



Title:

Factors Influencing the Integration of Product and Service Design in Product-Service System Development

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Introduction:

The core idea of Product-Service System (PSS) is to create added value by providing an integrated system of product and service with a total care throughout their lifecycle to meet the customers' requirements while reducing resource consumption and environmental impacts [1][2][3]. The traditional stage-gate product design process has to evolve to combine both product and service design to provide PSS. In this context, various models have been proposed to describe the PSS modular design process. Some authors suggested a parallel interactive method of product and service design for PSS by translating the traditional production process into a process of technical service [4][5][6]. Others considered PSS as an integrated system of products, services, stakeholders and delivery infrastructure and proposed a unified PSS design process [7][8].

Despite the wealth of research dedicated to the PSS design, existing methodologies for PSS design are not detailed enough [9]. Existing literature does not adequately explain how product and service can be combined efficiently; how their design can be affected by factors that define the offer and how to choose the most appropriate combination modes [10][11]. Also, the PSS literature highlights the importance of setting-up collaborative partners network and increased need for communication and coordination of activities [7][8]. In this matter, it is necessary to specify that the customer integration happen how and in which phase during the PSS design.

The specification of the product-service interactions is not explained in any models; which is to say the interfaces between both artefacts when building the PSS architecture as well as the influence of each artefact design on the other one is not clear. Furthermore, the existing models do not illustrate the specific activities related to the service delivery due to the simultaneity between service production and consumption.

This paper aims to fill this gap by investigating the factors that can influence the integration mode of product design and service design during the PSS development process. In this respect, the paper provides a conceptual framework based on a set of four factors that could influence the product and service design combination modes. Then, it describes a qualitative research method based on the cross-case analysis. Next, it reports some evidence of the exploration of the three cases according to the conceptual framework. Finally, the paper concludes with the theoretical and practical implications of this work, its limits, and potential for future research.

Theoretical background:

Combination mode of product and service design

Using the Lifecycle Engineering (LCE) concept, PSS results from the design of both tangible and intangible components [5]. In this context, the final solution creates value by simultaneous combination of the products and services [12]. The success of PSS design is highly dependent on the systematic combination of product and service design with a consistent PSS design process [5]. In order to be sure whether the PSS is creating the planned value, companies need to test the synergy between product and service when they are combined [13]. In this matter, three modes of combination between product and service lifecycle design are proposed in the literature [5][8].

The influencing factors

From the existing literature, three main classes of the influencing factors as the adoption strategy, type of offer and customer integration approach can be distinguished [4][14].

- PSS adoption strategy

Recent approaches focus more on characterizing the different dimensions of PSS offering [14]. There are relationships among companies' strategy, business models, and tactics for PSS [15][8]. Companies' core competence is a base for their PSS adoption strategy [15] and the type of PSS they propose [14]. When the adoption strategy is defined clearly, the type of PSS they propose will be clarified with a set of tactics to accomplish it [14]. Companies adopt various approaches beside using their own tools to design PSS [4]. As a result, PSS development must follow a flexible and dynamic roadmap [16].

- PSS offer type

The PSS typology has different effects on the PSS development complexity, collaboration tactics, customer integration, and the level of integration of PSS components [17][14]. There are various propositions for PSS typology distinguishing different categories of PSS provider [19][20]. The proposed typology for PSS by Tukker [18] is considered as the most preferred classification in PSS literature [19]. This typology proposes three type of PSS as Product-Oriented, Use-Oriented, and Result-Oriented [18].

- The customer integration in PSS design process

With PSS offer, the company provides additional value for the customer through a long-term relationship covering a large part of the PSS lifecycle. The complexity of PSS offer increases the need for "more personal communication and implement new working routines" in coordination activities, "low formalisation and highest complexity" in responsibilities of stakeholders [14]. It raises the question about the role of the customer in design and how they integrate their customer in the PSS design process [22]. Consequently, PSS design process should involve steps to review and improve the design process [4]. In this matter, customer integration is a critical issue that gives essential specificities for PSS design process regarding traditional product design processes [21] [23].

The Industrial cases analysis results:

Case A

Case A is an energy equipment manufacturer, which has evolved from an electro-mechanical producer to a solution provider and became a global leader in energy management technologies and services.

- PSS adoption strategy

Despite the fact that company A has debates on solution definition, the elements of this solution are similar to the PSS definition in the literature. Providing PSS is categorised into "predefined solutions" for similar projects and "customized solutions" for a particular customer.

Now, company A puts more energy on the product because it is their profession and they consider the service mostly as a mean to deliver a final solution, but they tend to focus on service and consider the product as a complementary element to provide service.

- PSS offer type

Company A provides three different types of solutions and tries to move to the “result-oriented” PSS:

Business Project Contracts: In many projects, company A builds and provides the solution to the customer. In this case, the customer is the owner.

Performance contracts with provider ownership: In some cases like equipping large buildings, company A is the owner and commits to the performance and efficiency management. If some benefits were gained, they would be shared with the customer.

Performance contracts with third-party ownership: In some cases, the bank will finance the project, so the owner is the bank. The customer is interested in the value but neither the customer nor Company A has the required financial resources, or they do not want to invest in the solution.

- Customer involvement

To propose the solutions, knowing the customer is always the first step, which the marketing team is in charge of. However, the project manager reported that their most basic difficulty, as a B2B, is gathering information about the market because the company does not have access to the end user.

Company A follows the classic waterfall model of the system design process. The design process of PSS is defined with requirement analysis, concept design, detail design, solution installation and production phases. It does not have a formulated step of customer integration. Instead, it has some interaction moments with customers that happen during the primary steps of requirement analysis, ideation and concept design. During these steps, company A develops demonstrators to test and validate with the customer. After the conceptual design with close collaboration with the customer, the company is responsible for the solution production and installation.

- Combination mode of product and service

Considering the different combination modes for product and service design, company A chooses a different combination mode according to the offer type. The integrated mode has the most added value for their customer, especially in the performance contracts. For the business contracts, the combination mode is parallel because it is an ad hoc adaptation between product and service lifecycle to provide the PSS offer. In both cases, for integration of product-service, company A sets-up a mixed project team for development of PSS and the mingling inside the project team is as vital as product-service integration.

Case B

Case B is an automotive equipment supplier that has moved from manufacturing the parts using bonding technology to provide a bonding solution to advance in the market of solution providing.

- PSS adoption strategy

They use “Turn Key Solution” expression for their bonding solution. This bonding solution includes providing raw material required for bonding technology, the bonding equipment and the managerial packages such as the solution commissioning, maintenance and training. The customer account manager plays the role of the project manager for solution providing.

- PSS offer type

Company B focuses on the solution contract by modifying the product design, which needs sometimes numerous changes. They integrate their lessons learned and the new capabilities they have gained from the previous projects. Finally, they do not even mention the product or equipment on the invoice and the customer pays for the whole package of the solution.

Their business model is mostly result-oriented PSS because the customer pays per service, and they are committed to customer satisfaction, but at the same time, their risk management strategy makes their contract different from the performance contract. They propose a service that also benefits customers while at the same time reduce their risk. The complexity of the contract and boundaries of the work seems high, and change and risk management need to be well defined and well managed.

- Customer involvement

The whole process of solution offer contains two interdependent processes: engineering process and customer integration process. The latter defines the necessary input to perform the engineering process. For company B, the objective of this collaboration with the customer is firstly, to understand their need and secondly, to validate the proposed solution according to its life cycle in the development process. For this purpose, the customer integration process is composed of four steps as follows:

1. Understanding and analyzing customer needs performance specifications, process integration, and services (maintenance, supply chain, assistance...).
2. Validation of interest: economic analysis, technical feasibility, service feasibility.
3. Solution approval: economic, technical, services, planning.
4. Solution installation: quality control, operators training.

Each step requires numerous exchanges before finalizing an acceptable solution. In their solution, the customer need is considered according to all aspects of the solution like technology, process, equipment, test, and validation, method, logistic, environment and workers. The customer satisfaction is measured by the validation plan that is the successful final solution as well as feedback from the continuous relationship with the customer.

- Combination mode of product and service

They need to know their customer, but at the same time, they need to consume a lot of energy discussing with customers to extract the real need and to translate this need to the input information of solution design. Their focus is on the integrated mix of product and service. This point of view makes their collaborative design process continuous and integrated.

Case C

Company C is a machinery manufacturer, which traditionally provides maintenance services on site. To reduce travel costs and maintenance delays as well as extending product life, Company C offers a new solution based on remote maintenance.

- PSS adoption strategy

Their offer is enhanced by the use of Augmented Reality (AR) platform. The customer may visualize its machine in its environment, and then select the components that should be replaced. The AR platform managed by Company C generates the appropriate AR scenes and supports the remote maintenance procedure.

Company C adds software to PSS to facilitate the product remote maintenance as well as to provide further information about the product lifecycle to improve the company competitive knowledge. So the PSS adoption strategy is strongly based on avoiding any radical changes in the machine. Meanwhile, one of the main incentives to monitor the machine's whole lifecycle is to increase their knowledge about the machine during the usage phase as a critical input for their machines' improvement program. On the other hand, the customer needs maintenance and other after-sales services. Conducted by the engineering team, the proposed PSS is a win-win strategy to fulfil the customer needs as well as to improve the OEM competitiveness in the machinery market.

- PSS offer type

The most critical challenge in company C to move from product-oriented to the result-oriented PSS is to remove the barriers related to the project culture, which is strongly focused on reducing risk. There is still some confusion in PSS concept adoption. On the one hand, maintenance is part of the offer and considered during PSS production phase and not after. On the other hand, company C still distinguishes between PSS design, delivery, and after-sale services. What differentiates between the classical machine producing and PSS in such a company is not the addition of the platform, it is the use of information acquired from the platform. The ownership of the product is the same, but the ownership of the information has been changed. In this case, company C is now the owner of the information and can use this information to propose additional services.

- Customer involvement

For company C, the design of the solution is driven by the specificities of the machine which is implemented within the customer environment. The process of PSS design is highly collaborative and IT-centered. Due to the IT-based platform, the company is connected with customers and has real-time data and feedbacks from different stages. By analysing the customer requirements, they extract the required information to acquire during the product lifecycle. Next steps are design, testing and final solution commissioning. They do not have a formulated moment of customer integration in design, but they interact with the customer during requirement analysis and solution testing.

- Combination mode of product and service

The combination mode of the product and service is parallel. Company C creates the AR-based service parallel to their product.

Discussion and conclusion:

This research made a literature review to extract the product and service design integration mode in PSS and the factors influencing this integration. The result of this literature analysis is then used as a guideline for an industrial case study.

The results of this research reveal some significant gaps between the theory and practices in PSS design. These gaps allow identifying some theoretical and managerial implications. From a managerial point of view, PSS providers need to consider the influencing factors to define the PSS design process. These factors are PSS type, the company position on the market, the customer accessibility, and the offer creation strategy. From the theoretical viewpoint, PSS design should be evolved based on the integration modes and according to the offer's specifications.

Companies evolve to PSS providers based on their core competences. As a result, the PSS type they adopt is according to their actual business. This adopted typology has a crucial effect on the product and service design combination. Beside these factors, the collaborative nature of PSS affects its design and integration process. Comparing to the classical product design process, PSS design process consists of more customer integration phases to increase the performance as well as to reduce the risk. Which is to say, an iterative process to integrate PSS elements and stakeholders is necessary?

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