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Smart Manufacturing & Future Prospects on Logistics

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Abstract - *"Smart manufacturing" is currently a much-discussed topic that supposedly has the potential to affect entire industries by transforming the way goods are designed, manufactured, delivered. This paper seeks to discuss the opportunities of smart manufacturing in the context of logistics management, since implications are expected in this field. At first, a logistics-oriented smart manufacturing application model as well as the core components of Industry 4.0 are presented. Different logistics scenarios illustrate potential implications in a practice-oriented manner and are discussed with industrial experts. The studies reveal opportunities in terms of decentralization, self-regulation and efficiency. Moreover, it becomes apparent that the concept of Industry 4.0 still lacks a clear understanding and is not fully established in practice yet. The investigations demonstrate potential Industry 4.0 implications in the context of Just-in-Time/Just-in-Sequence and cross-company Kanban systems in a precise manner. Practitioners could use the described scenarios as a reference to foster their own Industry 4.0 initiatives, with respect to logistics management.*

1. INTRODUCTION

In recent years, complexity and requirements in the manufacturing industry have steadily increased. Factors such as growing international competition, increasing market volatility, demand for highly individualized products and shortened product life cycles present serious challenges to companies. It seems that existing "approaches" of value creation are not suited to handle the increasing requirements regarding cost efficiency, flexibility, adaptability, stability and sustainability anymore. On one hand, requirements in the manufacturing industry have increased. On the other hand, the rapid technological progress in the more recent past has opened up a range of new business potentials and opportunities. Trends and new catchwords such as digitalization, the internet of things (IoT), internet of services (IoS) and cyber-physical systems (CPS) are becoming more and more relevant. Against this backdrop, Germany, which is well known for its strong manufacturing sector, launched the so-called "Industry 4.0" initiative in 2011 as part of its high-tech strategy, introducing the idea of a (fully) integrated industry. Since then, Industry 4.0 has gained attention importance – also beyond the German speaking area – and has even been listed as a main topic on the 2017 World Economic Forum's agenda.

2. LITERATURE REVIEW

The industrial sector plays a crucial role in Europe, serving as a key driver of economic growth (e.g. job creation) and accounting for 75% of all exports and 80% of all innovations. However, the European manufacturing landscape is twofold. While Eastern Europe and Germany show a constantly growing industrial sector, many Western European countries such as Great Britain or France have experienced shrinking market shares in the last two decades. While Europe has lost about 10% of its industrial share over the past 20 years, emerging countries managed to double their share, accounting for 40% of global manufacturing.

3. INTERNET OF THINGS (IOT)

The term "internet of things" became popular in the first decade of the 21st century and can be considered an initiator of Industry. "Smart, connected products offer exponentially expanding opportunities for new functionality, far greater reliability, much higher product utilization, and capabilities that cut across and transcend traditional product boundaries". Porter and Heppelmann,2014, Also Nolin and Olson note that the IoT "seems to envisage a society where all members have access to a full-fledged Internet environment populated by self-configuring, self-managing, smart technology anytime and anywhere".

4. SMART FACTORY

Up to now, CPS, the IoT and IoS were introduced as core components of Industry 4.0. It must be noted that these "concepts" are closely linked to each other, since CPS communicate over the IoT and IoS, therefore enabling the so-called "smart factory", which is built on the idea of a decentralized production system, in which "human beings, machines and resources communicate with each other as naturally as in a social network" .

5. INDUSTRY 4.0: IMPLICATIONS FOR LOGISTICS MANAGEMENT

We now aim to answer the question whether logistics management might be affected by Industry 4.0. Thereby, we follow the conceptual research approach suggested by Meredith. Our argumentation is based on a simple logistics-oriented Industry 4.0 application model as described in Fig. 1. The model encompasses two dimensions:

(1) Physical supply chain dimension: Autonomous and self-controlled logistics sub systems like transport (e.g. via

autonomous trucks), turnover handlings (e.g. via trailer unloading or piece picking robots) or order processing are interacting among each other.

(2) Digital data value chain dimension: Machine and sensor data are collected at level of the "physical thing" along the entire physical end-to-end supply chain. Via a connectivity layer the gathered data is provided for any kind of analytics (e.g. in the cloud), possibly resulting in potential value-added business services.

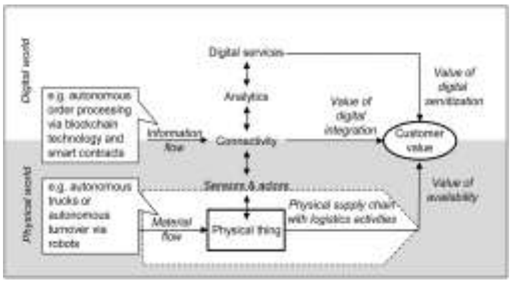

FIG-1 A logistics-oriented Industry 4.0 application model

Out of this two-dimensioned application model, three customer value components are expected. First, the "value of availability", meaning making products and services available to the customer via autonomous delivering.

6. SELECTION OF LOGISTICS CONCEPTS FOR THE INDUSTRY4.0 ANALYSIS

Our selection is based on three aspects. First, the concepts should comprise a cross-organizational component and therefore be closely related to logistics and supply chain management. Recently, articles and papers often focus on specific "intra-logistics" areas – e.g. production logistics.

7. POTENTIAL IMPLICATIONS OF INDUSTRY 4.0- JIT/JIS

Systems generally pass the following process steps and activities: (i) production planning, (ii) production order, (iii) disposition and production, as well as (iv) delivery. Since JIT/JIS particularly rely on planning accuracy, information transparency and well-coordinated transport processes, a special focus is put on these areas. Fig. 2 again illustrates the typical process steps and activities of JIT/JIS systems, highlighting the main implications of Industry4.0. As production planning is crucial in JIT/JIS systems, the increasing use of Auto-ID technologies has the potential to facilitate production planning or even make it futile (step 1).

8. CROSS-COMPANY KANBAN

The Kanban concept originated in Japan and, generally speaking, can be considered a scheduling system in manufacturing. Its core characteristic is a rigid pull-orientation of the production processes, which is why terms such as pull concept or pull system are often used synonymously.

Kanban systems across company boarders include the following process steps and activities: (i) demand assessment, (ii) Kanban signal, (iii) disposition and production, (iv) collection and delivery, as well as (v) goods receipt.

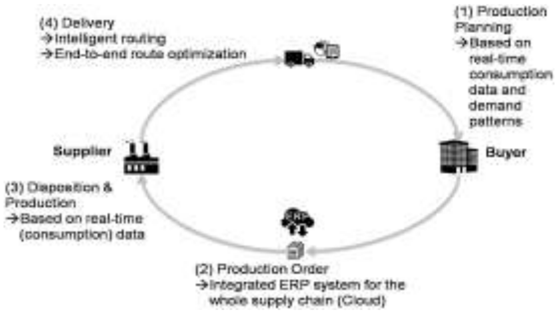

Fig. 2. Modified Just-in-Time/Just-in-Sequence cycle according the Industry 4.0 Scenario.

Due to the use of technologies such as RFID and sensor systems, demand assessment might follow a real-time approach in the future with only little or no need for human participation (step 1). In addition, material requirements may be digitally forwarded, whereas demand is signalled through (physical) Kanban cards or bins in conventional systems (step 2). Due to this precise and real-time oriented information flow enabled by the use of CPS (e.g. "intelligent bins"), suppliers may gain additional flexibility with regard to their replenishment activities (step 3). Furthermore, milkruns might follow a strictly demand-driven logic and therefore become highly dynamic, resulting in more efficient collection and delivery processes (step 4). Besides that, Auto-ID technology facilitates goods receipt processes (step 5).

9. DERIVATION OF KANBAN-RELATED PROPOSITIONS

Based on the findings, we derived a number of propositions (PP), comprising the key implications of Industry 4.0 on the concept of Kanban. In order to discuss and evaluate the relevance and feasibility of these propositions, again expert interviews were conducted. PP1Kanban: Collection and transmission of information within cross-company Kanban systems will be of an increasingly decentralised, automated and autonomous nature in an Industry 4.0 environment, with little or no human interaction through the integration of CPS and the use of Auto-ID technologies such as RFID.

PP2Kanban: Since CPS and the IoT enable a real-time or close to real-time exchange of information between buyers and suppliers, flexibility and ability to react – e.g. in case of sudden fluctuations in demand – will increase in Kanban systems. Expert 1 agrees with the proposition, arguing that market volatility will continue to increase in the future and that demand patterns will become more and more difficult to predict, which means that companies need to improve their flexibility in order to fulfil demand.

PP3Kanban: Due to the high degree of integration and information sharing between suppliers and buyers, Kanban systems will follow a strictly demand-oriented approach in the future, resulting in dynamic, more efficient milkruns and shortened cycle times. Both experts are in complete agreement with P3. However, Expert 2 notes that – from a practitioner's point of view – it remains unclear whether the potential benefits from Industry 4.0 will compensate for the (substantial) investments that are required so as to make companies "ready" for Industry. Nevertheless, both experts predict that Industry 4.0 will increase the efficiency of Kanban cycles.

10. ADDITIONAL FINDINGS

In addition to the concept-related propositions discussed in the preceding sections, all experts were also asked to state their opinion with regard to some concept-independent, generic propositions. PP1Generic: Industry 4.0 will cause a decoupling of the strategic and the operative level of logistics management.

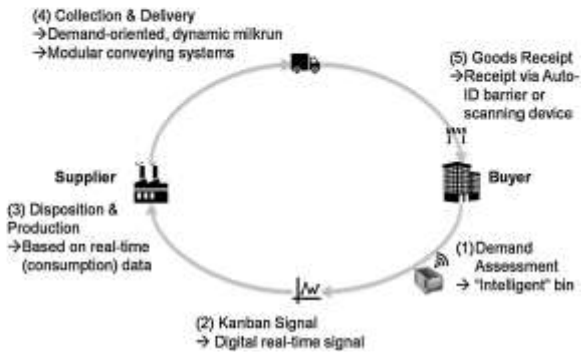

Fig. 3. Modified cross-company Kanban cycle according the Industry 4.0 scenario

11. DISCUSSION

The first cluster of the paper was dedicated to the fundamentals of Industry 4.0. A brief literature review showed that there is no commonly agreed-upon definition and understanding of the approach yet. This finding was also confirmed by the interviews that were conducted later on. Whereas some of the questioned experts are convinced that the Fourth Industrial Revolution will change existing industries significantly, others argue that Industry 4.0 is just a collective term for technologies and concepts that have been known and applied for quite some time. According to its promotors, the Industry 4.0 initiative aims to prepare the (German) industry with respect to the future of manufacturing, which will be characterised by e.g. an individualisation of products, an increasing integration of customers and (business) partners into the value creation process and a mergence of the virtual and physical world through CPS, IoT an IoS. Management fashions often evolve around highly topical issues and result in a substantial number of publications, workshops and conferences.

Conclusion- Within this paper we showed that there is no commonly agreed-upon definition and understanding of Industry 4.0. In the authors' opinion, the Fourth Industrial Revolution can be best described as a shift in the manufacturing logic towards an increasingly decentralized, self-regulating approach of value creation, enabled by concepts and technologies such as CPS, IoT, IoS, cloud computing or additive manufacturing and smart factories, so as to help companies meet future production requirements. The comprehensive nature of this definition requires companies to individually define what Industry 4.0 means to them. As a consequence, there is not one single truth and reality behind this approach. Thus, this paper supports a somewhat dynamic perception, proposing an application model that com-prises different dimensions and components of Industry 4.0. The investigations in the main part revealed different Industry 4.0 opportunities in terms of decentralisation, self-regulation and efficiency. With respect to Kanban, an improved demand assess-ment, dynamic and more efficient milkruns as well as shortened cycle times can be expected. As far as JIT/JIS systems are concerned, reduced bullwhip effects, highly transparent and integrated supply chains as well as improvements in production planning are among the potential benefits. The interviewed experts see the majority of implications on the operative level of logistics management. Yet, besides that, the scenarios also showed the significance of Industry 4.0 with respect to cross-organizational logistics, particularly in terms of real time information flows, end-to-end supply chain transparency and improvements in flexibility, thus helping companies to optimize value-creation. Eventually, Industry 4.0 potentials should be evaluated situationally due to the complex nature of logistics management.

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