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Archetypes for data-driven business models for manufacturing companies in Industry 4.0

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Short Paper

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Abstract

The Industry 4.0 phenomenon, internationally known as the Industrial Internet of Things, is expected to enable data-driven business models across the manufacturing sector. While data-driven business models in business-to-customer (B2C) markets are flourishing, driven by trends such as on-demand services, improved resource allocation, niche advertising and the sustainability movement at large, business-to-business (B2B) data-driven business models and the corresponding literature are less pervasive. While scholars have begun exploring firm-specific cases analyzing the introduction of new data-driven business models, e.g. on automotive shop floors, along manufacturing value chains, or in areas such as rail mobility, a comprehensive overview is missing. In response, this paper condenses extant research on data-driven business models in Industry 4.0 and develops several archetypes. These refer to (a) the types of data, which enable new B2B business models, (b), the forms of data-driven business models, e.g., building on sensor data for predictive purposes, and (c) new monetization forms for data-driven business models. The paper further distinguishes the accelerating and decelerating forces, which influence the implementation of data-driven business models in organizational ecosystems. In doing so, the paper intends to create a framework for future research and for practitioners on data-driven business model innovation in Industry 4.0.

Keywords: Industry 4.0, Industrial Internet of Things, Digital Transformation, Data-driven business models, Business model innovation, Servitization

Introduction

The concept Industry 4.0, internationally also known as the Industrial Internet of Things, describes expectations towards a fourth industrial revolution. At its core, digitally enabled horizontal and vertical interconnection of industrial Value Creation shall enable several potentials (Kagermann et al., 2013; Lasi et al., 2014). Industry 4.0 has gained large interest in managerial practice and academic research throughout several research disciplines. So far, technological research and showcases on Industry 4.0 dominate the academic debate, which are often furthermore limited to single factories or showcases. How to generate value out of the technological developments of Industry 4.0, such as through new business models, remains less understood in the current academic debate, especially in traditional industrial sectors (Horváth and Szabó, 2019; Müller, Buliga and Voigt, 2018).

Many potentials of Industry 4.0 are grounded on the generation of Big Data across industrial supply chains, enabling several potentials, such as new, data-driven business models, or data transparency and data analytics (Kagermann et al., 2013; Kiel et al., 2017; Lasi et al., 2014). However, the systematic understanding of business models and business model innovation as a result of Industry 4.0 has just commenced in academia (Frank et al., 2019; Ibarra, Ganzarain, and Igartua, 2018; Müller, Buliga and Voigt, 2018; Weking et al., 2018). Further, the understanding of how Big Data can be turned into Industry 4.0-based business models effectively must be better integrated in this research (Gölzer, Cato and Amberg, 2015; Günther et al., 2017a; Günther et al., 2017b; Witkowski, 2017). Further, while many examples of business model innovation in Industry 4.0 relate to business-to-consumer (B2C) contexts, while many examples cannot be transferred to business-to-business (B2B) contexts easily. Further, many examples for business model innovation within Industry 4.0 include purely service-driven examples, while examples for the manufacturing industry are less prominent within extant literature (Müller and Däschle, 2018; Weking et al., 2018). In response to this research gap, this paper analyzes extant literature on Industry 4.0 and business model innovation and develops archetypes for data-driven business models in B2B and manufacturing contexts

Background

Industry 4.0

Industry 4.0 refers to the expectations towards a fourth industrial revolution. While the previous industrial revolutions (based on steam power, electrification and mass production, and automation) were described sometime after the technological developments were introduced, Industry 4.0 was proclaimed before an actual industrial revolution could be observed. The term Industry 4.0 first occurred in 2011 at the Hanover Fair, describing a concept of the German government to safeguard the competitiveness of its manufacturing industry (Kagermann et al., 2013; Lasi et al., 2014).

Industry 4.0 is based on Cyber-Physical Systems which allow to merge the physical and virtual worlds. This requires sensors to replicate the physical world in the virtual one, data processing and analysis capabilities, and capabilities for communication and interaction. The latter is especially represented within the concept of the Internet of Things. This is why Industry 4.0 is also referred to as the Industrial Internet of Things. Additionally, concepts such as "Made in China 2025" exist worldwide (Kagermann et al., 2013; Kiel et al., 2017; Lasi et al., 2014; Müller & Voigt, 2018).

The integration of Cyber-Physical Systems and the Internet of Things enables three central characteristics of the concept: Horizontal integration, i.e., digitally-enabled interconnection across the supply chain, vertical interconnection, i.e. digitally enabled interconnection across company functions, and end-to-end engineering, i.e., across the entire product lifecycle, from production and product usage to recycling (Kagermann et al., 2013; Lasi et al., 2014).

Additionally, to the technological foundations of Industry, 4.0, economic and social benefits, but also challenges can be observed. These include organizational change, effects on job profiles and tasks, but also new business models that are required in order to benefit from the concept of Industry 4.0 (Barata and Rupino Cunha, 2018; Birkel et al., 2019; Bordeleau and Felden, 2019; Matthiae and Richter, 2018).

Business Models and Business model innovation

Business models have received a lot of attention in research and business practice in recent years (Zott, Amit and Massa, 2011). Although there are a variety of different definitions of business models, most dimensions can be traced back to the following three main elements of a business model: Value Creation, value proposition, and value (Chesbrough, 2010; Foss and Saebi, 2017). Value Creation refers to the tasks a company performs to offer value to its customers. In industrial production, value added comprises the sum of tasks performed at our own production sites as well as those realized by suppliers and partners in the business ecosystem.

Value Capture, also known as monetization, refers to the ways in which a company is rewarded by customers for its value proposition. There are three components: customer groups, customer interaction and payment methods (Baden-Fuller and Haefliger, 2013). Customer interaction refers to the type and intensity of communication with customers, such as personal or impersonal communication. The payment methods describe how a company monetizes its offerings, for example, whether it offers pay-per-use, pay-per-feature or cyclical payments as subscribed to its customers. In terms of customer groups, companies can differentiate between B2B and B2C customers, among others.

Finally, the value proposition is the assortment of products and services of each company and can be on a continuum from pure product offerings to pure services. "Servitization" represents a growing research direction regarding the provision of product-service combinations in industrial manufacturing (Frank et al., 2019; Kohtamäki et al., 2019; Müller, Buliga and Voigt, 2018).

Existing studies show that innovative technologies are of no economic value if they are not embedded in an adequate business model that enhances their potential. In response, companies are required to adjust or innovate their existing business model, described as Business model innovation (Baden-Fuller and Haefliger, 2013; Chesbrough, 2010; Foss and Saebi, 2017; (Zott, Amit and Massa, 2011). This also applies for Industry 4.0, as explained in the following section.v

Business model innovation within Industry 4.0

While the concept of Business model innovation has gained increasing attention from scholars in the last years, the interconnection to Industry 4.0 has been less regarded in comparison to other research fields of Industry 4.0. Only recently has research begun to investigate the topic more closely and in a structured manner (Frank et al., 2019; Ibarra, Ganzarain, and Igartua, 2018; Müller, Buliga and Voigt, 2018; Weking et al., 2018). In the following, a brief overview of extant literature is presented, divided for Value Creation, Value Offer, and Value Capture.

Value Creation

Described changes in production equipment and processes due to Industry 4.0 include, in particular, the increase in overall system efficiency, energy savings, better capacity utilization and lower susceptibility to errors, reduced and predictable maintenance requirements, simplified condition monitoring, autonomous production control and lower inventories (Frank et al., 2019; Müller, Buliga and Voigt, 2018). All these changes require new machinery or updates of existing production facilities, also known as "retrofitting" (Müller, Buliga and Voigt, 2018).

Further, changes in employees as a result of Industry 4.0 are described. In short, it should be assumed that there is a reduction in simple activities and thus also the change in requirement profiles. However, there is a great demand for retraining and retraining. Here, the acceptance of the workforce and access to staff for Industry 4.0 is a challenge for firms that should not be underestimated (Birkel et al., 2019; Müller, Buliga and Voigt, 2018). Further changes include adjustments in suppliers and partners through Industry 4.0. Increased networking is expected to result in a highly collaborative nature of Value Creation, which extends all the way to the end customer. In addition, through increased data transparency, common potentials and efficiency gains would be exploited by means of Industry 4.0. In addition, standardization and the creation of interfaces is a major challenge for partners and suppliers (Birkel et al., 2019; Horváth and Szabó, 2019; Müller, Buliga and Voigt, 2018).

Value Offer

New Value Offers include flexible and customer-specific production facilities, which would significantly increase the quality and efficiency of the machines. New product offerings are also to be expected in the area of data acquisition and analysis, for example in sensor technology or in human-machine interfaces (Müller, Buliga and Voigt, 2018; Weking et al., 2018). Further, novel service offerings through Industry 4.0 are described. On the one hand, this included remote maintenance, simulation and data analysis for the pure service offerings. On the other hand, new product and service combinations can be expected from Industry 4.0, such as the already described "retrofitting" of existing plants, predictive maintenance services, and virtual product development (Frank et al., 2019, Müller, Buliga and Voigt, 2018).

Value Capture

A digitization of payment methods is expected that is more transparent along the value chain. In addition, subscription models such as pay-per-use and pay-per-feature are described, where the customer only pays for the actual service requested (Müller, Buliga and Voigt, 2018). Further, changed customer relationships through Industry 4.0 include a digitized and thus simplified communication, resulting in reduced transaction costs (Kohtamäki et al., 2019; Leminen et al., 2019; Müller and Däschle, 2018).

Findings

Central Requirements for Business Model Innovation in Industry 4.0.

In the following, Figure 1 summarizes the Relationship between Value Creation, Value Offer and Value Capture for business models in Industry 4.0. At the left side, the necessary key resources and key activities (Value Creation) are subsumed. This includes data-based analytics from past or present data, serving to predict future events. In the middle of Figure 2, examples for Value Offers are shown. At the right side, several possibilities for monetization (Value Capture) are highlighted. It is necessary to understand that only a balanced interplay of these three dimensions can form a successful business model innovation.

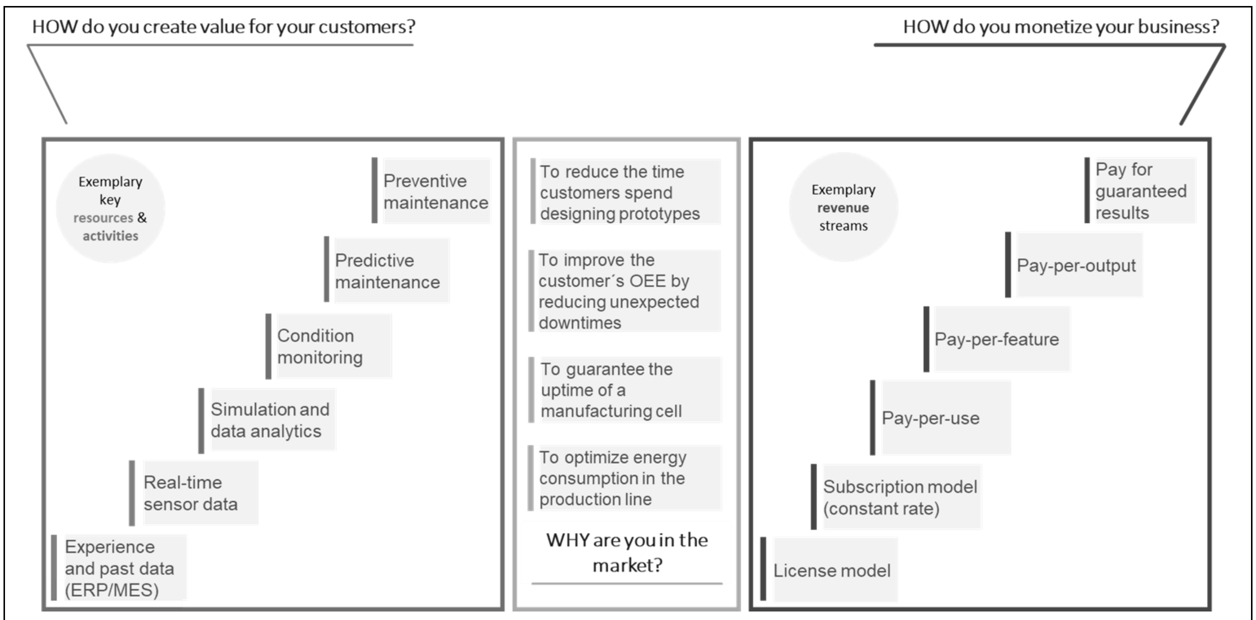

Figure 1. Relationship between Value Creation, Value Offer and Value Capture

In order to illustrate the required fit between Value Creation, Value offer and, Value Capture, Figure 2 below depicts the target of business model innovation in Industry 4.0, aiming for customer success, resulting from an overlap of the promise of a supplier's technology and the customer's business outcome.

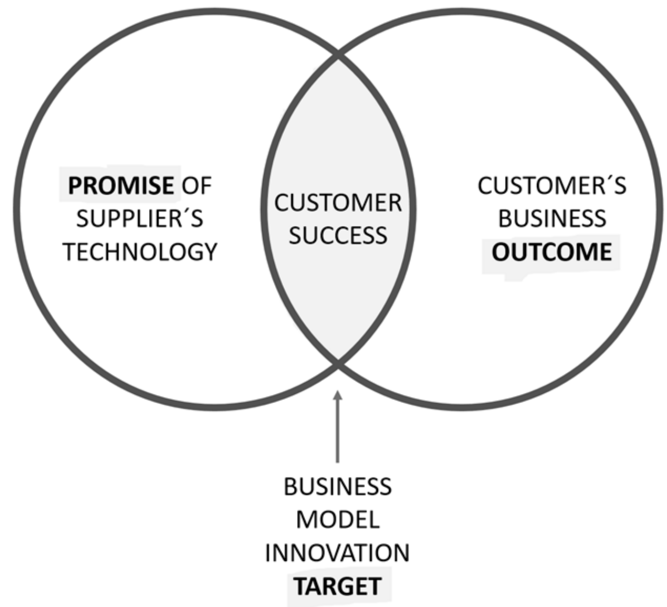

Figure 2. Target of Business Model Innovation

Archetypes for Data-driven Business Models in Industry 4.0

Based on the basic requirements for Business Model Innovation explained above, Table 1 below lists three archetypes for data-driven business models that arise from Industry 4.0 in the B2B context. Further, Figure 1 below lists the respectively most suitable possibilities for Value Creation, Value Offer, and Value Capture mechanisms briefly. Afterwards, the three archetypes for business model innovation are presented in detail.

Table 1. Archetypes for Data-driven Business Models in Industry 4.0

Archetype	Value Creation	Value Offer	Value Capture
Platform-based business models	Data collection and analysis across entire value chains or ecosystems, serving multiple customers.	Sharing data allows multiple stakeholders to optimize existing or uncover unknown potentials.	License, model, Subscription model, Pay-per-use
Use-based business models	Data collection and analysis is conducted constantly, but presentation and evaluation is specific.	Optimization and insights regarding existing processes when needed for customer.	Pay-per-use, Pay-per-feature
Outcome-based business models	Data collection and analysis that is combined with specific, individual services and knowledge.	Services targeted for specific purposes, such as reducing downtime or improving quality, combined with services.	Pay-per-output, Pay for guaranteed results

Platform-based business models

Platform-based business models aim for the generation of Big Data from entire value chains or ecosystems. The idea is to serve multiple stakeholders and customer groups at the same time, thereby creating multi-sided platforms. Platform-based business models typically build on data generated from origins such as Enterprise Resource Planning (ERP) or Manufacturing Execution Systems (MES). Since this data is collected across entire value chains and ecosystems, platform-based business models are not aiming for targeted data collection, but to generate value from the generation of Big Data that is combined on this platform. Therefore, platform-based business models are rather oriented towards generating value for many customers rather than for targeted improvements. Such are rather found in use-based or outcome-based business models, that are described below. It must be noted that platform-based business models in manufacturing environments can only be established by larger machinery or plant engineering companies or by cooperation of several firms. Otherwise, data generation would not be sufficient for data analytics within a Big Data environment. Due to the rather broad range of customers, platforms' monetization model is often based on subscription or license models.

Use-based business models

Use-based business models can often be integrated within platform-based business models, or can be established individually. Instead of offering a broad range of value propositions, use-based business models are based on more specific data-driven services that are only paid for if used by the customer. These include data analytics approaches that collects and evaluates additional data than the one available on a platform, such as real-time sensor data. Since this requires extra efforts for the provider of such a service, and the customer might only require it in specific cases, the use-based business model can be a benefit of both, customer and provider. Typical value offerings include value stream analyses or real-time optimization of production and logistics processes.

Outcome-based business models

Outcome-based business models monetize their value proposition based on an actual outcome achieved for the customer. This can include, among others, the reduction of downtime and improved Overall Equipment Effectiveness (OEE) within a manufacturing cell or improved product development processes. Due to their specifically targeted outcome for the customer, outcome-based business models also require specific data collection and analysis that can be based on, but mostly exceeds data collection of platform-based business models. Often, value propositions of data evaluation and analysis are combined with specific services, such as implementation, consultancy, and process optimization. For Small and Medium-sized Enterprises (SMEs) or firms outside a platform, outcome-based business models present a niche in which they can prevail while preserving their specific customer base and retaining their individual customer contact.

Conclusion

This paper generates an overview of data-driven business model innovations within the concept of Industry 4.0 in the B2B context. In this regard, it extends extant knowledge for many B2C applications to B2B contexts. Especially, the relationship of a value proposition that addresses an actual customer problem with a form of monetization of the provider of this business model is highlighted. Thereupon, several archetypes for business model innovation are developed, including platform-based business models, use-based business models, and outcome-based business models.

For future research, it is recommended to deepen the understanding of data-driven business model innovation in B2B contexts using a) case studies from industrial application and b) broader approaches that compare and explain patterns of business model innovation. For the latter, a better understanding of what type of data generates which type of value proposition that generates a customer benefit and which forms of monetization is advised. As a limiting factor, demand for data-driven value propositions that address customer problems of firms in B2B contexts tends to be present, while acceptance of new forms of monetization is limited. Therefore, the providers of such new business models might be confronted with the efforts, but cannot claim the value added for the customer as a new revenue easily. A better understanding when this problem is present and when it is not, for example in different applications, as well as the communication and acceptance factor of new monetization forms, should be better investigated in future studies.

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