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STATE-OF-THE-ART AND FURTHER DEVELOPMENTS IN BUSINESS MODEL RESEARCH FOR INDUSTRY 4.0

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As the development of Industry 4.0 is predicted to disrupt the current industrial system, newer research studies need to focus increasingly on analyzing the resulting economic implications of these technological changes. One of the most important topics in this context is the influence of Industry 4.0 on business models (BM) and business model innovation (BMI), since for most firms, a change of their extant business model or a completely new business model is needed to fully capture the opportunities offered by the Industry 4.0.
This paper analyzes the existing literature to identify, address and examine the major outcomes, similarities and differences of the important studies, allowing for better description of the current state-of-the-art regarding the influence of the Industry 4.0 on contemporary BMs. Based on this, reoccurring core concepts such as data-centricity, efficiency and individualization, servitization, value networks and platform-based BM are identified and their impacts as well as implications for future research are outlined. To gain additional insights, the use cases of the most prominent business model frameworks in the context of the Industry 4.0 are illustrated and compared side-by-side, highlighting their specific applications, benefits, and limitations.

Keywords: Industry 4.0, industrial Internet, business model, innovation.

Introduction

The concept of Industry 4.0, also known as the Industrial Internet of Things (IIoT) (Schlaepfer et al., 2014) can be described as the application of the Internet of Things (IoT) in the context of industrial production. Industry 4.0 can also be understood as the bundling of different disruptive technologies such as cloud computing, cyber-physical systems, big or

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smart data and augmented reality along with their application in the industrial context specifically.

The use of these technologies will lead to fundamental changes in production processes, including workpieces autonomously finding their way through production, manufacturing facilities mounting themselves based on the information transmitted by products as well as automated ordering of the equipment requiring replacement. To realize this, enormous amounts of data need to be collected, automatically processed and analyzed as well as incorporated into internal and external operational planning process, thereby optimizing the production process overall (Weinberger et al., 2016).

Implementation of these changes is predicted to disrupt the current industrial system (Kagermann et al., 2013). While for a long time, the research in this regard was mainly focused on technologies and standards, it becomes increasingly clear for all actors today that this phenomenon will encompass significant changes on the business level as well (Burmeister et al., 2016; Kiel et al., 2016). One important topic in this context is the influence on business models (BM) and business model innovation (BMI).

Literature review

The business model was defined by (Teece, 2010) as design and/or architecture of value creation, delivery and capture mechanisms that a firm employs. It has become an accepted tool for the analysis of business practices on the holistic level (Laudien and Daxböck, 2016). However, there exists a multitude of different approaches and frameworks that mainly differ in the components used and the level of aggregation (Osterwalder et al., 2005; Casadesus-Masanell and Ricart, 2010; Zott and Amit, 2010).

Overall, the impact of Industry 4.0 on business models is a relatively new research area that has emerged to account for the predicted technological changes and also to integrate their implications into business research.

Kiel et al. (2016) conduct a systematic literature review to identify the way in which academic literature addresses the impact of the IIoT on the business models of established manufacturers from 2011 to 2015. They conclude that there exists no comprehensive picture about the impact of the IIoT on the established BM, but that customized and individualized value propositions as well as smart products and services accompanied by a consequent service-orientation and thereby customer integration are identified in literature as critical changes. In a subsequent study, Arnold et al. (2016) used exploratory, semi-structured interviews to identify the change importance of the BM components by 69 experts across five different industry sectors. These experts identified changes in value proposition based on the optimization at the customers' site via data mining and analytics, a change to the needed core competencies, the intensified customer relationship and the modification of manufacturing activities based on strategic partner networks in interconnected value chains as the most important changes across industries, with varying focuses within these industries.

Laudien and Daxböck (2016) used an inductive, multiple-case study to gather insights on this new topic, thereby identifying the three archetypes of IIoT-based BM for German manufacturing firms: a technology adoption model that uses technology to optimize and rethink processes, a virtual diversification model that establishes a value network, allowing for more complex and complementary offerings while concentrating on the focal firms' core competencies, and a full IIoT BM that utilizes and integrates the usage data from the customers into value creation. According to these authors, IIoT-based BM are driven by themes such as enhanced efficiency of the production process, decentralized real-time information flow and process optimization within the partner network, new value propositions due to digitally enhanced products and direct interaction with customers as well as data access and needed information processing capacities, bundling of resources and capabilities with partners, and access to new data in conjunction with the development of new IT capabilities (big data analytics).

Burmeister et al. (2016) have conducted an explorative, comparative interview study with large companies and industry associations to analyze the Industry 4.0 business model characteristics and implementations, focusing on the innovations within their business models and gaining qualitative insights into how firms approach the innovation process as such. The perception of the 14 interviewed firms ranges from seeing Industry 4.0 as a tool for data-driven efficiency improvements to entirely new roles and product/service combinations, while being hesitant to proactively capture opportunities, especially if these are more distant from their core businesses. The resulting ability to control digital structures, information availability and access may have an impact on firm boundaries, highlighting the increasing importance of networks and platforms.

Based on entrepreneurship and transaction cost theories, Ehret & Wirtz (2016) explore the conditions for designing non-ownership BM that work as an insurance or hedging instrument against uncertainty downsides of manufacturing performance due to Industry 4.0 technologies. Mellor et al. (2016) highlight that no enterprise possesses the full range of skills that are required to address the challenges associated with the IIoT, and this fact increases tremendously the importance of partnerships and networks.

Vandermerwe S. & Rada J. (1988) described a research project that enabled firms to innovate their business models with regards to Industry 4.0 by offering a structured and guided process, using a database of identified business model patterns and IT tools to facilitate the stepwise creation of a new BM while also accounting for potential general and Industry 4.0 specific risks. Even though Weinberger et al. (2016) focus on the IoT, their results capture the same customer specific changes that occur due to the IIoT. Using business model patterns they identify the ones that could profit the most from IoT and coin the term High Resolution Management to account for the greater insight into industrial processes based on the existence and application of high-resolution data.

Weill P., and Woerner S. L. (2015) present their ten theses regarding business models within Industry 4.0, including blurring boundaries between physical products and enhancing services that result in data generation, efficiency gains and cost reduction due to automation and interconnection, new pricing and revenue models, platforms as a dominant design for digital BM, and flexible production and service networks.

Main focus of the study

Within the identified above literature, three frameworks were used most frequently: Osterwalder and Pigneur’s (2010) Business Model Canvas, the Business Model Patterns as well as a third, less defined category that can be loosely traced back to Teece’s (2010) three components value creation, value delivery and value capture. In general, business model frameworks overlap in large parts: all mentioned approaches agree on the components of value generation, delivery as well as a mechanism to generate revenue and differentiate regarding the aggregation level and the boundaries of specific components. However, while the Business Model Canvas aims to be an analysis tool applicable and usable in the business context, Teece's three components are more suited for a descriptive approach, and the Business Model Pattern approach aims to support enterprises in their implementation of new BM by categorizing the existing BM and combining them into new ones.

In the academic context of the Industry 4.0, the Business Model Canvas and the three component approach are used to generate analytical insights into the changes to specific components based on the predicted changes (Arnold et al., 2016; Burmeister et al., 2016; Kiel et al., 2016) or to identify archetypes (Laudien and Daxböck, 2016), while the business model patterns are mainly used to support enterprises in adopting and providing guidelines or structures to design new BM with some exceptions (Weinberger et al., 2016).

In practice, frequently used tools are the Business Model Canvas as a tool for structuring BM ideas and Gassmann's BM Patterns for creativity support (Burmeister et al., 2016). Overall, using mainly three out of several existing BM seems to be based on the prevalence of the respective models and increases their comparability.

As it is typical for nearly all new concepts, the initial studies focus mainly on studying the early adopters using exploratory case studies or aim to derive descriptive and conceptual frameworks to build a solid foundation for future research. These methods shape the current research landscape as they are best suited to generate new insights while large empirical studies are difficult due to still low adoption rate (Laudien and Daxböck, 2016). This is also a major limitation in the current research, actually: Without the existence of sufficient data points regarding the implementation, due to restrictions predetermined by data security and safety as well as missing standards and technical capabilities, investigations are limited to generalize findings from qualitative studies or to rely on projected developments. Therefore, the literature tries to generate insights based on small, qualitative studies, identifying best practices and issues, or tries to develop implementation strategies or frameworks, thereby supporting future implementations for the firms.

However, as results are uncertain, many firms hesitate to take such rather large financial risks while innovating their BM in accordance to the Industry 4.0 needs – which in turn increases the opportunities for those firms which try and succeed. While some authors predict a better handling of uncertainty downsides (Ehret and Wirtz, 2016), Arnold et al. (2016) find no empirical or even perceptive evidence within the current management practices to verify these assumptions. However, this might be explained by the early phase of the adoption process within the Industry 4.0 in general.

Across the reviewed literature, some core concepts seem to reoccur that are agreed upon by practitioners as well as researchers:

The most prominent concept for BM within Industry 4.0 appears to be data-centricity. Based on the enhanced products that include sensors, actuators, and interconnection, additional data can be collected within a firm as well as across firm boundaries, even extending to end users to enhance consumer value and experience (Mellor et al., 2016). This needs to be accompanied by sufficient analysis competencies. Using this data, the lowest hanging fruit is the improvement of the existing processes by increasing efficiency and reducing costs. The presented studies show that this is widely accepted by the firms and most often implemented, creating a lock-in with suppliers (Laudien and Daxböck, 2016; Burmeister et al., 2016).

The generated data allows for customization to customer-specific needs or even integration of a customer into the value generation, thereby enabling an intensification of customer relationships (Arnold et al., 2016; Kagermann et al., 2013), e.g., via enhanced products serving at points of sales (Weinberger et al., 2016). This enables a joint development of new products and services with customers (Kiel et al., 2016). It also allows for customization of products, based directly on customers' needs that no longer contradict cost leadership. Accordingly, the Industry 4.0 is perceived to offer new value propositions and advancements in the value-creating structures, even allowing for B2B2C connections (Burmeister et al., 2016; Kagermann et al., 2013).

These changes of perception and technical possibilities also serve as the foundation for another reoccurring core concept: servitization. Even though this concept has already been widely discussed back in the 1990s (Vandermerwe and Rada, 1988), the enhanced products and gathered data allow for additional services, ranging from predictive maintenance over the offering of assets, processes, capabilities and output as a service to synchronized product/service combinations and value added services (Ehret and Wirtz, 2016; Kiel et al., 2016; Burmeister et al., 2016). This enables new revenue opportunities and allows firms differentiate their offerings so that to win successfully in intense competition.

However, the capacity to analyze the generated data in real time or other challenges associated with IIoT often cannot be handled by individual companies, giving rise to the importance of value/partner networks (Mellor et al., 2016; Kagermann et al., 2013; Arnold et al., 2016) as well as a change in workforce qualifications and culture. Those networks are necessary to acquire the required skills to develop sophisticated solutions for Industry 4.0 and thus are predicted to become decentralized and possibly even created ad-hoc, allowing for real-time and flexible data exchange as needed (Laudien and Daxböck, 2016). Currently, smaller companies are adapting faster to this ecosystem concept than larger ones, probably due to smaller scale and the lower numbers (Weil and Woerner, 2015).

Another, frequently stated concept is the creation of open platforms, where technology leaders or OEMs evolve into platform owners (Burmeister et al., 2016), enabling the offering of specialty solutions. This is closely linked with value networks, highlighting an ecosystem thinking that gains importance due to interconnectedness. Here, platform leadership or at least membership can become vital for a competitive advantage, especially when network effects are considered (Barbian et al., 2016). Even though platform-centricity is predicted to gain importance, companies do not seem to adopt actively or even neglect these opportunities and remain close to their core business (Burmeister et al., 2016; Kiel et al., 2016; Arnold et al., 2016).

Other major outcomes of the current papers are the different business model concepts that categorize and structure possible changes to the BM based on qualitative insights. These are the basis for future quantitative studies as well as for practical implementations by the industry. Additionally, the results correspond in the importance of business model innovations to exploit the possible opportunities. By outlining the importance of value networks, small and medium-sized enterprises should seize the opportunity and distribute possible risks across their partner networks.

Conclusions

Currently, academic and management literature is trying to gain insights on the impact of Industry 4.0 for business models by developing suitable analysis frameworks related to business implications of the phenomenon. This paper has aimed to provide an overview for practitioners and scholars regarding the most important concepts for the implementation, the currently used analysis tools and the state-of-the-art in the research as of today. The presentation of the framework might generate a common ground to keep the usage of frameworks more compact and thus more comparable.

The identified core concepts along with the current research directions indicate that business implications of the transformative effects of the Industry 4.0 have common and important characteristics the literature agrees upon. These concepts comprise the effects on three levels: direct technological implications such as data centricity and efficiency gains, the subsequent implications in the form of servitization, individualization and customer integration as well as indirect implications that require the interconnectedness of value networks to implement changes and open platforms to gain further advantages against the competition.

The main limitations in this research area overall are related mostly to the small amount of actual Industry 4.0 implementations. This serious limitation is likely to diminish in size as both practitioners and scholars are aiming today to develop pilot projects to help facilitate the actual implementations in the industry, thereby gaining additional insights and data for further studies. Leveraging the increasing experience within Industry 4.0, the analytical and perceived concepts should be studied quantitatively to gain more reliable insights. Additionally, the identified concepts are not limited to Industry 4.0 and have already been examined in different contexts. Therefore, it is important to further include other research areas, such as IoT, servitization, open platforms and value networks so that to synthesize the existing knowledge within the Industry 4.0.

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