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The influence of the Industrial Internet of Things on business models of established manufacturing companies – A business level perspective

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ABSTRACT

The emergence of the Industrial Internet of Things (IIoT) poses a large impact on established business models of manufacturing companies. This study aims at analyzing the influence of the IIoT on these business models from a business level perspective. In particular, it focuses on the interrelationships between business model component changes. While the sparse body of extant management literature examines just a subset of business model elements as affected by the IIoT, a framework comprising an entire set of elements is provided. Besides, their direct and indirect interrelationships, and the most important changes in each of the elements, are investigated. For this purpose, an exploratory multiple case study approach is employed, which is based on relevant IIoT-related experiences of 76 German manufacturing companies. By triangulating data from semi-structured expert interviews and archival company material, the study provides in-depth insights and a better understanding of IIoT-driven effects on manufacturing business models. It contributes to extant management literature by revealing the value proposition, internal infrastructure management, and customer relationships predominantly influenced by the IIoT. Moreover, it is shown that IIoT-triggered business model changes are offer-driven, particularly by production and process optimization within customers' production systems. These value proposition changes result in subsequent modifications of the remaining business model elements.

1. Introduction

The article at hand is dedicated to the following research question: How does the Industrial Internet of Things (IIoT) influence business models (BM) of established manufacturing companies?

Against the background of today's multifaceted challenges for manufacturing companies, e.g., shortened technology and innovation cycles, as well as the necessity to offer customized products at the cost of large-scale production, the German government passed the future project Industrie 4.0 in 2011. The term refers to the more internationally known and academically applied IIoT (e.g., Hartmann and Halecker, 2015; Kiel et al., 2016), which underlines the integration of the Internet of Things and Services (IoTS) into manufacturing as well as internet-based communication of objects. It characterizes the proceeding digitized connection of industrial manufacturing resulting in a completely intelligent, connected, and autonomous factory (Kagermann et al., 2013).

The IIoT results not only in a production-technical change, but also in extensive organizational consequences and opportunities (Arnold et al., 2016). Established value chains are changing and enabling novel business conceptions and models. Established manufacturers are well advised to critically reflect, innovate, and adapt their BMs to stay competitive (Iansiti and Lakhani, 2014; Loebbecke and Picot, 2015).

While prior literature on the IIoT has concentrated on technological foundations, challenges, and opportunities, management research has a backlog (Brettel et al., 2014). With regard to the latter, research deals rather with general influences of the IIoT on BMs. These include, for instance, manufacturers providing novel value offers, the importance of collaboration and networking, and changing workforce qualifications. Precise effects of the IIoT on business concepts are yet insufficiently and not systematically examined. There is no scientific work analyzing an entire BM with regard to its interdependent building blocks (Kiel, 2017). However, it is necessary to examine the complete set of BM components since they are closely interrelated and constitute a BM exclusively in their entirety (Schneider and Spieth, 2013).

In order to address this gap, the article at hand aims at analyzing the IIoT's influence on BMs of established manufacturing companies. It thereby reveals concrete changes in each BM component and their relative importance in terms of their absolute change frequencies. In addition, this allows obtaining an indication of the relationships between component modifications in the context of the IIoT. Owing to the lack of prior systematic research on IIoT-driven business model changes

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and their interrelationships, an exploratory and qualitative case study research design based on 76 in-depth expert interviews as a primary source and, e.g., annual reports and company websites for verification purposes as a secondary source is used. The interviewees' statements were systematically and inductively analyzed and comprehensively displayed by applying the BM ontology (BMO) of Osterwalder et al. (2005), taking a business level perspective. Eventually, this study suggests a framework of IIoT-specific BM component interrelationships.

By doing so, current state of research is extended in several ways. Firstly, while prior research has concentrated on technological challenges or merely single effects of the IIoT on distinct BM areas, this article contributes to the literature by integratively identifying BM elements, which take on a key role in this context, i.e., the value proposition, the internal infrastructure management, and the customer relationships. Secondly, the understanding of IIoT-inherent BM influences is enhanced by focusing on the precise BM changes required in each of its constituent elements. This study extends the current state of research by revealing the possibility of offering production and process optimization within customers' production systems and the emergence of novel contact persons originating in interdisciplinary teams. Thirdly, an integrative illustration of the direct and indirect interrelations of interplaying BM elements contributes to BM and innovation literature since the understanding of relationships between IIoT-triggered BM component changes is enhanced.

The remainder of the manuscript is structured as follows. Section 2 outlines the theoretical background of this research by defining the terms 'IIoT' and 'BM' and explaining the BMO serving as an analytical framework for this multiple case study. The section concludes by displaying the current state of research. Section 3 describes the research design employed and characterizes the examined sample. Section 4 presents the results and Section 5 discusses the findings by illustrating a framework comprising the empirical findings. It concludes with the contributions and managerial implications, along with limitations and further research recommendations.

2. Theoretical background

2.1. The Industrial Internet of Things

The IIoT integrates recent trends from the information and communication technology (ICT) area in industrial manufacturing. It is based on the IoTS, which refers to the "seamless integration of physical objects such as sensors or home appliances (i.e., things) and services" over online networks (de Leusse et al., 2009, p. 47). It serves as a key enabler for the creation of networks comprising manufacturing processes and consequently converting factories into a smart manufacturing environment. In other words, the IIoT involves the integration of both Cyber-Physical Systems (CPS), which connect the physical and the virtual worlds, and the IoTS into industrial processes. This results in several novel implications for value creation, business models, service orientation, and job design (Kagermann et al., 2013).

Correspondent to the definition of Bauer et al. (2014), the IIoT is defined as the "real-time capable, intelligent, horizontal, and vertical connection of people, machines, objects, and ICT systems to dynamically manage complex systems" (p. 18). In this context, the IIoT refers to recent developments with regard to the creation of a novel manufacturing paradigm and environment comprising intelligent and self-controlling objects: smart products are constantly identifiable and steadily locatable, as well as being aware of their latest condition and alternative paths to their destination. Envisioning an extensive penetration with this manufacturing approach, orders guide themselves through entire value chains autonomously and machines set-up automatically as well as rescheduling production on their own if an error is predicted. This so-called 'smart factory' is in control of complexity and is less vulnerable to losses of production.

Consequently, resource efficiency in terms of material usage, energy consumption, and human work is significantly enhanced (Rehage et al., 2013). Further opportunities and potentials associated with the IIoT are, for example, increased flexibility (Saberi and Yusuff, 2011), optimized decision making (Ganiyusufoglu, 2013), customization (Kalva, 2015), highly profitable BMs (Lee et al., 2014), demography-sensitive job design, and improved work-life balance (Kagermann et al., 2013), just to name a few. In parallel, IIoT business ecosystems emerge which interconnect the virtual and the real worlds, involving companies and individuals in different roles, e.g., module providers, machine-to-machine service providers, network operators, and users, that interact and share connected hardware, software, and platforms with one another (Iansiti and Levien, 2004; Mazhelis et al., 2012).

2.2. Business model

Academic literature has begun to agree on some common central characteristics of a BM (Zott and Amit, 2013). These are a BM's focus on the value creation logic for all stakeholders; the consideration of crucial value creating activities performed by parties external to the company, like suppliers and customers; a comprehensive approach to explain the value creation logic of a company; and the fact that BMs emerge as a new unit of analysis in academia. Nevertheless, Zott and Amit (2013) argue that there still does not exist one established BM concept, which is in line with several other authors (e.g., Casadesus-Masanell and Ricart, 2010; George and Bock, 2011; Johnson, 2010). As one universally valid BM definition would have to be very broad to be appropriate for every case, such a standard definition is not even possible, since it would lack specificity and lead to misunderstandings (Zott and Amit, 2013).

Within the multitude of BM definitions emerged to date, Weill and Vitale (2001) regard a BM as the "description of the roles and relationships among a firm's consumers, customers, allies, and suppliers that identifies the major flows of product, information, and money, and the major benefits to participants" (p. 34). Their BM framework is focused on e-business and is constituted by the addressed target customers, product and service offers, revenue sources, critical success factors, core competencies, channels, and IT infrastructure. Linder and Cantrell (2000) stay more abstract, arguing that a BM is the "organization's core logic for creating value" (p. 2). Referring to the BM configuration, pricing and revenue model, channels, and value proposition overlap with those elements described by Weill and Vitale (2001). Linder and Cantrell (2000) differently view a commerce process model, relationships, and the organizational form as further necessary BM elements. Afuah and Tucci (2003) represent another view by regarding a BM as a method to build and use a firm's "resources to offer its customers better value than its competitors and to make money doing so" (p. 4).

Since it is necessary to clearly state, define, and explain the BM concept applied to answer research questions in the respective field of interest (Zott and Amit, 2013), this requires agreement on one definition for the further proceeding of the article at hand. Therefore, the BMO of Osterwalder et al. (2005) is applied as analytical framework. In their work, they systematically identify the nine most common BM components in academic literature by synthesizing the models and conceptualizations most often cited, mentioned, and examined (Osterwalder et al., 2005). Furthermore, the BMO has been developed in the context of information systems, which represent a technological core of the IIoT, is comprehensive, and encompasses a comparably high spectrum of BM components necessary for analyzing BMs as completely as possible (Wirtz et al., 2016).

According to Osterwalder et al. (2005), a BM is a "conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to

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