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## Development of a PSS-oriented business model for customized production in healthcare

Golboo Pourabdollahian<sup>a\*</sup>, Giacomo Copani<sup>a</sup>

<sup>a</sup>ITIA-CNR, Via Bassini 15, 20133 Milan, Italy

\* Corresponding author. Tel.: +39-02-2369-9924; fax: +39-02-2369-9925. E-mail address: [Golboo.pourabdollahian@itia.cnr.it](mailto:Golboo.pourabdollahian@itia.cnr.it)

### Abstract

In recent years Mass Customization has been considered as a proper strategy to provide customers with individualized products with a reasonable price. Meanwhile, the trends of aging population and rapid technological evolution have initiated the interest of healthcare sector to production of customized medical devices. Pursuit of such a strategy can result in introduction of manufacturing operations of customized medical devices inside the hospitals. To this end, an innovative business model is required to facilitate and support such a shift by focusing on both product and service perspectives and hence taking into account an integrated product-service system approach. This paper aims at introducing a PSS-oriented business model to support customized production by hospitals. Moreover, a qualitative analysis of pros and cons of each business model configuration is presented in the paper. Eventually, considering each configuration along with its benefits and challenges, the hospital selects the most proper business model base on its strategy and long-term oriented objectives.

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### 1. Introduction

In the past two decades Mass Customization (MC) has been broadly discussed as a potential business model for heterogeneous markets in management literature [1]. In the market settings that are characterized by high levels of customer need heterogeneity, MC has to be considered as an economically viable strategy. On one hand, companies can benefit from higher prices of customized goods due to the increased willingness of customers to pay more for these goods [2]. On the other hand, thanks to the rapid progress in terms of flexible manufacturing processes and suitable customer interaction tools, the customized goods can be provided at a cost level that is comparable to those of mass produced goods [3]. Healthcare is a sector in which product personalization generates a fundamental adding-value for patients. Thus, entering the domain of customization is crucial for healthcare sector considering its potential significant impact on people lives. Additionally, manufacturers of personalized medical products can benefit from market,

financial and strategic advantages compared to traditional manufacturers in this field. Aging population, which is a common demographical trend all over the world, requires improved performance of the players of the healthcare sector [4]. Such improvement can be achieved through both improved services and medical products. Accordingly, production of customized medical devices which are designed based on individual requirements of each patient, is a promising solution. Following this argument, the emerging manufacturing technologies such as additive manufacturing can be considered not only as an enabler for customized production in healthcare, but also as a possibility to eventually change the role of the hospital from a solely user to a producer of products and devices for assisted patients.

Until now, the concept of Product Service Systems (PSS) has been widely discussed as a potential strategy that can be pursued by manufacturing firms. The economic volatility as well as other trends such as globalization and increasing demands for differentiated value propositions have highlighted PSS as a potential approach in many industries.

However, in order to successfully implement the PSS principals, a suitable business model is required to define not only the way in which the company creates, delivers, and captures the value [5], but also the required components to deliver such value.

In order to target the above mentioned issues, this paper aims at investigating the links between these concepts by firstly proposing a business model for customized production of medical products and secondly by defining the PSS-oriented alternatives of the developed business model as well as a qualitative analysis of pros and cons related to each alternative.

## 2. State-of-the-art

From its early introduction as a strategy, Mass Customization has changed significantly the market offer and the value proposition for customers. The concept of Mass Customization is based on the fact that customers like to be treated as individuals and want to be felt important. They do not want to be involved only in purchasing process but they tend to be a part of an experience while buying a product [2]. Meanwhile customers are more concerned about design, aesthetic, function and other attributes of the product they purchase [6]. From the companies' perspective, MC acts as an economically viable strategy. Pursuing Mass Customization enables companies to provide their customers with personalized products, which are produced with near-to-mass production efficiency [7]. MC generates benefits for both company and customers. It enables companies to follow emerging customer trends and bring value to them so that they can be a source of profit generation for the company.

However, despite of all the studies in terms of MC and personalization, customization in healthcare is one of the areas which has been rarely investigated in the body of literature. In fact, the very few existing studies that investigate customization in healthcare are mainly focused on healthcare management rather than manufacturing [8]. Although personalized manufacturing of the medical products might be considered as a revolutionary approach in the healthcare sector, but the lack of enabling technologies to support the efficient production of personalized medical products has been an obstacle and a potential reason of lack of studies in this regard. Nevertheless, the emerging technologies in recent years such as additive manufacturing, 3D printing and micro manufacturing open up new streams of potential application for efficient manufacturing of customized medical devices and products. In fact, these technologies can support the realization of robust production processes as one of the key capabilities of Mass Customization [3]. They have the potential of not only producing high-quality personalized medical products, but also opening the way to innovative business models where the hospital can change its role from a solely user of medical products to a producer. Accordingly, the hospital might extend its core business from a healthcare service provider to a healthcare product manufacturer and service provider at the same time, experiencing the advantages of such an integration. Thus, a new business model is required to be adopted to facilitate and support such

a shift by focusing on both product and service perspectives and hence taking into account an integrated product-service system approach.

The concept of product-service system (PSS) came into exist during 90s by Goedkoop et al. who defined the term as "a marketable set of products and services capable of jointly fulfilling a user's needs" [9]. Nevertheless, the concept has evolved during the time and different authors have looked at it through different lenses. While some studies emphasize on eco-efficient and sustainable nature of PSS [10, 11], others look at the term from a business perspective pointing out PSS as an innovative strategy [12,13]. During the last two decades PSS has got a notable attention and several studies have been carried out investigating the concept, its design methodologies, enabling tools and potential impacts [14]. Although in some studies PSS has been referred as a "business model" [15] itself, it's not enough to consider only the value creation perspective in order to define a PSS business model. In fact, over the past few years the term "business model" has become a fashionable trend and a prevalent term both in academia and industry, while there is still much confusion about a standard definition of what a business model is and how a company can develop a proper business model. From the very first definitions of business model by Jones in 1960, which was focused on money generation as the basic principle of the term, to the more detailed ones including the value creation, information flow [16, 17, 18] and product and services as major pillars, and finally to the most recent and detailed business model canvas pointing out nine main building blocks [19], it can be observed that there are a few studies investigating the business model within the PSS concept [20]. Thus, there is a gap in the literature in this regard.

The current paper tries to target this gap by developing a PSS-oriented business model for customized production in healthcare. Such a business model can be used by manufacturers as a reference to configure their tailored business model alternative considering the context they are operating in.

## 3. PSS-oriented business model alternatives for personalized manufacturing in healthcare

The development process of the PSS-oriented business model for customized production in healthcare has been taken place in two steps. In the first step, a general business model structure has been developed for customized production in healthcare considering the hospital as the manufacturer. The developed business model covers the main strategic decisions to be handled by the hospital. In the second step, the developed business model has been extended to the context of PSS through configuration of four different alternatives for the business model which entail different levels of servitization and customization.

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