

Product-Service Systems across Life Cycle

Toward development of PSS-oriented business models for micro-manufacturing

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Abstract

Micro-parts and microsystems-based products are considered as a crucial value-adding factor for many industrial sectors and thus an increasingly important contributor for the industrial and economic future. The rapid growth of deployment of micro-manufacturing technologies in several sectors necessitates the development and implementation of a proper business model for micro-manufacturing. This paper introduces innovative business models for micro-manufacturing through integration of the concept of product service systems to develop such a business model.

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1. Introduction

Micro-manufacturing applies techniques to produce the micro-sized components and structures. Accordingly, micro-manufacturing technologies involve scaling down of the common and widely used machining processes (i.e. milling and drilling). At the micro-scale level, these technologies are known as micro-technologies (i.e. micro-drilling, micro-machining, micro-embossing). The economic relevance of micro-parts and components has been widely investigated by several market reports [1], [2]. According to the published studies and analysis, many micro-manufacturing related areas and sectors will experience an increasing market share on a continuous basis. Innovative and more affordable products, varying from products for healthcare, safety and communication to those for ambient living and mobility, have been already developed thanks to the micro-manufacturing technologies. Based on the official reports it is estimated that in 2019 the market for micro-electronic and mechanical systems (MEMS) will reach nearly 25 billion Dollars [3]. Such an economic relevance has been a trigger for many industries to pursue, apply and develop new technologies of

micro-manufacturing. In this regard, it is quite essential for the players in the market of micro-manufacturing to apply a proper business model in order to ensure their competitive advantage.

The current business models applied by the players in micro-manufacturing market can be mainly divided into two categories. The first category includes traditional machinery selling business model in which a company buys the micro-manufacturing equipment from the machinery suppliers and operates them in-house. The second category contains the production service business model in which a company having several micro-manufacturing machinery and competency in the operation process offers production as a service to the final product manufacturers. However, the emerging trends in the market of micro-manufacturing necessitates the generation and development of innovative business models which can embrace the new technological development in order to satisfy the evolving needs of the users.

In recent years the concept of Product Service Systems (PSS) has been broadly discussed as a viable strategy for manufacturing firms. Globalization and economic volatility

along with other trends such as increasing awareness for environmental sustainability and growing demand for differentiated value propositions have shifted the attention of many industries, including the players of micro-manufacturing market, toward PSS as a potential beneficial concept to design innovative business models. From the perspective of suppliers of micro-manufacturing equipment, PSS can be a source of potential benefits. It can enhance the integration level with customers, reduce the risk of customer-related uncertainty and even convert it to potential opportunities and benefits and transforms the business model to a more sustainable one. Moreover, in some cases the small-dimensions of the micro-manufacturing equipment (i.e. desktop 3D printers) is a facilitator to move the production to downstream at customer's site through establishment of micro-factories.

To this end, this paper aims at targeting the challenge of introducing new business models for micro-manufacturing following a PSS approach. The proposed business models link the features of product service systems with the potential opportunities created by micro-manufacturing technologies in order to overcome the existing challenges of the current business models for micro-manufacturing.

2. Current business models for micro-manufacturing

The existing business models in micro-manufacturing market can be divided into two main types.

The first type is the traditional type of product selling where the producer of the micro-manufacturing equipment (supplier) sells the physical tangible product (micro-manufacturing equipment) to the user of micro-manufacturing technology (customer). This traditional business model entails a typical production-consumption feature with very limited relationship between the manufacturer and the consumer. Within this model the management of the product will be entirely carried out by the consumer upon its purchase and there is no further involvement of the producer [4], [5]. Eventually the customer is responsible for the usage, operation and disposal of the product. However, in some cases the manufacturer provides the additional service of maintenance to the customer either as a part of the product package or as an on-demand service through specific maintenance contracts. In this business model the operation takes place in-house and the customer (user of technology) is responsible for the operation of machinery. Figure 1 depicts the configuration of traditional selling business model, highlighting the features of the business model for each innovation dimension. The structure of the business model is based on the methodological box for configuration of new business models proposed by Copani et al. [6]. The business model structure consists of two types of building blocks. The first ones identify the characteristic features of a business model such as location of production, payment modes, operation personnel, etc. The second ones are the existing alternative for each characteristic feature. Through combination of different alternative, a new configuration of a business model can be generated. The green circles in Figure 1 represent the configuration of

traditional selling business model for micro-manufacturing where all the dimensions are covered by the customer as the main responsible of the product further to its purchase. This includes areas such as operating personnel, maintenance, procurement, transport, etc. Although the traditional business model makes the consumer independent from the manufacturer, but it has several shortcomings specially considering the market volatility. The initial investment to buy a micro-manufacturing machinery is quite considerable. Moreover, the continuous technological progress of micro-manufacturing technology might increase the risk of obsolescence of the equipment that incurs an additional cost to the consumer. In addition, in most of the cases the user of the micro-manufacturing machinery does not necessarily own the required technological knowledge and resource to run the operation. While the core business of the consumer is much different, it only needs the machinery as a tool to produce the final product and putting additional investment and effort can cause a distraction from the core business.

In order to address the challenges of the traditional business model for micro-manufacturing such as high level of investment and lifecycle cost, lack of competency and resources, and changing the traditional production processes and minimize the risk, in recent years another type of business models are adopted that offer a production service rather than a physical product. In the production service business model, a company that owns several types of micro-manufacturing machines can act as an external skilled partner. A micro-manufacturing production service business model is based on offering the service of production or prototyping of final products to the customer through using various micro-manufacturing technologies owned by the provider. This type of business model entails the concept of servitization where the service is replaced a physical product. Consequently the consumer receives no micro-manufacturing equipment as a tangible product but the production of the final product as a pure service. In addition to the production service, the provider usually offers other services dealing with product/process design, product industrialization, etc. The blue circles in Figure 1 show the configuration of the production service business model where the equipment producer plays a critical role. The configuration is very close to the definition use-oriented business models by Tukker [7]. Most of the critical activities such as operation, maintenance, procurement, and transportation are carried out by the equipment producer while the operation takes place in equipment producer's plant using its own personnel. Having a production service business model, the company operates as a provider of micro-manufacturing services and solutions. While the core value proposition of the company is usually focused on production service, it can propose additional value propositions such as engineering and software development too. In order to run this business model, the company needs a large fleet of micro-manufacturing machines and equipment to ensure the production of custom prototypes and end-use parts for the customers. Usually, the provider is specialized in a range of micro-manufacturing technologies. The target market segments usually include several sectors, but the main final markets are: Medical devices (healthcare), electronics,

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