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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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Keywords: Distributed manufacturing systems; Distributed manufacturing; Decentralized production networks; Business models; Business model innovations

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.

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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-orientied technologies [12,13,14] Thus, different specialized Distributed Manufacturing Systems will be 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

used in this paper in an approach known as Business Model Engineering:

- Analyzing and Planning,
- Designing and Prototyping,
- Optimizing and Implementation,
- Maintain and Re-Design.

All phases are connected and can be repeated many times as well as needing to be detailed according to the objective and situation. In the following sections, these four phases will be used to develop business models for Distributed Manufacturing Systems.

3.2. Distributed Manufacturing Systems as an Innovative Manufacturing Concept

As we discussed in the literature review, the concept of DMS isn't completely new and was particularly looked to be established in some countries in Eastern Europe as well as in the new federal states in Germany. Not all efforts were successful and established networks didn't work as they were developed theoretically and were often supported by a government-funded organizational-unit. The question arises at this point as to whether barriers exist which hamper the adoption and usage of DMS as a manufacturing concept and business model. Theory of diffusion deals with the question of which factors support or hinder the adoption of innovations in the event of not considering the innovation development process [31]. DMS, as a modern form of organizational manufacturing concept, could be considered as organization innovation, which needs to be adopted by the market and decision-makers in companies. These factors were identified in countless studies across different kinds of innovations (technologies, products, services, etc.) and, in a large number of them, the following six factors were decisive as to whether an innovation was adopted or not [31,32,33,34]:

- Relative Advantage,
- Compatibility ,
- Complexity,
- Trialability,
- Observability,
- Perceived Risks.

The relative advantage has to be given in comparison to the exiting concepts in the market and the more benefits enabling through DMS are provided, the faster the concept will be adopted. Compatibility facilitates the application in existing environments and networks and links to established business models in deep-rooted value chains. Complexity describes the extent of the perceived transparency of the new concept and the efforts to establish it. Trialability supports the decision-making process, as does Observability. The perceived risks associated with DMS should be also considered when designing DMS business models and networks.

3.3. Design the appropriate business model based on DMS

The first step should be the analysis of the existing situation, the clarification of the objectives and the potential of DMS, as discussed in section 2.1. This paper is focusing on the second step, the designing and prototyping of DMS business models. Therefore, an approach for Business Model Engineering will be proposed (see Fig. 1). This approach for describing and designing business models distinguishes between the following business model elements [25,35,36,37]:

- Value Proposition,
- Revenues,
- Value Chain and Processes,
- Technologies, Competencies and Key Resources.

The subject of the business model element value proposition is the exact formulation of the products and services provided to the business model. Close to this element is the revenue model, which has to be considered at an early stage by designing the Distributed Manufacturing Systems. The revenue model constitutes the economic basis of the system and organization form. The business model element value chain and processes is concerned on the one hand with the basic value structure of the business model and, the other, with the processes necessary for the performance of the value proposition. Basic-addition aligns the value structures and processes solely in achieving added value to its value proposition. The applied technologies (technical and manufacturing) and competencies as well as the key resources are often the unique selling points from a competitive perspective. Therefore, they should be regarded as the fourth business model element for designing new business models for DMS.

3.4. Value Proposition and Revenue Model Design

The value proposition and revenue model are two closely connected business model elements (see Fig 1). In many cases, the design of one of them has an impact directly on the design parameters of the other [38,39]. The design of both elements reflects the offered value generation through the DMS and the organization, as well as how they can achieve revenues as a result of value creation.

To design the value proposition, Osterwalder et al. [40] distinguish the clarification of customer profiles as well as the definition of the value map.

Depending on the target groups and differentiation of value propositions, one or more customer profiles should be described. Customer with similar "jobs", pains and gains can be subsumed to one customer profile. To understand the customer environment and the way it does business are the basis and should be clarified in customer tasks as part of the customer profile. Customer jobs can be issues which they have to deal with or needs they are trying to satisfy. In many cases, clarifying the customers value creation is crucial to defining own value proposition. The listing of customer pains is also a part of the customer profile. Customer pains can be

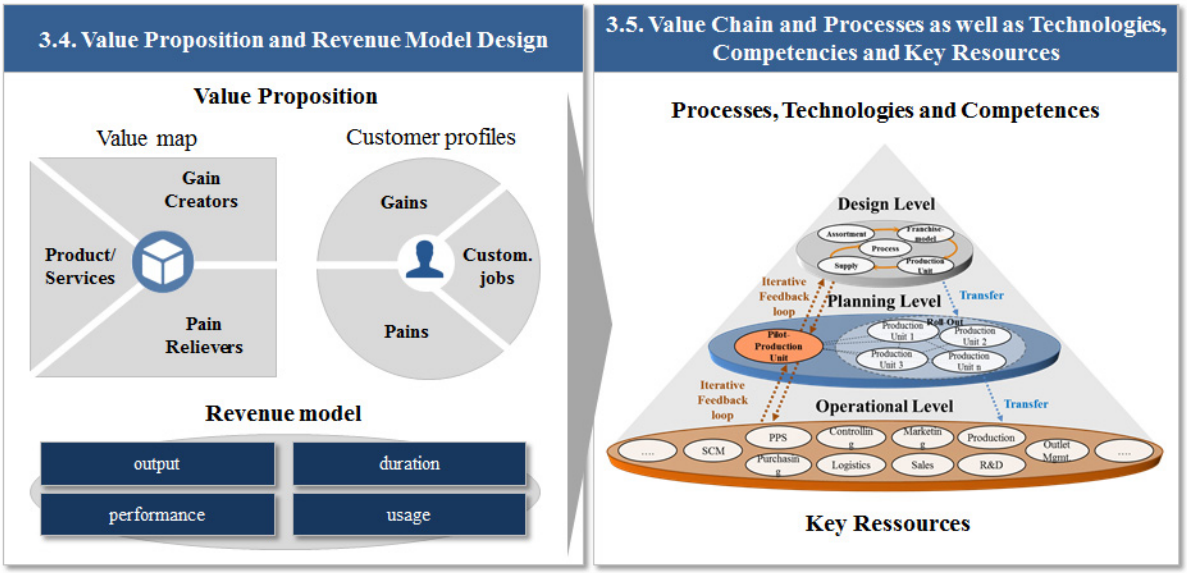

Figure 1: Proposed Business Model Engineering approach.

undesired outcomes and problems, barriers and risks. The third part of the customer profile is gains, what they want to achieve. The distinction between basic (or required) gains and unexpected needs and delighters can be useful to identify a unique value proposition.

The counterpart of the customer profile is the value map. It comprises the offered products and services, the pain relievers as well as the gain creators. The category products and services include all kinds of goods, intangible products, digital services, etc. Displaying possible interdependencies between the offered products can be useful to identify feature gaps as well as leverages. The pain relievers explain how the offered products and services meet customer pains. Tailored pain relievers might be more attractive from a customer's perspective than one general pain reliever and cost-effective overall for both sides. The gain creators are enablers for customer's needs, expected and unexpected outcomes. These gain creators aren't limited to functional or economical aspects, but also emotional and social benefits can be valuable in the customer's perception and an essential part of the formulated value proposition.

By describing the customer profiles and value maps, the value proposition can be developed and defined. However, the final draft of the value proposition can only be done after identification and consideration of the appropriate revenue model.

Achieving revenue as a result of value creation can be done through four types. The revenue model can be based and depend on [41,42]:

- output (unit),
- duration of provision,
- performance level,
- usage.

The first type represents the common model to achieve revenues by selling the produced units. Per each unit, the vendor will be compensated for its value creation. This type also includes the selling of intangible products, in the case of the value creation being specified and defined as a value package in advance.

The second type on which a revenue model can be based is the duration of value creation provision. Revenues are calculated depending on the period for which the services are provided. It is irrelevant as to whether and to what extent benefits are obtained from the customer. However, depending on value proposition, there might be technical restrictions that limit the customer to a certain level.

The third type targets the performance level which can be reached by the vendor. The performance level and revenues calculation are based on predefined performance parameters. Suitable for this are measurable criteria, such as availability, scrap rate, process stability, etc. This revenue model type might be appropriate for more complex services or service bundles. Also, the perceived risk from a customer perspective could be minimized in this option and, thus, increase the likelihood of adoption.

The achievement of revenues based on the usage of the value creation depending directly on customer consumption of the value creation. By applying this type the customer behavior (usage) as the input parameter in contrast to the third type, the level of performance is the output parameter, on which the achievement of revenue depends. This fourth type requires a wide and deep knowledge regarding customer requirements and behavior.

3.5. Value Chain and Processes as well as Technologies, Competencies and Key Resources

By using key resources and competencies, as well as applying technologies, the desired value proposition can be realized. To order and coordinate all used resources, the designing of a business model element value chain and processes is required.

Economies of scale are the principal argument of a centralized manufacturing concept. Thus, the learning curve effect is one which should also be used in the same manner in decentralized manufacturing systems. Therefore, Matt et al. [43] suggest the implementation of a three level model for designing, planning and managing the operations (see Fig. 1).

The first level deals with the general design of the distributed manufacturing system. It describes the architectural design of the applied DMS, the generic configurations on a normative level. For instance, the definition of general quality standards might be part of this level, depending on the DMS type, as well as to ensure the competencies and process knowledge achievements are used through all production units. Also, technology scouting activities are appropriated at this level, as well as other high-strategic tasks.

Derived from the design level, the planning level, known as the second level, describes the pilot production unit as well as addresses all other production units which have to be established and implemented. The designing of the pilot production unit is an essential task within this level, as well as the planning of roll-outs and production transfer projects. Ensuring profitability and ongoing optimization and testing, in particular of scouted new process technologies and the production of new products, are activities on this level. Nevertheless, a lot of the configurations and learning which had to be done in the pilot production unit are more or less also used to describe generic standards on the design level. Thus, the connection between both levels, especially in the beginning of the DMS development, is quite close and iterative feedback loops are usual at this stage.

The third level manages all operations and should achieve highest performance in operation excellence. All processes and configurations of key resources should be tested before they are officially transferred to distributed units and operational issues which can occur in operation should be minimized as much as possible in advance.

The three level model provides feedback and control loops, which are activated by trigger-points. These points initiate re-designing and controlling activities to reconfigure, adapt and transfer the production unit to a higher production excellence, as well as to the next evolutionary stage of DMS.

3.6. Combine the business model elements and validate the design of developed business models for DMS

The fitting of all business model elements has to be verified and regarded after the first design phase of each business model element. In many cases, the elements and differences have to be adjusted and detailed so that the addressed customers achieve value created by technologies, competencies and key resources based on efficient value chains and processes. Checking the consistency of the designed business model is also a crucial step at this point, to identify early on as to whether the business model includes non-matching designed parameters, so that they can be eliminated or reduced.

In checking the potential of competitiveness and increasing the adoption rate of DMS, the criteria mentioned in section 3.2 should be applied and the developed business model should be optimized in such manner so that these criteria are fulfilled as much as possible.

Nevertheless, the design of the developed business model for DMS can be classified as a prototype, which has to be tested under market conditions and optimized in cooperation with customers and partners.

4. Conclusion

The redesigning of manufacturing concepts has only just begun and new concepts as DMS will become an important role in practice. The connectivity and achievements in IoT will drive forward decentralized concepts and will enable other planning and control systems in manufacturing based on DMS thinking.

The development of business models for DMS is also an essential tasks in research, as well as the development progress in cloud computing or standardization. Thus, this paper deals with the question of how business models for DMS can be designed. Starting with a literature review of DMS, business model innovation learning from engineering approaches are outlined and used for a draft business model engineering approach, considering all phases through which a business model often passes, like a life-cycle model.

DMS as an innovative manufacturing form draws on the findings of diffusion theory, which should be given consideration when designing new business models. The suggested business model concept comprises four elements which need to be designed. Value proposition and revenue model are two of these and should be adjusted closely and tested in cooperation with customers and partners. The two other business model elements enable the creation of the offered values. The three level model supports the differences between the various activities necessary to ensure effectiveness and efficiency within the network and each distributed production unit. Thus, it is possible to spread tasks and efforts and provide operational profitability and strategic proactiveness.

The combination of all four business model elements provides a business model which needs to be consistent and should be designed to bring together the centralized manufacturing concepts and yield the benefits of DMS.

The shown Business Model Engineering approach in this paper needs to be applied and proven in further research activities. Based on the DMS manufacturing concept a study should analyze potential applications of DMS. By means of the identified applications case examples of DMS business model innovation will be selected. The described approach should then be applied and validated through real case studies from industry.

References

[1] Loy J, Tatham P. Redesigning Production Systems. In: Muthu SS, Savalani MM, editor. Handbook of Sustainability in Additive Manufacturing, Environmental Footprints and Eco-design of Products and Processes. Singapore: Springer; 2016. p. 145-168.

[2] Butala P, Vrabiè R, Oosthuizen G. Distributed Manufacturing Systems and the Internet of Things: A Case Study. SAIIE25 Proceedings, 9th – 11th July 2013, Stellenbosch, South Africa. Available from: https://ujdigispace.uj.ac.za/bitstream/handle/10210/13015/565-20121-PB.pdf?sequence=1&isAllowed=y [Accessed 25th March2016].

[3] Matt DT, Rauch E, Dallasega P. Trends towards Distributed Manufacturing Systems and modern forms for their design. Procedia CIRP. 2015;33:185-190.

[4] Kohtala C. Addressing sustainability in research on distributed production: an integrated literature review. J. Clean. Prod. 2015;106:654-668.

[5] Putnik G, Sluga A, ElMaraghy H, Teti R, Koren Y, Tolio T, et al. Scalability in manufacturing systems design and operation: State-of-the-art and future developments roadmap. CIRP Ann Manuf Technol. 2013;62:751–774.

[6] Windt K. Distributed Manufacturing. In: The International Academy for Production Engineering, editor. CIRP Encyclopedia of Production Engineering. Heidelberg: Springer; 2014. p. 400-404.

[7] Rauch E, Matt DT, Dallasega P. Mobile On-site Factories - Scalable and distributed manufacturing systems for the construction industry. Appl Mech Mater. 2015; 752-753: 1368-1373.

[8] Kühnle H, Bitsch G. *Foundations & Principles of Distributed Manufacturing Elements of Manufacturing Networks, Cyber-Physical Production Systems and Smart Automation*. Cham: Springer; 2015.

[9] Rauch E, Matt DT, Dallasega P. Mobile On-site Factories - Scalable and distributed manufacturing systems for the construction industry. International Conference on Industrial Engineering and Operations Management (IEOM) Dubai, 3-5 March 2015, Best Track Award.

[10] Kendrick BA, Dhokia V, Newman ST. Strategies to realize decentralized manufacture through hybrid manufacturing platforms. To be published in Robot Cim-Int Manuf. [Prepint] 2015. Available from: http://dx.doi.org/10.1016/j.rcim.2015.11.007i [Accessed 09th April 2016].

[11] Kang HS, Lee JY, Choi SS, Kim H, Park JH, Son JY, et al. Smart Manufacturing: Past Research, Present Findings, and Future Directions. Int J Precis Eng Man. 2016; 3(1):111-128.

[12] Wu D, Greer MJ, Rosen DW, Schaefer D. Cloud manufacturing: Strategic vision and state-of-the-art. J of Manuf Syst. 2013;32:564-579.

[13] Gao R, Wang L, Teti R, Dornfeld D, Kumara S, Mori, M. et al. Cloud-enabled prognosis for manufacturing. CIRP Ann Manuf Technol. 2015;64(2):749-772.

[14] Adamsona G, Holma M, Mooreb P, Wanga L. A cloud service control approach for distributed and adaptive equipment control in cloud environments. Procedia CIRP. 2016;41:644-649.

[15] Stock T, Seliger G. Opportunities of Sustainable Manufacturing in Industry 4.0. Procedia CIRP. 2016; 40:536-541.

[16] Jiang P, Ding K, Leng J. Towards a cyber-physical-social-connected and service-oriented manufacturing paradigm: Social Manufacturing. Manuf Lett. 2016;7:15-21.

[17] Salgueroa J, Muñoz-Cauquia MC, Batistaa M, Calvinoa A, Aguayob F, Marcosa M. R&D&i Management System in Distributed Manufacturing Systems. Procedia Eng. 2015; 132:54-61.

[18] Spieth P, Ricart JE, Schneckenberg D. Business model innovation – state of the art and future challenges for the field. R&D Manag J. 2014; 44(3):237-247.

[19] Dasilva CM, Trkman P. Business model: what it is and what it is not. Long Range Plan. 2014; 47(6):379-389.

[20] Matzler K, Bailom F, von den Eichen SF, Kohler T. Business model innovation: coffee triumphs for Nespresso. J Bus Strategy. 2013; 34(2):30-37.

[21] Teece DJ. Business models, business strategy and innovation. Long Range Plan. 2010; 43(2/3):172-194.

[22] Casadesus-Masanell R, Ricart JE. From strategy to business models and onto tactics. Long Range Plan. 2010; 43(2):195-215.

[23] Zhang Y, Zhao S, Xu X. Business model innovation: an integrated approach based on elements and functions. Inf Technol Manag. 2015:1-8. Available from: doi:10.1007/s10799-015-0225-5 [Accessed 05th March2016].

[24] Werani T, Freiseisen B, Martinek-Kuchinka P, Schauberger A. How should successful business models be configured? Results from an empirical study in business-to-business markets and implications for the change of business models. J Bus Econ. 2015:1-31. Available from: doi:10.1007/s11573-015-0795-z. [Accessed 05th March2016].

[25] Seidenstricker S, Linder C. A morphological analysis-based creativity approach to identify and develop ideas for BMI: a case study of a high-tech manufacturing company. Int J Enterpren Innovat Manag. 2014; 18(5/6):409-424.

[26] Spieth P, Schneider S, Business model innovativeness: designing a formative measure for business model innovation. J Bus Econ. 2015:1-26. Available from: doi:10.1007/s11573-015-0794-0. [Accessed 05th March2016].

[27] Buliga O, Scheiner CW. Voigt KI. Business model innovation and organizational resilience: towards an integrated conceptual framework. Business model innovation and organizational resilience: towards an integrated conceptual framework. J Bus Econ. 2015:1-24. Available from: doi:10.1007/s11573-015-0796-y. [Accessed 05th March2016].

[28] Seidenstricker S, Scheuerle S, Linder C. Buisness Model Prototyping–Using the Morphological Analysis to Develop New Business Models. Procedia - Social and Behavioral Sciences. 2014;148:102-109.

[29] Burgelman R, Christensen C, Wheelwright S. *Strategic Management of Technology and Innovation*. 5nd ed. New York: McGraw-Hill/Irwin; 2008.

[30] Seidenstricker S, Ardilio A. Increase the diffusion rate of emergent technologies. In: Khosrow-Pour M, editor. Encyclopedia of Information Science and Technology. Hershey, PA: IGI Global; 2014, p. 5381-5391.

[31] Rogers EM. *Diffusion of Innovations*. 5th ed. New York: Free Press; 2003.

[32] Rotolo D., Hicks D, Martin, BR. What is an emerging technology?. Res Policy. 2015; 44(10):1827-1843.

[33] Planing P. *Innovation Acceptance: The Case of Advanced Driver-Assistance Systems*. Berlin: Springer Gabler; 2014.

[34] Albar F. *Technology assessment: Forecasting future adoption of emerging technologies*. Berlin: Erich Schmidt; 2011.

[35] Osterwalder A, Pigneur Y. *Business Model Generations. A Handbook for Visionaries, Game Changers and Challengers*. New Jersey: John Wiley & Sons; 2010.

[36] Onetti A, Zucchella A, Jones MV, McDougall-Covin PP. Internationalization, innovation and entrepreneurship: business models for new technology-based firms. J Manag Gov. 2012; 16(3):337-368.

[37] Copani G, Urgo M. Innovative flexibility-oriented business models and system configuration approaches: An industrial application. CIRP J Manuf Sci Techn. 2015;11(11):10-17.

[38] Zott C, Amit R. Business Model Design: An Activity System Perspective. Long Range Plan. 2010;43(2/3):216-226.

[39] Lubik S, Lim S, Platts K, Minshall T. Market-pull and technology-push in manufacturing start-ups in emerging industries. J Manuf Tech Manag. 2013;24(1)10-27.

[40] Osterwalder A, Pigneur Y, Bernarda G, Smith A. *Value Proposition Design*. New Jersey: John Wiley & Sons; 2014.

[41] Bonnemeier S, Burianek F, Reichwald, R. Revenue models for integrated customer solutions: concept and organizational implementation. J Rev Pric Manag. 2010;9(3):228-238.

[42] Desyllasa P, Sako M. Profiting from business model innovation: evidence from payas-you-drive auto insurance. Res Policy. 2013;42(1):101-116.

[43] Matt DT, Rauch E. Design and Implementation Approach for Distributed Manufacturing Networks using Axiomatic Design. In: Farid AM, Suh NP, editor. Axiomatic Design Theory: Recent Developments & Applications. Cham: Springer; 2016.