase of the production equipment, maintenance and investment history, changes in stress, process conditions (including, for instance, temperature and humidity), and overloads. This information makes it possible to plan a balanced maintenance programme with correct modes of operation.

- **Customer's organization**: The customer's know-how and capabilities are explored and resources are studied in order to reflect these issues against the requirements of the business environment and thereby identify the potential for new services. Furthermore, the customer's planned reaction and development plans for the organization given the changes in the business environment are scrutinised.

The knowledge framework presented provides an overview of the knowledge which is of use in the creation of new business. Since customer interfaces and the various forms of customer collaboration and interactions are underexploited, the framework is also intended to exploit the potential in the current ways to collaborate and to develop new channels for gathering information when needed. Thus the
employees of service provider companies are given a ‘map of aspects’ which is important for identifying new opportunities.

Being closer to the customer’s core business is moreover easier when there is already knowledge in place regarding, for instance: product and service design processes; the design of the production process; the business and operations network of the customer; capacity, demand, supply chain and planning; development projects; requirements for future products and services; quality, characteristics and practices for operations improvement, reliability management and quality management.

By using questionnaires a service provider may gather useful information in order to obtain feedback for new product and service ideas. However, the structure of questionnaires seldom encourages the customer to think of any real innovations and many needs may still remain unarticulated. Thus, while customers may be able to evaluate the proposed ideas against their predefined criteria, greater interaction may be required in order to identify new opportunities together with the customer. We contend that efficient utilization of the existing forms of collaboration for gathering new knowledge needs to be supported by the kind of framework presented above.

4. CONCLUSIONS

Since it has been widely agreed that innovativeness should not be impeded by excessively strict guidelines and external restrictions, the front-end of the innovation process (and specifically idea generation) has been considered as a stage where processes should to some extent remain unstructured and uncontrolled. We agree, but claim notwithstanding that the process can be considerably improved by systematic approaches to gathering and analysing supporting information in order to more effectively use this knowledge in the idea generation process. Regarding services in particular, the importance of understanding customers’ business has generally been emphasised, often not specifically addressing the more detailed requirements for improving the understanding. In this paper, we have proposed a generic framework for gathering customer knowledge in the case of industrial PSS solutions.

The work on this theme is being continued, paying particular attention to the practical forms of collaboration with the customer in order to identify new business opportunities. Furthermore, the research work is planned to be continued on a broader theme, where a framework for designing product–service systems will be developed.

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