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Digital lean production – An approach to identify potentials for the migration to a digitalized production system in SMEs from a lean perspective

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Abstract

In times of rising product variants, individualization and demand for flexibility, manufacturing companies are forced to meet economic target values to stay competitive within volatile markets. In order to accomplish these targets, companies implement the principles of lean production to ensure efficient and productive manufacturing processes. As the lean production philosophy is based on synchronization and standardization, currently it is stretched to its limits due to its lack of required flexibility in manufacturing processes and ability to cope with the complexity caused by variants and individualization. Digitization offers the possibility to extend the ability of lean production systems in order to adapt manufacturing processes with respect to the requirements resulting from challenging markets. This paper demonstrates the state of the art regarding lean production as wells as digitization and presents an approach based on the consistent opinion of reviewed literature, which formulates digitization as the next step of lean management in production systems. This study reveals the demand for a methodological approach in a SME environment that quantifies the profitability of the implementation of digital technologies in lean production systems. Based on this study a model for the identification of relevant technologies is suggested and the scope of further research is derived.

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Keywords: Lean production; Digitization; Methodology; Model; Production system

1. Introduction

Manufacturing companies have to prove themselves on challenging markets in particular with low production costs and high quality products. Furthermore celerity regarding innovation and processing times as well as mutability in order to be able to adapt the own manufacturing landscape are vital to be successful in the future [1, 2, 3]. A survey among 280 participants of internationally manufacturing companies confirms the importance of differentiation to the market, raising flexibility and quality, individualization of products, reduction of processing times and processing costs as well as mastering volatility [4]. Efficiency in terms of investment, manufacturing processes and resources is an essential control variable to face future challenges in this context [1].

In Germany, small and medium-sized enterprises (SMEs) have an enormous economic significance as they make up almost 90 % of all the companies of machinery and plant engineering [5, 6]. Especially such companies are challenged by means of implementing lean processes within their manufacturing departments [7, 8] as well as digitization [5]. Concentrating on SMEs this paper focusses the following question from a lean perspective: How can SMEs realize the vision of digitization on the groundwork of lean production in order to raise their competitiveness?

2. Lean production and digitization

2.1. Lean production

Lean management "*provides a holistic, self-contained framework that covers a certain philosophy as well as various methods and tools for the creation of transparency and improvement*" [9]. Lean management is the permanent,

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consequent and integrated assignment of a bundle of principles, methods and actions for an effective and efficient planning, design and control of the whole supply chain of industrial goods and services [10]. It subsumes lean administration and lean production. While lean administration focusses on business processes of indirect corporate divisions lean production prioritizes direct processes [11]. Operations like production planning and control as well as maintenance and repair of necessary machines and workstations are categorized as indirect as they are required but non-value adding. Direct corporate divisions focus on manufacturing and assembling processes as well as logistic operations like provisioning, stocking, commissioning, transporting and handling [12]. Lean management is in an international perspective one of the most commonly used approaches for improvement in manufacturing companies regarding quality, cost and time [13]. Lean production, which has its origin in the Toyota Production System, follows plain rules to reduce waste in processes – so called muda – and focusses on value-adding actions [2, 14, 15, 16, 17]. Methods of lean production are predestined to raise the efficiency of the production department by focusing on value adding processes and reducing non-value adding processes [12, 18]. Therefore, lean production has become an admired conglomeration of methodologies for productivity and efficiency improvement [7, 19], since its principles have been externalized out of its origin in Japan's automotive industry [20].

Practices of lean production – also known as lean manufacturing – are embedded in five core principles [8, 21, 22]:

- Determing the value of each product by the end customer
- Identifying the value flow, core and support processes
- Generating continuous value flow and eliminating waste
- Pulling value from the manufacturer initiated by the end customer
- Seeking continual improvement and perfection

Basically, lean manufacturing principles can easily be applied in manufacturing systems with a low level of mass customization. Less individualized products facilitate the utilization of the stated core principles, as e.g. a manageable number of manufacturing processes can be standardized and synchronized more efficiently. If the level of mass customization rises, the implementation of lean manufacturing becomes more and more difficult [23, 24]. As small and medium sized companies often produce individual products in low volumes, the implementation of lean manufacturing is challenging [8]. Hence, SMEs fear an unfavorable cost-benefit ratio for the implementation of lean manufacturing as they initially see the costs without having certainty about the economical outcome [7]. Furthermore, operative processes are often prioritized as SMEs have an aggravated access to loan financing why investments for the implementation of and migration to lean processes suffer [25].

2.2. Digitization: Definition, potentials and distribution

What is digitization in the context of manufacturing? Besides being a technological trend digitization is an approach to react to rising dynamization and complexity with digital technologies [26, 27]. Manufacturing companies seek to generate high quality goods with the aim of low cost and less time. Digitization offers tremendous potential regarding the improvement of quality, flexibility and productivity [28], as e.g. enterprise resource planning systems enable to raise quality of information management and provide the basis for flexibility of manufacturing processes regarding variants.

On the way to today's phenotype of manufacturing companies underwent three industrial revolutions and are now in the fourth (r)evolution. The first three revolutions had following characteristics and outcomes [29, 30]:

- Mechanization: Introduction of mechanical manufacturing machines run by water power or steam power
- Labor division and large-scale production: Introduction of labor division and large-scale production by means of electric energy
- Numerical controlled machines and microprocessors in manufacturing: Use of electronics and information technology for the automation of manufacturing

The subsequent and pre-announced fourth industrial (r)evolution – also known as Industrie 4.0 in Germany – is digitization. Digitization represents a new level of organization and control in manufacturing landscapes by using digital technologies. Relevant information needs to be available at any time in order to deduce an optimal value flow for producing individualized products down to batch size one. The use of such real time information enables to conjunct objects, systems and humans in order to provide dynamic and self-organizing digital production systems, which can be optimized regarding costs, efficiency or resources [31].

Industries in Germany expect high benefits and immense opportunities with digitization. Digitization especially addresses entrepreneurial core processes – e.g. production planning, manufacturing, assembly, disposition, and logistics – for a significant enhancement of added value. Hence, digitization involves technologies that facilitate to react appropriately to the requirements of challenging markets. 60 % of solutions that have been implemented in companies thus far draw on value adding activities [6]. It offers potential to encounter [29]

- individualization of customers' wishes,
- flexibilization,
- optimized decisioning,
- productivity and efficiency regarding resources,
- added value by new services,
- demography sensible design of workplaces and
- competitiveness of high wage countries.

Despite the apparent potentials, there is an immense spread among manufacturing companies regarding their level of