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Business model engineering for distributed manufacturing systems

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Abstract

Distributed Manufacturing Systems (DMS) and collaborative, decentralized production networks are enablers to establish sustainable and high-competitive value chains. To support the diffusion of DMS, the systematic development of new business models for DMS should be considered in an early stage of forming such value chains. This paper introduces an engineering-based approach to develop and design new business models based on a distinction of four business model elements and using a three level model for designing, planning and managing operations to achieve production excellence in each production unit and ensure strategic probability to enhance implemented DMS to the next evolutionary stages.

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1. Introduction

Product Intelligence is employed in order to know which manufacturing technologies and processes are needed depending on customer requirements. In addition, cost-efficient production is a challenge discussed in the topic of industry 4.0 and 'Internet of Everything' (IoE). The achievements and developments in self-organizing production systems adapted to producing a single part and its production requirements might have a leverage effect on radically changing production concepts and driving concepts such as Distributed Manufacturing Systems (DMS) [1,2].

DMS already provide several benefits in comparison to traditional centralized production concepts [3,4]. Megatrends as Sustainability, Democratization of Design and Open Innovation, Regionalism and Authenticity and Instant Availability can be provided by DMS and drive the change to modern organizational decentralized production [3,5]. Despite the benefits of this concept, some barriers in applying DMS exist in practice. The economies of scale and all associated positive effects in production are among these, as well as the complexity in management of independent production units. In addition to the increasing product intelligence and possibilities through cypher-physical systems in production, the development of adapted business models within DMS

might be an enabler to boost the diffusion of DMS in practice. Therefore, research in DMS should also provide findings as to how DMS business models can be designed, which factors have to be considered in the design process and how such concepts can be developed.

A research topic that has emerged in the past several years, and is also driven by IT and data-driven business opportunities, is Business Model Innovation (BMI). Therefore, BMI will be used in this paper to deal with the question of how business models can be described to match the different value captions and value propositions of networked decentralized DMS and which steps should be part of designing new business models for DMS.

This paper introduces an engineering-based approach to develop new business models for DMS and distinguishes between four business model elements: value proposition, revenue model, value chain and processes, as well as technologies, competencies and key resources. To validate and increase the diffusion rate of a DMS-based business model, the findings of theory of diffusion should be regarded to boost the decentralized production approach as well as the megatrends supporting DMS.

2. Literature Review

2.1. Distributed Manufacturing Systems

Geographically distributed and independent manufacturing units are the common understanding of the term ‘distributed manufacturing’ [6,7]. Kühnle et al. [8] describe distributed manufacturing as a “manufacturing network, whose functionality and performance is independent of the physical distance between the involved systems, units and elements”. Matt et al. [3] provide a set of common and possible forms of distributed manufacturing. One of them, mentioned as the most commonly used and basic type of distributed manufacturing, is to spread the manufacturing capabilities of a standardized product-portfolio globally in local markets close to the customers. Other types are modular and scalable model factory, flexible and reconfigurable model factory, changeable and “smart” model factory, service model contract manufacturing, mobile and non-location-bound model factory, production-franchise-concept and cloud production [9]. In addition to these forms of distributed manufacturing, different combinations exist as well as emerging forms increasingly appearing [3,10,11]. For instance, cloud production has been enabled and driven forward by cloud computing, IoT, virtualization, high-performing computing and service-oriented technologies [12,13,14]. Thus, different specialized Distributed Manufacturing Systems will appear in the next few years and have to be developed from a technology and process architecture as well as from a business and commercial perspective [10,15,16,17].

2.2. Business Model and Business Model Innovations

According to Spieth et al. [18] research activities and the importance of the practice of business models has increased enormously in recent years. Some reasons have been a lack of explanation of the mechanism for doing business with the existing approaches, a perceived gap between the strategic management research and management research on an operational level, as well as that, by changing the traditional value capturing and revenue model within an industry, several companies can challenge the whole market and attack well-established market players.

The concept of Business Modeling provides a describing framework for the business logic or, in other words, how is a company able to generate value and how can it capture some of this value in order to make profit [19,20,21,22]. To describe the business logic, a business model is divided into different core elements or components. There is still an ongoing discussion in research as to which elements or components describe and represent a business model [23, 24,25]. Despite the differences, it is quite clear that, by describing a business model, at least three business model elements will be used to understand the mechanism of value generation through using resources and technologies and value capture by offering unique value proposition and relations with customers and partners. In addition to describing the business logic, the business model concept should serve for opportunity facilitation and

commercialization of new ideas and technologies [26]. In particular, for high-innovative manufacturing companies, it is important to effectively transfer their technological competencies in beneficial value offerings for customers.

Business Model Innovation is often mentioned as a powerful approach and ability to increase the performance in value generation to enable enterprise survivability and growth [27]. Zhang et al. [23] describe Business Model Innovation as a “process to optimize and reengineer complex resources”. It could be appropriate to use a systems engineering approach to identify, develop, optimize and re-design business models [28]. Additionally, the dimensions of innovation or newness should be regarded in this process: new to whom, what is new and the level of newness [29]. Business Model Innovation can be new to the industry or only for a specific market. Regarding the dimension of what is new, Spieth et al. [26] distinguish between three areas: value offering, value architecture and revenue model. These three dimensions are connected to the business model elements, which are nine in total, in this approach. The level of newness is also important to consider according to the addressed industry and influences the diffusion rate of the offered new business model and its characteristics [30].

The research area management of business models and business model innovations attempts to support identifying new logics to generate and capture value. In conjunction with Distributed Manufacturing Systems, the research of business model innovations might be able to propose some valuable recommendations to progress the decentralized manufacturing concept.

3. Business Model Engineering approach for Distributed Manufacturing Systems

3.1. Business Model Engineering – Learning from engineering approaches

Engineering has a long tradition of the systematical development of products, processes, systems (e.g. as manufacturing systems), services, etc., as well as using structured development process models and thinking in development stages. These process models have been designed, applied and optimized for many years. Therefore, they are well-suited for use in designing and developing business model innovations.

Depending on the specific requirements in the applied engineering field, there exist countless process models and approaches. Nevertheless, there are some phases which can be found in many similar models. The analysis of current situation, issues or claims is often the first phase of such development models. After analyzing the status-quo approach to solve issues, ways of departing from the current situation or reaching the target will be explored. After creating and designing various proposals, the newly designed system, product, etc. will be tested. This testing phase includes prototyping, implementing, verifying and optimizing the system or objective and will be rounded off by an official launch. After this phase, the re-design and maintenance will be on-ongoing activity. The following four phases will also be

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