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DESIGN OF SUSTAINABLE PRODUCT-SERVICE SYSTEMS (PSS): TOWARDS AN INCREMENTAL STEPWISE ASSESSMENT METHOD

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Abstract

Companies are increasingly selling functionalities of integrated solutions of products and services instead of selling mere products. This integration of products and service solutions is known as Product Service Systems (PSS), which allows to maximize customer value and overcome increasing competition in the manufacturing sector. In this sense, PSS designers require adapted tools to support the design of sustainable solutions. This article aims to address this question by proposing a methodological framework for integrating sustainability considerations into the PSS design process. To this end a review of the peculiarities of the PSS design process was performed and which aims to explore potential ways of integrating sustainability considerations within PSS design. Several requirements have been drawn from PSS design and sustainability literature which contributed towards the formalization of a methodological framework supporting the design of sustainable PSS.

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Keywords: Product-Service System (PSS); Sustainable Assessment; Design Process

1. Introduction

Industries are currently confronted to high competition markets induced by globalization (1). Moreover, the traditional production and business models, based typically on manufacturing and selling products, are reaching some limits due to multiple reasons such as natural resource depletion, market saturation, increasing costs, shortening product life times, etc. This situation generates structural crises within the manufacturing sector. As a matter of fact, the hyperconsummerism and planned obsolescence are seen by the consumer as a problem instead of a vector of growth for the industry. In fact, consumers' needs are changing and consumers are looking for more sustainable solutions (2).

In this perspective, companies are seeking to develop both profitable and eco-friendly offers without degrading the fulfillment of the consumer needs. One of these solutions is the transition from a traditional selling model (e.g. sales of product) to selling the functionality or the result provided by an integrated solution of product(s) and service(s), called Product-Services System (PSS) (3,4).

At this point, PSS sustainability assessment is a critical question that needs to be carefully addressed by designers in order to ensure PSS sustainability throughout its life cycle. However there is a lack of well–adapted methods and tools for this purpose (5). Most of the existing sustainability assessment approaches applied to the PSS design suggest that the design process is achieved prior to the assessment step which means that only slight changes can be made in order to reduce the impact of the existing PSS solution. However, it is commonly admitted that the earlier the sustainability impact of a system is assessed, the better the design can be directed towards improvement of such impact.

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Consequently, an *a priori* assessment method which would be integrated into the various steps of the PSS design process could be particularly valuable. This article aims to identify the requirements for such a new methodology and to set its basic assessment principles and general structure.

To this end, Section 2 investigates the peculiarities of the PSS design process while putting forth main design steps. The subsequent findings of sections 2 shape up the main requirements for PSS sustainability assessment during the design process. Section 3 reports a proposal on a methodological framework for PSS sustainability assessment in an *a priori* context. A PSS use case is used to illustrate the proposal. Concluding remarks and research perspectives are presented in Section 4.

2. Designing sustainable PSS

PSS design is driven by a decision making process which is driven by choices at different points of time. The aim of this section is therefore, to understand these choice phases in order to identify how to take into account sustainability at each phase.

The design process of a PSS involves not only the design of a service or a product, but also a whole system including also a network of actors and support infrastructure.(6)

2.1. PSS design

Since the introduction of the PSS concept by Goedkoop et al., practitioners have acknowledged in it the myth of a sustainable and competitive alternative of the traditional business (i.e. business as usual, sale of a product). In contrast, selling a function – usage and result – instead of a product is only a building block of a holistic answer to sustainability and competition requirements (7).

As the offer is no longer based on the product, the design of this offer – as well as the product itself – has to be modified to fit the new goal and scope of the system designed, including sustainability. Several evidences from the literature show that a PSS is not simply an answer to the sustainability issues by nature (8–10). As such, the benefits for the whole Planet, People and Profit are not systematic if the PSS is not designed with particular attention to its sustainability impact. Thus, PSS assessment is required and the earlier an offer is assessed, the earlier it can be improved. This means that the assessment is particularly needed during the design process.

A quite straightforward PSS design process is reported by Cavalieri et al. (11) (**Table 1**). In their state-of-art, Cavalieri et al. (11) underline the lack of evaluation in the design process. The potential steps requiring evaluation and where evaluation can be integrated, as reported by the authors, are highlighted in bold in **Table 1**. *Concept generation and evaluation* relates the strategic level. *Concept development and evaluation* and E*mbodiment design and evaluation* are concerned with the PSS design.

Table 1 : PSS design steps (11)

#	Steps
1	Requirement generation
2	Requirement identification
3	Requirement analysis
4	**Concept generation and evaluation**
5	**Concept development and evaluation**
6	**Embodiment design and evaluation**
7	Detailed design
8	Test
9	Final design

2.2. Specific characteristics of sustainable PSS design

Involvement of actors and configuration of the value network

Morelli describes a sustainable PSS as a social construction, based on “attraction forces”, which catalyze the participation of several partners, which need to be identified (12). Consistently with this idea, some authors argues that PSS are forcing a new understanding of stakeholders’ relationships (11, 13).

The designers should therefore focus on defining the actors who have to be involved in the design process in order to ensure that the impact of the PSS on them will be analyzed and to introduce them in the early stages of the design process in order to co-produce the envisioned PSS solution.

Beyond partners identification, these must be linked to their own involvement and value in the life cycle (11,14) and thus their potential contribution to a sustainable solution.

Complexity of PSS life cycle design

As a PSS offer is a combination of products and services provided by a network of actors (7), it is necessary to consider various life cycles during the design process namely product, service, and their organization.

Additionally, the PSS provider’s responsibility is extended to almost the whole life cycle of the product. Consequently it is important for the PSS provider to take all the life cycle steps into account, from the cradle (i.e. extraction of raw materials) to the grave (i.e. end-of-life of the product).

Few authors introduce a distinction between different life cycles, e.g. product life cycle, service (or activity) cycle (15, 16). The service life cycle differs from the product life cycle because it is intangible and has a smaller lifespan. Indeed, in the case of a service, the production is simultaneous to the use.

Consequently remain necessary a real integration of all these life cycle as well as a progressive life-cycles specification with a view to sustainability assessment.

Sustainability assessment of PSS

The sustainability as a multi-dimensional concept cannot be approached by a unique criterion. Sustainability has to be assessed in its complexity and wholeness rather than an addition of its dimensions (i.e. environmental, economic and social) (17). Clearly, such holistic assessment requires an adaptation of existing indicators or development of new ones.