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Advancing Development of Product-Service Systems Using Ideas from Functional Product Development

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Abstract

In existing literature concerning integrated product-service (IPS) offers within manufacturing industry there are various closely related business concepts covering the shift from offering only physical artifacts (e.g. material goods, hardware) towards provision of integrated products and services, as well as further advanced offers. It has been observed that manufacturing companies offering, for instance, Product-Service Systems (PSS) face certain challenges during the development process. Further, research regarding Functional Products (FP) has developed ideas and methods that are also applicable to the PSS development process. FP and PSS are, depending on the level of complexity, often developed and later operated by regional or global provider consortiums. This paper, based on a literature review, highlights unsolved challenges in the development of PSS offerings and further proposes how ideas and methods from FP development (FPD) may resolve some of those challenges. Thus, ideas from FPD may advance the development of PSS, as well as other IPS offerings, towards being additionally robust and innovative, though also more complex.

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Keywords: consortium; Functional Product (FP); global; regional; product development process; Product-Service System (PSS)

1. Introduction

Due to increased competition, many manufacturing companies have, in business-to-business settings, started to "rethink" their ways of offering products to customers. Their business perspective has changed from offering only physical artifacts (e.g. material goods, hardware) towards integration of products and services, e.g. hardware with add-on services, as well as further advanced offers such as provision of a function [1, 2] .

Integrated product-service (IPS) offers have received increasing attention from manufacturing companies and researchers during the last decade. Park and Lee [3] use the term IPS as an umbrella for any business offers *"into which products and services are integrated, regardless of type, purpose, and features"* (p1). Various terms for such related offers have emerged in literature, e.g., Product-Service Systems (PSS) [4], Functional Products (FP) or Total Care Products (TCP) [5, 6], integrated solutions [7], and Functional Sales (FS) [8], etc. It is assumed, when developing such offers, that products and services are integrated to better fulfill customers' expectations and requirements. Thus, products and services are designed to be inter-connected, not just packaged together [9, 10]. The additional complexity added has created a need to often build regional or global provider consortiums in order to have the necessary skills, competencies and capabilities to develop and operate advanced offers such as FP [11, 12].

Research has shown that manufacturing companies offering, for instance, PSS face certain challenges during the development process [13, 14]. Kurak et al. [15] identify and classify a number of challenges related to PSS implementation, and propose a classification which can support proactive development of actions within companies to prevent difficulties, challenges and barriers during development of a PSS [15]. Considering that IPS concepts are

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related, ideas for possible solutions to challenges can be sought within the related concepts.

Functional Product Development (FPD) can be seen as a highly multi-disciplinary activity [6]. Referring to recent research on FPD [12], an FP consists of four concurrently developed constituents: Hardware (HW), Software (SW), Service Support System (SSS) and Management of Operation (MO). The main objective for FP is to offer the customer a function with an agreed-upon level of availability [6, 16]. The underlying idea of FP design is to meet the individual needs of customers; e.g., providing torque (rotation), power-by-the-hour, etc. [17]. According to Lindström et al. [11, 12], offering FP provision with a specified availability level requires identification of a future win-win situation with the customer, since the ownership of the FP is foreseen to remain with the provider or consortium providing the function. Therefore, the development of an adequate FP business model is necessary for manufacturing companies striving towards provision of FP [18].

The objective of this paper is to highlight unsolved challenges in the development of PSS offerings and propose how ideas from FPD may resolve some of those challenges.

2. Methodology

The paper is based on an extensive literature review covering publications within the PSS and FP development areas. The focus of the literature review has been on identifying unsolved challenges concerning the development of PSS offerings and how existing FP development ideas and methods may resolve those challenges.

The review was limited to three of the main scientific search engines: Web of Science, Scopus and Google Scholar. The following key search terms were: integrated product development, challenges and opportunities in product-service systems; challenges of Product-Service Systems (PSS); developing Product-Service Systems; Product-Service Systems development methodologies, Product-Service System implementation AND challenges; Product-Service System AND challenges; "Functional Product development process" AND simulation-driven design.

The data collected during the literature review was displayed, categorized, and analyzed using matrices [19]. During the analysis of the identified challenges it was noted that certain challenges had similar implications and meanings. Therefore, some of challenges were merged into groups and, consequently, some of the groups have several associated references.

3. Functional Product Development

The initial definition of a FPD process, proposed by Brännström et al. [5], involves three integrated and concurrently developed constituents: HW, SW and Services. Later, Alonso-Rasgado and Thompson [16] specify the FP content as a product-package comprising HW and SSS with integrated SW. The SSS includes maintenance of the product, decision-making, operations planning, remanufacturing, and education [6]. Lindström et al. [12] extend the FP constituents by adding MO as a new constituent. The MO includes matters of responsibility, risk management, transfer of intellectual property, building up trust and relations, availability, cost, revenue, etc., that are needed to create and maintain a win-win situation in between the provider and customer. The MO is found to be crucial for creating and maintaining a sustainable win-win situation between the provider and customer, as well as within the consortium that, through a shared effort, provides the function. Thus, FPD involves coordination of four concurrently developed constituents: HW, SW, SSS and MO [12].

In addition, Lindström et al. [11, 12] highlight that it is important in FPD for the provider or provider consortium (on both regional and global levels) to be able to simulate at least the most important constituents and assess the cost for different availability levels; this allows them to find and manage the major cost drivers early on in the FPD process.

Research regarding simulations in FP has gained increasing interest in academia. For example, Sandberg et al. [20] propose a model for lifecycle cost prediction in the conceptual development of HW in an FP. Further, Li et al. [21] present a simulation-based methodology for assessing the service reliability in the context of FP, where a graphic representation is used to describe the simulation model of SSS. Additionally, a simulation-driven approach is introduced by Löfstrand et al. [22] for predicting and optimizing the availability and cost of FP in both development and operation. The proposed approach includes coupling between the HW and SSS, as well as concurrent simulation of both constituents.

4. Identified Product-Service System challenges and Functional Product Development ideas as possible solutions

PSS can be seen as a market proposition that extends the traditional functionality of a product by incorporating additional services [23]. A PSS can thus be described as a "system of products, services, networks of 'players' and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models" [4]. Despite the benefits gained through the adoption of PSS ideas, manufacturing corporations face various challenges while developing PSS. Although, according to, e.g. Kimita et al. [24], Muller and Schmidt-Kretschmer [25], Wagner et al. [26] and Sundin et al. [27], some of those challenges have already been addressed and possible solutions provided. For example, as a lot of attention is paid to issues occurring in collaboration between designers from different disciplines in the PSS development. Kimita et al. [24] propose a design method that allows designers to address different conflicts such as incompatibility among objectives and tasks of designers in the development phase. The effectiveness of this method is demonstrated by its application of an e-learning service. Due to heterogeneous characteristics of PSS constituents, which are "product" and "service", designers may have different