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Predicting the value of Product Service-Systems for potential future implementers: results from multiple industrial case studies

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Abstract

The great impact played by Product/Service-Systems (PSS) on industry and academia can be motivated by the need for modernizing business models, carrying out internal companies' reconfiguration, enhancing environmental sustainability. Despite the large number of objectives pursued by PSS, sparks of criticism have recently emerged, as well as the results ensuing from PSS adoption have not been rigorously assessed. In particular, the authors highlight a lack of quantitative analysis concerning the service aspects of PSS and hurdles in service modeling and evaluation. The paper's objective is to contribute in this field by individuating factors, advantages and disadvantages that are not directly measurable in monetary terms by companies. This kind of assessment might result crucial, as the implementation of PSS-oriented strategies require a not negligible amount of commitment, besides propensity to risk. A first activity was carried out thanks to a pilot group of firms that have not implemented any PSS initiative so far, which have been exposed to business reconfiguration scenarios underpinning PSS. A model for generalizing pros and cons of future PSS implementation has been subsequently experimented by a larger group of industrial organizations. Such a model has represented the backbone for the creation of a tentative quantitative estimation tool, which assesses and forecasts the added value of services featured by the introduction of PSS and hence represents a candidate criterion for undertaking decisions concerning the implementation of PSS strategies. The paper clarifies which assumptions are introduced in order to achieve this result.

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1. Introduction

PSS domain clearly represents a dynamic context. The paradigm behind PSS, whose launch has taken place in the 1990s, is attracting increasing interest in the last few years, as witnessed by the bibliometric study described in [1], which underlines, among the others, the growing collaboration opportunities across research groups. The fast-evolving literature production has attracted many scholars, who have contributed to the field through updated state-of-the-art works by focusing on the expanding body of objectives, perspectives and relevant characteristics pertaining to PSS experiences. Reim et al. [2] provide an overview of industrial applications implementing the different articulations of business models underpinning PSS, i.e. product-, use- and result-oriented

practices. The systematic review described in [3] is more concerned on design, evaluation and operations management issues, laying bare the most recent advancements. The reading of the state-of-the-art proposed by Annarelli et al. [4] seems to bridge diverse perspectives. The scholars highlight to which degree different scientific areas, e.g. economy and engineering design and management, focus on common PSS' primary objectives and strive to individuate fundamental research issues to be prioritized. Although presenting a different starting point, all the mentioned surveys share visions about the large variety of opportunities that the future developments of PSS can help to open up. Moreover, the intrinsic value of PSS introduction is actually crossing the traditional borders of sustainability and competitiveness goals.

For instance, [5] claims PSS capability to accelerate customers' acceptance of technological innovations.

Not surprisingly, as the reach of and interest for PSS are expanding, new challenges emerge. At the same time, weak methodological guidance affects, among the others, the chances of a further diffusion of PSS, which are conversely observing some unsuccessful experiences [6]. Sutanto et al.'s [7] work is also rooted in the remark that some PSS implementations have failed to deliver expected results in terms of both profitability and sustainability; a design method is illustrated that is supposed to support firms in shifting from product-intensive to service-oriented business gradually. Different design and modelling standards inherent to product and service engineering represent a primary source of concern in the view expressed by Trevisan and Brissaud [8]. Contextual factors are likely to strengthen the difficulties faced by PSS in terms of wielding its full potential. Song and Sakao [9] stress the importance to customize PSS and propose modular designs in order to match customer orientations and preference changes, which considerably affect both the product and the service dimensions [10]. Moreover, the fluctuations of the most relevant customer requirements and complex network of stakeholders determine particularly severe management problems in PSS [11]. In order to understand the complexity connected with PSS, it is worth mentioning the effort made by Kim et al. [12], who identified a non-exhaustive list of 94 items that should be used to characterize and evaluate the performances of PSS.

Consistently with these remarks, the implementation of PSS strategies require great internal commitment, structured processes, as well as the creation of a proper climate within the organization, e.g. [13].

Despite the large number of critical factors concerning PSS, the possible advantages outweigh risks based on literature scrutiny. In authors' vision, the PSS paradigm is currently underexploited in a large number of industrial domains (at least with regard to authors' national context). The industrial fields, whose investigation is illustrated in the next sections, range among the ones for which the introduction of PSS is seen as particularly valuable, especially from the viewpoint of the differentiation of the commercial offer. The understanding of what hinders the design and implementation of PSS strategies in these branches represents a complementary aim of the present study. Actually, the main goal of this research activity is to facilitate manufacturing firms' decisions concerning the introduction of PSS-driven design initiatives. The support the paper provides consists of an evaluation roadmap and a tentative quantitative estimate of the value provided by service aspects that can be easily overlooked because of the lack of acknowledged measurement processes, e.g. [14]. Whereas standard routines and tools are capable of evaluating and anticipating measurable product performances and monetary flows (like in [15]), the present contribution focuses on other characteristics, which are supposed to play a likewise relevant role in the success of PSS introduction.

The paper is structured as follows. Section 2 clarifies the objectives of the paper based on insights from the literature. Section 3 illustrates how the proposed tools have been

developed in a multi-stage fashion through the involvement of a sample of industrial companies that currently do not leverage PSS-based business models. The results are presented in Section 4 concerning the estimation of added value potentially ensuing from implementing PSS scenarios. Section 5 discusses the findings, draws conclusions and introduces future work.

2. Background

The Introduction section has already remarked the complexity of tasks that aim to model PSS and assess their performances. Many different aspects have to be considered that refer to diversified spheres [16]. Some of them are deemed as the most critical according to several scholars. In [14], it is claimed that the poor adoption of Modelling & Simulation techniques in the field of PSS is mostly due to the intangible and unquantifiable nature of services. In addition, [14] asserts that the non-deterministic behavior of customers represents a further cause of complexity. This vision is widely shared by [17], in which customer demand and the service supply chain constitute the major sources of uncertainty. Furthermore, still in the perspective of modelling and assessing PSS expected outcomes, [18] focuses on the interdisciplinary nature of service design, which has repercussions in terms of agreeing upon a common point of view for what concerns the definition of value. Eventually, [19] points out the difficulties in taking into account the dynamic aspects involved in PSS, among which some have been already highlighted in the Introduction.

The literature illustrates several contributions that deal with the necessity to model, evaluate and simulate PSS. However, no convergence has been reached yet. The authors argue that the existing contributions, although valuable, fail to provide a global view of PSS scenarios, focus on peculiar aspects only, or are difficult to use for a preliminary evaluation of the goodness of PSS proposals. A brief list follows of relevant contributions, for which limitations in the above perspective are highlighted.

- Allen Hu et al. [20] propose Fuzzy Delphi Method and Fuzzy Analytic Hierarchy Process to model PSS business models, but their aim is limited to the identification of the most impacting success determinants.
- Bertoni et al. [21] provide a technique that is capable of delivering value information across the various phases of PSS design, but the value flow is limited to the hardware dimension.
- Lee et al.'s [22] contribution is particularly appropriate for considering how dynamic effects influence the functional performance of PSS, but the proposed framework results in a complex scheme whose validation through industrial case studies has not been performed yet.
- Chen et al. [23] consider random effects and uncertainty in order to evaluate PSS with a particular focus on sustainability issues, but the proposed approach requires a large amount of historical data, which are not always available (particularly within result-oriented business models).

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