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Toward an improved strategy for Functional Product development by predicting environmental and economic sustainability

Daria Sas[a]*, Petter Kyösti[b], Magnus Karlberg[c], Sean Reed[d]

[a,b,c]Department of Engineering Sciences and Mathematics, Division of Product and Production Development, the Faste Laboratory, Luleå University of Technology, Luleå, 97187, Sweden
[d]Centre for Risk and Reliability Engineering, NTEC, The University of Nottingham, Nottingham NG7 2RD, United Kingdom

* Corresponding author. *E-mail address:* daria.sas@ltu.se

Abstract

Functional Product (FP) has emerged as a business concept aimed at offering a function or performance, mainly in business-to- business applications, on an agreed upon level of availability and cost as well as at providing incitements towards a sustainable growth. Today the literature expanded into various specific approaches and IT solutions measuring sustainability. However, the literature lacks such approaches within the FP context. This explorative paper proposes on a conceptual level a strategy to predict a sustainability impact of an FP in terms of environmental and economic sustainability and optimize the FP configuration. This strategy is based on scenario modelling and simulation - driven approach. The practical significance of the proposed strategy lies in its implication to avoid costly "trial and error" method performed in the real world and to enable the development of more sustainable products. Through the proposed strategy, it is foreseen that sustainability impact can be quantified and minimised during the FP system development.

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1. Introduction

The modern concept of sustainability was introduced globally by the Brundtland Commission in 1987. Since then, research into sustainable development and sustainability assessment has grown exponentially, e.g. Arena et al. [1] and Delai and Takahashi [2]. It has further been shown that sustainability aspects are important in both business-to-business (B2B) and business-to-consumer (B2C) setups [3, 4]. Hence, many manufacturing companies have started to promote manufacturing processes and manufacturing products that minimizes environmental impact whilst maintaining social and economic benefits [5].

According to Lindström et al. [6] there is an increased interest among many global manufacturing companies to transit from traditional business concepts, centered on the sale of products (e.g. hardware, physical artifacts) with additional service, towards sustainable Functional Product (FP) businesses. The FP business concept involves the offering of functionality to a customer under a contract that specifies guaranteed levels of availability and a fixed pricing structure, mainly in B2B setups [7, 8]. Lindström et al. [6] stated that FP consists of hardware, software, service support systems, and management of operation. These constituents shall be concurrently developed and operated in a coordinated way by an FP provider during the entire FP lifecycle [9]. In this paper, the term "FP configuration" is used to describe the design of the complete system (encompassing everything from the design of the hardware products to the choice of service support locations) used by a provider to deliver functionality to its customers under the FP contract.

In addition, the ownership of all four constituents remains at the FP provider [6]. Thus, in contrast to traditional business concepts, the FP therefore transfers responsibilities and risk from the customer to the provider. This includes responsibilities for how the required functionality is realised as well as risks

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due to uncertainties in availability, performance and functional provision costs. Therefore, simulation-driven approaches (frameworks, models, tools) have been developed to support the FP provider to manage responsibilities and mitigate risks [10-13].

Current research on sustainability within the FP context is rather limited. It has been suggested that through total-care commitment an FP provides incitements towards a sustainable business alternative [14, 15]. Sandberg et al., [10] proposed an FP life cycle simulation model for cost estimations. Later, the economic sustainability aspects have been further addressed by developing and implementing a model for predicting and optimizing FP cost and availability during the entire FP life cycle [11-13]. Recently, Lindström et al., [16] outlined how sustainability-oriented values related to management of operation of FP. In addition, sustainability-oriented customer values, e.g., fleet management, advanced service support system and focus on users, that should be communicated to customers when offering or planning the FP business have further been suggested [17].

However, since FP offer does not decrease sustainability impact per se, the FP configuration should be systematically evaluated for specific an FP application. The objective for this paper is to derive a strategy to predict economic and environmental sustainability impact during FP development. By utilization of this strategy it is expected that manufacturing companies can assess uncertainties and risk in terms of sustainability when considering FP as a business alternative.

2. Related research

In the current literature, there exist more than dozen various terms that describe business concepts integrating products and services into a single offer to meet better customer needs [18, 19]. Functional Product (FP) [20], Extended Products [21], Through-life Engineering Services (TES) [22] and Product-Service System/ Industrial Product-Service Systems (PSS/IPS2) [23, 24] are examples of such business concepts.

According to Tukker [25] there are three main categories of PSS, i.e., product-oriented, use-oriented and result-oriented services, which are also, could be applicable for all related business concepts mentioned above.

At first glance, an FP has most commonalities with result-oriented PSS since an FP offers a function. However, an FP has no aim at converting a hardware- based offer into services. The underlying ideas with an FP is to have suitable composition of all four constituents, which should be developed concurrently, and in coordinated way. The FP also involves freedom for the provider to determine the constituents used to deliver the functional performance.

In addition, the FP is similar to use-oriented PSS. In contrast to such type of PSS, the FP business concept can be viewed as a performance-based solution since the FP provider takes full responsibilities to provide function to an agreed upon level of availability and costs. Hence, FP creates incentives for resource efficiency in the value chain during the life cycle. Moreover, an FP business alternative is applicable for the B2B setups and long-term business relationships due to an increased development and operational effort (e.g. sustainable win-win situation, managing risks, and uncertainties) required.

Furthermore, Boehm and Thomas [19] concluded that there is a need for further clarification of terminology, in the field of integrated product service concepts, which should be either clearly distinguished or combined.

Currently, there exists wide range of frameworks and guidelines to evaluate sustainability. However, the literature expanded into various specific approaches and IT solutions measuring sustainability, for example, of PSS business concept. Chen at al. [26] presented state-of-the-art of PSS sustainability assessment approaches including other related works, concluding that still *"existing PSS evaluation researches failed to guarantee the completeness of PSS evaluation."(p. 5823)* Therefore, the use of information axiom to evaluate PSS sustainability, considering all three pillars, has been proposed [26].

In contrast, to the strategy proposed in this paper, the existing PSS sustainability assessment approaches do not explicitly take functional performance in terms of availability into account. Availability refers to the fraction of total time that an FP system is able to perform its required function [27].

3. Research methodology

The simulation-driven strategy presented in this paper was derived through a systematic analysis of existing research from previous research projects carried out within VINNOVA Excellence centre the Faste Laboratory for innovation in the area of FP dating back to 2007. Thus, an extensive literature review was conducted to extract relevant information about simulations of performance-based solutions (e.g. FP, TES, and PSS) and established sustainability indicators including methods for how to derive those. Then, information from the previous research projects regarding models and tools for prediction of FP availability and cost was selected and analysed. These models and tools have been verified and validated by industry partner companies of the Faste Laboratory. These companies operate in manufacturing industries or process industries and are plausible utilisation organisations for the strategy developed in this work. The information flows of the FP availability prediction process was then compared to the information flows when deriving several of the sustainability indicators to identify similarities and possible connection. Finally, based on the findings from the analyses, a simulation-driven strategy was derived through iterations where suggested sequences of activities and resulting states were verified by use of existing methods (for predictions of FP-availability and cost as well as sustainability indicators) and then refined until achieved consistency.

The initial ideas for FP simulation-driven approach have been developed by Löfstrand et al. [11] who proposed a framework for optimisation of FP cost and availability through coupled (hardware and service support system) multi-objective optimisation. Further, Löfstrand et al. [12] described a model based on the discrete event simulation (DES) approach for predicting the availability and service support costs for a single FP contract based on the coupled design of the hardware and service support systems used for the functional provision.