Industrial Internet of Things (IIoT) Business Model Classification

Completed Research Paper

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Abstract

Currently, there is a mismatch between the potential and the reality of capturing value from the Industrial Internet of Things (IIoT). Furthermore, the lack of empirical guidance on appropriate IIoT business models isn’t helping to address this mismatch. Based on a content analysis of IIoT projects from entrepreneurial firms and incumbents, which we collected from 1,043 publications in industry trade magazines and newspapers over a six-year period (2011-2017), this article identifies IIoT-specific business model elements and archetypes. Our study provides two main contributions. First, our analysis enables a broad understanding of IIoT business models in practice by taking into account different perspectives. Our findings reveal different business model archetypes in the context of IIoT, namely: IIoT digital, IIoT service-centered, IIoT data-driven, and IIoT platform. Second, we derive specific management implications for capturing value from IIoT business models based on our exploration of IIoT business model elements.

Keywords: Industrial Internet of Things (IIoT), Industry 4.0, business model classification, content analysis
Introduction

The Industrial Internet of Things (IIoT) is becoming increasingly important for many companies across different industries (Wan et al. 2016). IIoT technologies interconnect objects/systems and enable the creation of dynamic and self-organizing cross-firm value networks. This new form of flexible and adaptable value creation helps to deal with the increasing volatility of markets, high competition, customer demand for individualized products and shorter innovation cycles (Bauer et al. 2014; Endres 2018). IIoT not only has an impact on production processes but also on business models (Obermeier 2016). Indeed, 80% of firms expect IIoT to have an impact on their business model (BM) (McKinsey Digital 2015). Accordingly, incumbents have to adapt and innovate their BMs to stay competitive—particularly because many entrepreneurial firms are entering the market with innovative BMs.

The emerging literature on IIoT BMs provides valuable foundational knowledge while also highlighting the importance of the phenomenon (Müller et al. 2018; Schaefer et al. 2017). Yet, many IIoT innovations experience difficulties in the search for viable BMs. These difficulties often result from a lack of capabilities and knowledge. In a recent McKinsey (2018) survey, 60% of managers stated that data from sensors provide insights that could be used for business purposes. However, only 10% or less of this data is used. We see this as a BM design challenge that gives salience to the issue of value creation and value capture in IIoT contexts. Our study aims to provide guidance to address this issue. Specifically, our research question is – what types of BMs are appropriate to unlock the potential of IIoT? We answer this question through a qualitative analysis, which leads us to identify four different IIoT BM archetypes that firms should consider. Further, we discuss the BM building blocks through which IIoT technologies can be leveraged.

The importance of engaging in answering such a research question can be linked to an important practical and a theoretical reason respectively. First, despite the widely acclaimed promise of the potential of IIoT for business, there are emerging stories of challenges and struggles in unlocking this potential (e.g., challenges General Electric faced in their highly publicized IIoT initiative (Dignan 2018). This suggests that there is a mismatch between the potential and the reality of capturing value from IIoT. Prior research has shown, however, that this is not necessarily a technology challenge but a BM challenge (Ehret and Wirtz 2017, Müller et al. 2018). Second, at this stage, the literature on IIoT BMs is still in its infancy, with a lack of related empirical research (Baiyere et al. 2016). Although we acknowledge existing BM studies related to the Internet of Things (IoT) such as the works done by Leminen et al. (2015), and Turber & Smiela (2014), these IoT BM studies, however, have a different focus than IIoT studies. IIoT challenges and opportunities that are the drivers of new BMs differ from IoT ones in terms of the manufacturing/production/machine focus (i-Scoop 2019). As a result, there is a lack of guidance on how organizations can configure their BMs to capture business value from IIoT. Thus, to provide specific management guidance on how to capture value from IIoT technologies, it is necessary to adopt a specific focus on IIoT. Accordingly, our study aims to reduce this gap by examining IIoT BMs and their archetypes. By doing so, we aim to provide empirical guidance to managers on IIoT BMs used in practice. To achieve this, we conduct a content analysis of IIoT projects from incumbents and entrepreneurial firms. We found these projects in 1043 publications in industry trade magazines and newspapers over a six-year period (2011-2017).

This study makes two main contributions to IIoT BM practice and theory. First, we add to the limited body of knowledge on IIoT BMs. Based on our analysis of IIoT BMs in practice, we reveal new BM archetypes that were not identified by prior research. In contrast to previous survey-based or case-study based studies on IIoT BMs (e.g., Arnold et al. 2016; Dijkman et al. 2015), our analysis also allows us to focus on a lower level of granularity to analyze IIoT-driven BM elements and their interrelationships. The IIoT projects analyzed are from a broad range of firms, across different sectors and countries, and therefore, provide a broad understanding of IIoT BMs by taking different perspectives into account. Further, the focus on BM elements in our analysis offers businesses insights into concrete IIoT BM elements in place in other firms and industries.

Second, to compare IIoT BMs, we distinguish between start-ups and incumbents. Due to organizational inertia, incumbents often have problems finding new ways to create value (Carroll and Hannan 2000). In
contrast, entrepreneurial firms are more flexible because they are able to design new, more radical BMs from scratch. Further, entrepreneurial firms — in comparison to incumbents — have limited financial resources.

The remainder of this paper first provides background on IIoT and summarizes current studies on BMs in general, and IIoT BMs specifically. The following section then outlines our dataset and analysis approach, which is followed by an explanation of the four identified IIoT BM archetypes, and concluded by a discussion of implications.

**Theoretical Background and Related Work**

**The Industrial Internet of Things**

IIoT (Industrial Internet of Things, also referred to as Industry 4.0) refers to the use of smart machines and sensors to facilitate modern manufacturing and industrial activities. IIoT is a specialized application of the Internet of Things (IoT), which refers to “a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies” (ITU 2019). Although the number of publications in the area of IIoT has increased over the last years, there is no generally widely accepted definition of the term “Industry 4.0” or “IIoT” (e.g., Arnold et al. 2016; Roth 2016) owing to its interdisciplinary nature. We adopt a definition based on a literature review conducted by Liao et al. (2017, p. 3611), who define IIoT as: “the technical integration of CPS (cyber-physical systems) into manufacturing and logistics and the use of the Internet of Things and Services in industrial processes.”

Thus, IIoT emphasizes that the main innovation is the consistent interconnection and digitization of the whole value chain (e.g., Bischoff et al. 2015; Roth 2016). Many of the technologies in the context of IIoT have existed for many years but were used independently of each other. New opportunities arise, however, by joining these technologies in the industrial context (Roth 2016). It is now possible for almost all stages of the production process to be connected, which results in shorter lead and delivery times or the reduction of mistakes. These factors contribute to an increase in productivity (Roth 2016). In addition, production can be individualized due to consistent digital engineering making it cost-feasible, in certain situations, to have a batch size of one, which results in greater customer intimacy (Arnold et al. 2016).

Apart from optimization, companies can use IIoT to expand or innovate their BM. Due to its value-adding potential, companies can expand their product and service offerings. By combining intelligent services, firms are able to develop into solution providers (Roth 2016). It is not surprising then that in recent years IIoT deployment has seen a significant increase. For example, it has been implemented in healthcare for real-time health monitoring to prevent medical failures. In this setting, smart sensors collect health information and send it to the cloud for further access by medical professionals (Hossain & Muhammad 2016). IIoT plays a significant role in other industries as well. For example, according to Jacobson et al. (2017) and Szymanski (2016), IIoT enabled aircraft manufacturing industries implemented IIoT to automate and trace the equipment information while processing large aircraft components assembly. Also, IIoT helps to improve the safety and the security of aircraft products by detecting the use of unapproved parts that don’t meet the requirements of the aircraft design, thus preventing the violation of security standards (Liu & Yu 2013). Secure interoperability between consumers and industries are ensured by providing a standard communications platform that identifies, assembles, and promotes the best communication practices between the IIoT devices and their applications (AllJoyn 2019; Industrial Internet Consortium 2014; OCF 2019).

Some prior studies have focused on the importance and influence of IIoT, and network technologies more broadly, for value creation for an organization, and for society. In particular, they found that business value of IIoT is much higher than what is represented by the number of devices (Roblek et al. 2016) i.e., IIoT’s potential is not yet realized. This is because, while there are many potential benefits, implementation of IIoT also brings major challenges (Müller et al. 2018). The implementation effort is significant and challenging (Li et al. 2011; Moorhead 2013), and requires significant investments in IT infrastructure, IT personnel, and technical training (Popescu 2015).
**Business Models**

A business model (BM) explains how a company creates and captures value (Osterwalder and Pigneur 2010; Teece 2010), and considers both the activities of a focal firm and the operations performed by partners, suppliers, and customers. Accordingly, BMs emphasize a system-level, holistic approach to explaining how firms ‘do business’ (Zott et al. 2011). Over the last two decades, many authors have examined the structure of BMs and described components, elements, types, and ontologies of BMs. The majority agree that *value proposition* (products and services offered by the company; value offered to the customers), *value capture* (method for how the company generates profit from the offer; profit formula), *value creation* (how the value is generated; partners, resources, processes) and *value delivery* (how the value is delivered to the customer; distribution channel, customer segments), are key components of a BM (e.g., Ehret and Wirtz 2017; Johnson et al. 2008; Osterwalder and Pigneur 2010; Teece 2010).

The Business Model Canvas by Osterwalder and Pigneur (2010) also relies on these key components. Osterwalder et al. (2005) and Osterwalder and Pigneur (2010) see the BM as a “conceptual tool that contains a set of elements and their relationships” and “describes the rationale of how an organization creates, delivers and captures value.” The Business Model Canvas is the most widely applied BM framework (Aagaard 2019) and consists of nine interrelated building blocks and is categorized into four pillars of a BM: product (value proposition), customer interface (customer segments, channels, and customer relationships), infrastructure management (key resources, key partnerships, and key activities), and financial aspects (cost structure and revenue streams). The differentiation between nine BM building blocks offers us the opportunity for a fine-grained analysis of BM elements to derive specific management implications for capturing value from IIoT BMs.

**IIoT Business Models**

The research field of IIoT technology-driven BMs is still in its infancy. The majority of studies focus on the technological aspects of IIoT (Arnold et al. 2016; Emmrich et al. 2015). In recent years, several authors have begun to address the impact of IIoT on BMs (e.g., Arnold et al. 2016, 2017; Dijkman et al. 2015; Ehret and Wirtz 2017; Porter and Heppelmann 2014, 2015). However, these studies have constraints. New BMs are often only examined in a specific context (Ehret and Wirtz 2017). Some authors focus on a particular industry, such as machinery and plant engineering (Emmrich et al. 2015). While literature on IIoT BMs is sparse, some initial publications have attempted to categorize such BMs (See Dijkman et al. 2015). However, the siloed view adopted by these emerging studies limits the understanding of IIoT BMs across industries. Previous research has neither focused at a ground level to analyze IIoT-driven BM elements and their interrelationships nor distinguished IIoT specific aspects between start-ups and incumbents.

Studies have classified IIoT BMs into divergent categories based on new innovation methods in multiple business areas such as IIoT combines market resources and customer insights for the planning and control of industrial manufacturing activities, which leads to the latest innovation methods. This has been achieved through the interactions between service markets and manufacturing assets. Based on innovation methods, IIoT-enabled BMs are grouped into provision of manufacturing assets, maintenance and repair, and their operation followed by the innovative information and analytical services that help to manufacture (for example, artificial intelligence and Big data analytics), and latest services for end users (for example, providing customization by integrating end users into the manufacturing chain) (Ehret & Wirtz 2017). Provision of manufacturing assets and their maintenance benefits clients for attaining their residual rights for implementing the manufacturing innovation and offer work contracts. The manufacturing innovations and analytical services help in the development of new models. Combining manufacturing with customers, designers, and entrepreneurs as end-users provides the potential to stimulate the transformation of manufacturing services. Opportunities unfold for companies that attract and stimulate web-enabled co-creation (Ehret & Wirtz 2017). In another recent study, Prause (2015) classified IIoT BMs into open innovation models and service design models based on different business areas for new BMs. When there is a shift from an industrial society to a network-based knowledge and
communication society, the open innovation model plays a role. Developments in information and communications technology have enabled new forms of user integration in innovation methods. Service design models help the clients to design and customize the products according to their specific requirements. After use, the parts of the products can be recycled to generate new products for the same client (Prause 2015).

While several IIoT BMs are in use, market dynamics ultimately determine the BM that the specific company should follow at a given point in time. The Business Model Canvas by Osterwalder and Pigneur (2010) has been utilized in the context of the IIoT as well (e.g., Arnold et al. 2016; Dijkman et al. 2015). It is therefore expected that an IIoT based company will switch its BMs as and when required. This means that an IIoT based company may evolve from one manufacturing style to another due to the changes in BM elements such as value proposition, customer segments, key activities, channels, key resources and key partners, cost structure, revenue streams, and customer relationships (Gierej 2017). Specifically, IIoT is thought to trigger the following changes in the traditional Business Model Canvas’ components:

Value proposition: A value proposition is the primarily influenced BM element that leads to the evolution amongst all examined industries. Value proposition changes, for instance, due to the increasing amount and higher availability of data (Arnold, Kiel & Voigt 2016; Kiel & Arnold 2016).

Customer Segments: Manufacturing companies integrating IIoT into their value chain need to create new markets that didn’t exist previously but require IIoT products. Automotive manufacturers use IIoT technologies to develop a new market segment for an enhanced driving experience for their customers. Tesla, an American automotive company uses IIoT technologies to produce driverless cars marking a new era in the automated driving technology (Gierej 2017).

Key Activities: This BM element is the reason for the evolution in the medical engineering industry sector, electrical engineering sector, and the ICT. Key activities help to realize the IIoT industry value by making it unique in the marketplace (Gierej 2017).

Channels: Companies use channels such as social media and online communities to deliver the value of IIoT technologies. Keeping in mind the opportunities that can be gained through e-commerce, companies utilize e-commerce sites to track potential clients and deliver the values to them. The key partners and the potential clients need to be updated in real-time about the new developments by the company in IIoT specific aspects by integrating them into the corporate infrastructure (Gierej 2017).

Key resources and key partners: Value creation networks are the critical resources for the evolution of any industry that enables an enterprise to produce flexible value propositions. An automated and intelligent connectivity system linking the manufacturers, suppliers, and customers via the cloud platform is crucial as it delivers cost values and efficiency. IIoT implementation requires compatible infrastructural and software resources. For an IIoT-based company, customers are also the collaborative partners that have led to open innovation processes. Therefore, they are also key partners in any IIoT sector.

Cost structure: When it comes to the financial BM, the cost structure element is the most affected one. ICT industries’ production costs are most affected when there is a financial investment surge in the software platform, for example, implementing IIoT technologies to automate the software platform incurs additional costs (Arnold et al. 2016; Laudien and Daxböck 2016). Software-defined IIoT architecture has been suggested to manage the industrial manufacturing units, and the software platform provides an interface for information exchange. The software platform also allocates the network resources to the manufacturing units as and when required (Wan et al. 2016).

Revenue streams: Integration of physical and digital components along with IIoT solutions will alter the revenue stream of a company. The company can then increase its number of product lines and evolve into different industrial manufacturing sectors to increase their profit (Kiel and Arnold 2016; Schaefer et al. 2017).

Customer Relationships: At times, the customers have unique demands that hamper the implementation of IIoT solutions. Individual customer demands lead to lesser standardization in the production cycle, triggering problems in the value proposed. The issue generated due to fluctuating customer relationships creates problems in the IIoT BM value proposition element. Thus the issues in one BM element lead to issues in another (Li et al. 2017).
Data and Method

Data Collection

To investigate IIoT specific BMs, we identified IIoT projects of key industry players in the period 2011–2017. The starting point of 2011 was chosen because the term “Industry 4.0” was first mentioned at the world’s leading industrial technology show HANNOVER MESSE in that year. Similar to Bohnsack et al. (2014), we conducted a content analysis of nine German and international industry trade magazines and newspapers offering different perspectives on IIoT. We mainly focused on German outlets because Germany is a pioneer in IIoT due to its strong mechanical engineering industry (Arnold et al. 2016). These publications provide insights into various industries and firm perspectives. Four of our chosen sources (The Financial Times, The Economist, Handelsblatt, Wirtschaftswoche) are business magazines that focus on business strategy and broader economic contexts. The other five are industry trade magazines that pay particular attention to IIoT affected industries, such as manufacturing (Maschinenmarkt, VDI Nachrichten) and IT and telecommunication (Computerwoche, Markt und Technik). Most of the trade magazines have special sections about innovative technologies and business strategy. VDI Nachrichten, for instance, has an “IIoT and digitization” section, that focuses on topic areas of automation, additive manufacturing, or big data. In all magazines, IIoT and the underlying technologies and BMs are a central pillar of the coverage. These practical papers provide insights into industry and firm perceptions and offer rich descriptions of technologies and associated BMs.

We performed a keyword search for the period from 2011 until 2017 using search terms referring to Industry 4.0 and IIoT, such as “cyber-physical systems”, “batch size one”, “predictive maintenance”, or “smart factory.” A recent study shows that these keywords are most often associated with IIoT (Mauerer 2017). The keyword search resulted in a set of 4963 articles. Afterward, we excluded articles not related to BM elements, which resulted in 1043 articles. We screened the articles for terms associated with BM elements. These are the same terms we used for the coding, as illustrated in Table 2. We derived those from the BM ontology from Osterwalder et al. (2005) and Osterwalder and Pigneur (2010). We segregated the remaining articles according to the companies mentioned - Table 1 provides an overview of the identified companies and the respective number of articles per year.

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Table 1. Articles per firm for the time period 2011-2017.

Because more than one company is addressed in some articles (e.g., cooperation between companies), one article can be assigned to more than one company. Overall, these companies were mentioned 1210 times in a total of 1043 articles. We then analyzed the content of the articles using the qualitative data analysis software NVivo (v12) and the coding scheme. For reliability, we conducted a dual coder analysis and calculated the interrater reliability, which resulted in an acceptable value for Cohen’s Kappa of 0.6 (Fleiss et al. 2013). The two coders coded the whole article collection independently and both used the same codes as listed in Table 2.

**Data Analysis**

We based our content analysis on the BM ontology of Osterwalder et al. (2005). The BM ontology used in this work — the Business Model Canvas — is structured (into nine building blocks) and shows possible expressions of the individual BM elements (for example, quality is part of the value proposition). Based on literature analysis, relevant terms were identified for each building block. We created a code for each BM element, which consists of various search terms related to the respective element (e.g., the search terms: mass customization, risk reduction, cost reduction, convenience, or batch size 1 for the element value proposition). These search terms were derived from existing literature in the area of BMs and the IIoT (e.g., Arnold et al. 2016, 2017; Dijkman et al. 2015; Osterwalder and Pigneur 2010) and enabled us to trace the changes in each BM component. The objective was to identify BM archetypes and its specific elements in the context of the IIoT. Table 2 provides an overview of the terms used for the coding in our content analysis.

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**Customer Interface**

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**Code name** Customer segments


**Code name** Channel

| Used terms| Communication, Distribution, channel (s), Field Sales, Sales, Homepage, Online (Shop | Sales | Platform | Dealer) |

**Infrastructure management**

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<tr>
<td>Used terms</td>
<td>Resource, Personnel, Employees, Software, Knowledge, Know-How, Technology, Data</td>
</tr>
</tbody>
</table>

**Code name** Key partners
Results: IIoT Business Model Classification

In our analysis of 1043 articles based on the codes shown in Table 2, we identified 1353 references to product or value proposition, 2257 references to customer interfaces, 8783 references to infrastructure management, and 1146 references to financial aspects. Drilling down further, the references to customer interface were in relation to customer relationship (38), customer segments (66), and channels (2153). In terms of infrastructure management, 6397 mentions were made in relation to key resources, key partners (746), and key activities (1640). Financial aspects are related to revenue streams (88) and cost structures (1058). Drilling down into our analysis, we were able to identify different types of BMs. In the following sub-section, we present four IIoT BM archetypes as the result of our content analysis and our literature review.

We derive our four BM archetypes by distinguishing between four types of value proposition that result from the merging of the physical and the digital world (Vermesan et al. 2016). Arnold et al. (2016) show that the value proposition is the most often affected BM element in the context of the IIoT. Then, we applied coding queries in NVivo (v12) to connect the other eight BM building blocks to the particular type of value proposition. Finally, since our data varied with regard to the organizational context (incumbents vs. start-ups) and the type of IIoT use (IIoT user vs. IIoT vendor), we added this information to the respective archetype. This led to our four BM archetypes. Our content analysis reveals four types of IIoT driven BMs: (a) IIoT digical, (b) IIoT Service-centered, (c) IIoT Data-driven, and (d) IIoT Platform. The IIoT projects analyzed in our content analysis capture 25 references to IIoT digical BM, 40 to IIoT Service-centered BM, 138 to IIoT Data-driven BM, and 202 to IIoT Platform BMs. In Table 3, we explain the characteristics of these BMs and address the organizational context (incumbents vs. start-ups), the type of IIoT use (user vs. vendor), and Osterwalder and Pigneur’s (2010) four BM pillars. In the following four subsections, we illustrate the particular BM type and include practical examples from the companies in our sample.

<table>
<thead>
<tr>
<th>IIoT Digical BM</th>
<th>IIoT Service-centered BM</th>
<th>IIoT Data-driven BM</th>
<th>IIoT Platform BM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organizational context</strong></td>
<td>Mainly incumbents</td>
<td>Mainly incumbents</td>
<td>Mainly start-ups</td>
</tr>
<tr>
<td><strong>Type of IIoT use</strong></td>
<td>Mainly IIoT-users</td>
<td>Mainly IIoT-users</td>
<td>Mainly IIoT vendors</td>
</tr>
</tbody>
</table>
| **Value Proposition** | - value proposition remains similar, but improvement due to increasing digitalization and process optimization  
- development of hybrid products / digicals  
- additional services, which are close to the current product | - radical change of the value proposition: not the product itself is sold, but the availability of the product  
- producer remains machine owner and operates the machine  
- payment is dependent on the actual use | - data collection, processing and analysis as value proposition  
- customers gain insights into their machines and processes  
- on basis of the data analysis and insights the customers can improve the business outcome | - efficiency enhancement of the entire value chain  
- facilitates transactions between different types of organizations  
- creation of a value creation network  
- creation of new services and BM |
| **Customer Interface** | -Target group: B2B and B2C  
- increasing individualization of the products  
- customer integration in the value creation process | -Target group: especially B2B  
- companies gain insights into the user behavior of the customer ⇒ customer-tailored, additional services can be developed  
- long-term customer relationships | -Target group: IIoT users, who use the data analysis for process optimization or for the development of new BM  
- Higher customer loyalty due to lock-in and new functionalities | -Target group: B2C (mainly transaction platforms) and B2B (integration platforms)  
- Companies can develop new target groups since former competitors often become important customers in platform BM |
| **Infrastructure management** | -process optimization due to the integration of new technologies and the digitalization of the value chain  
- investment in technology factories  
- development of comprehensive software know-how  
- acquisitions and cooperation | -production of the goods as well as data analysis as key activities  
- software specialists  
- acquisitions and cooperation  
- IIoT vendors (e.g., analytics companies) as key partners  
- operation and maintenance of the product as key activity (technicians at customer site) | -data generation, processing, aggregation, analysis, and visualization as key activities  
- descriptive / predictive / prescriptive analysis  
- sensors, adaptable algorithms and efficient IT-infrastructure as key resources  
- development of suitable interfaces for the customer systems and software updates as key activities | - key activity: integration of new customers, developers and partners in order to increase the attractiveness of the platform  
- platform integration |
| **Financial aspects** | -revenues still mainly generated with the product sale | - pay-per-use-model (e.g., operating hours of the machine, | - subscription fee  
- pay-as-you-grow pricing and freemium models | - subscription fee  
- freemium models |
Improved value proposition allows companies to set higher prices - additional revenues due to higher number of product-related services

<table>
<thead>
<tr>
<th>Table 3. IIoT Business model classification</th>
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<tr>
<td><strong>IIoT – Digical Business Model</strong></td>
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<tr>
<td>In this BM archetype, the existing BM is progressively developed, but there is no radical change that alters the industry logic (Emmmrich et al. 2015). Established industrial companies mainly use it (e.g., traditional engineering companies, automobile manufacturers) that use IIoT technologies to optimize their existing value creation processes. This type of BM develops through an evolutionary process – i.e. companies make continuous, gradual changes to the existing BM. Mostly, there is still no complete and consistent digitization of the entire value chain, the focus is usually only on particular sub-areas. Therefore, the extent of change is still limited in this BM type. Companies gradually seek to cover multiple layers of the value creation layer model by increasingly adding digital elements and connectivity to physical products. The value proposition itself remains largely similar and is not fundamentally questioned, but improved by increasing digitization of products or processes. A machine manufacturer, for example, still focuses on the sale of the machine, but additional functions will extend existing hardware or software offerings. Classic, purely physical products are equipped with sensors, actuators or communication systems and become hybrid products, which we call &quot;digicals&quot;. Digicals are a combination of physical and digital components and are able to communicate, and are customizable and expandable. This enables companies to offer numerous product-related digital services such as remote maintenance. BMW, for instance, is driving forward the digitization of the vehicle in the Connected Car segment and offers additional digital services such as real-time traffic information, security warnings, or maintenance services. In addition, by optimizing internal processes companies can achieve shorter delivery times, better quality, or greater flexibility (e.g., greater degree of customization). In this manifestation, the sale of a physical product (asset sale) is still at the center of the BM but is combined with additional, customized services. The increasing share of digital components in the products enables companies to collect additional data about user behavior and therefore enables tracking of customer behavior. The data can be used for specific product improvements and additional services (Hui 2014). A company from the machine engineering sector, for instance, could use the generated data and offer customer predictive maintenance. Plant manufacturers can — and have to — extend their core competencies (not solely production, but also data analysis and consulting) to generate additional revenues. Moreover, providers can create a digital lock-in by integrating digital components in their products and limiting the compatibility (Fleisch et al. 2015). In the connected world, regular updates or new functionalities can enhance customer loyalty (Hui 2014).</td>
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<tr>
<td><strong>IIoT – Service-centered Business Model</strong></td>
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<td>In this BM archetype the IIoT vision — the blend of the physical world with the digital world — is notably reflected. Classic physical products such as machines are connected with digital components such as sensors and the internet (cloud). This enables new value propositions, which are characterized by an increasing service-orientation. This service-orientation can be categorized in two manifestations: (1) creating a product-service-system, where besides the core products sold, additional services are created and commercialized by the use of the above described “digical BM” and (2) selling the product as a</td>
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service, where the customer only pays for the usage. We call the latter service-centered BMs, and note they are expected to be more common in the future (McKinsey Digital 2015; Obermaier 2016; Porter and Heppelmann 2015).

In this BM archetype, technology and machine vendors change from current models, where products are sold once for a fixed price, to pay-by-usage models, where the payment is dependent on the actual use. The product is fully sold as a service. A machine manufacturer, for instance, remains the machine owner and is responsible for the operation of the machine (Obermaier 2016). The new value proposition is the availability of the product at a given time. Siemens, for instance, is using a service-centered BM with a Spanish train operator. Instead of selling trains or maintenance agreements Siemens sells availability (Markt & Technik 2016). By using these BM and the associated non-ownership contracts, customers can reduce uncertainty and “reap the benefit of manufacturing performance as an input for their own value creation” (Ehret and Wirtz 2017, p. 119).

Furthermore, in a service-centered BM, it is possible that the machine is used by more than one customer: during inactive times of one client the machine can be used by another client (McKinsey Digital 2015). This enables companies to increase their customer base. Increasing service-orientation enables companies to generate recurring instead of one-time revenues. Key resources in the service-centered BM are value creation networks and machine specific know-how in order to develop new services. Key partners are companies, which have their core competence in the data analysis.

**IIoT — Data-driven Business Model**

We identified the IIoT data-driven BM as the third archetype. The basis of this BM is the new method of data collection and usage, which is, among other things, enabled by the integration of sensors. The efficient usage and analysis of data is the main success factor of these BMs (Porter and Heppelmann 2015). To create a data-driven BM, companies have to define what they want to achieve with big data and how the data can be generated. Furthermore, it is essential to know how the data will be monetized and which barriers will arise while setting up the BM. Studies show that the largest percentage of the established companies uses the data for advertisements (McKinsey 2018). They gain the data to get better insights into the customer needs. Based on these data, they can adapt their products or services according to the customer needs. So far, the established companies mainly use the data for BM evolutions.

Start-ups, by contrast, mainly use usage-fee (fee for the use of a particular service) or subscription fee (fee for the use of the service) revenue models, where the data are at the center of the BM (Porter and Heppelmann 2015). The companies charge a fee for the generation, preparation, aggregation, or analysis of the data. The main difference to service-centered BMs is that in data BMs the data generating products are not the focus but the data itself are the core of the BM. In the literature, the term “sensor as a service” BM is used as a synonym (Fleisch et al. 2015) to the data-driven BM.

In the industrial context, data-driven BMs can be successful and should be increasingly used in the future, since they help companies to handle the enormous data volume generated by the connected products. The IIoT creates new opportunities beyond the factory floor because companies can use new capabilities like industrial clouds or analyzing methods for big data and exploit information available worldwide information for raising productivity. Especially the integration and combination of data from different areas and sectors (e.g., industrial data, service market data, data from the micro- or macro-environments) enables new BMs. GE, for instance, offers services for optimizing power generation plants connected to the IIoT. The company processes important information from weather forecasts or energy markets and sells the data to the customers (Ehret and Wirtz 2017).

**IIoT — Platform Business Model**

Platforms can support companies in the implementation of the data BM because they connect the market players and enable the exchange of best practices (Evans and Gawer 2016). Hence, firms often apply platform BMs together with data-driven BMs. An example is Relayr that enables industrial customers to analyze the data generated by their machines. The data is combined and processed to identify new BMs in the cloud. The elevator manufacturer Schindler, for instance, services its elevators with the help of Relayr (Handelsblatt 2016). Relayr’s BM is solely based on the provision and processing of data and the associated consulting activities. The company is operating in the industrial sector without producing a
physical product (except sensors, which are necessary to generate the data). The data itself and the analysis of these are the central value proposition of Relayr.

In the context of the IIoT, different sectors are growing together more strongly. Companies try to establish product-service-systems, where products and services of different sectors are integrated because they aim to create a holistic solution for the customers (Porter and Heppelmann 2014). Therefore, companies should use open-innovation approaches and platforms in their BMs to integrate external and specific knowledge in the production process (BMWi 2015). The case of the agricultural engines producer “Claas” illustrates how this can work. The company developed an internal, closed platform to gain information about the machine usage behavior of its customers. Unfortunately, this closed platform was not successful. Thus, Claas decided to solve this problem by establishing of an open platform structure, which is called 365Farm Net, where, Claas and other companies (also from different sectors) offer services. The chemical concern Bayer, for instance, provides information about the agricultural weather and gives advice about which time which plant protection products should be used. The farmers share their experiences about fields, harvests and pest infestation. All the information is collected in a virtual cloud. Currently, more than 2000 farmers are using the chargeable platform. This example shows how a successful platform between business (key) partners and customers can be created (Emmrich et al. 2015; 365FarmNet 2017).

The incorporation of the IIoT via a platform enables the vendors to create new niche markets with new customer segments. Due to the increasing service-orientation products are becoming more interesting for other customers, since they do not have to buy the whole product, but only pay for the usage. Moovel, a subsidiary of Daimler, exemplifies this. The platform sells mobility as a service and places different means of transport via a mobile application to customers. Moovel has shares in MyTaxi, Carpooling.com or Flixbus and has created an extensive partner network. Serving as a mediator for means of transport, Moovel broadens the portfolio of Daimler (Emmrich et al. 2015; Moovel 2017). Apart from selling cars (target group: mainly affluent, 40+) Daimler additionally takes on the role of the mobility provider, which enables the company to reach different customer segments (young people).

The importance of platforms as a communication and distribution channel is increasing in the IIoT context because it enables firms and customers to exchange products, services, and information via predefined communication streams. First, platforms can be used to increase attention about and awareness of new products (McKinsey Digital 2015). Second, these channels can be used for machinery and plant engineering. On a technology platform, various companies from one sector (and also external firms) could offer diverse services and solutions (e.g. availability of production capacity, an efficient configuration of production lines, training) to the customers. Third, platforms can support the clients during the buyer decision process. In the manufacturing industry, there is a trend towards “contract manufacturing,” where companies predetermine the desired parts with the help of CAD models (McKinsey Digital 2015). Based on these specifications, the machine manufacturer realizes the production of the parts. SLM Solutions, a producer of 3D printers, and the software company Atos, for instance, have started a pilot project for the development of an integrated B2B platform for 3D printing (Atos 2014). The aim of this project is the creation of a production network, where the machines are connected via the Internet and the orders can be produced with an optimal operating rate.

**Discussion**

By using the Business Model Canvas, we were able to illustrate how particular BM elements can be changed or refined within four different archetypes. First, our study shows the relationship between BM elements that underlie different BM archetypes. Such knowledge can be useful for organizations striving to formulate and implement an IIoT BM. We also observe differences in the configuration of BM elements within the different archetypes that companies subscribe to. Additionally, our analysis suggests that a major IIoT-specific BM aspect lies in the distinction between IIoT vendor/provider and IIoT user. This indicates that the IIoT BM archetypes unfold differently for companies depending on whether they are positioned as IIoT providers or IIoT users as illustrated in the example of Relayr and Schindler. An analytics firm such as Relayr is a typical IIoT vendor or provider that enables industrial customers to analyze the data generated by their machines. This company provides a cloud-based platform where the data are combined and processed in order to identify new BMs. The elevator manufacturer Schindler services its elevators with the help of Relayr and is, therefore, a typical IIoT user. Our analysis shows that
because companies have different roles (as either IIoT provider or users) in the market, they need to identify the most fitting IIoT BM archetype for their context, regardless of industry. On the one hand, there are some IIoT providers that provide the technologies and infrastructure needed to connect machines, products, processes, and people. These include, for example, telecommunications and software providers, IT service providers and manufacturers of automation technology. On the other hand, there are IIoT users, who use the technologies and products provided by the IIoT providers and integrate them into the value chain to optimize existing processes or pursue new BMs (see also Kagermann et al. 2013: a dual strategy to increase the competitiveness of the German industry). Second, our content analysis also shows that start-ups and incumbents often pursue different BMs due to various underlying conditions (resource constraints, path dependency). Therefore, it is useful to examine which BM types are primarily used by start-ups and by established companies (incumbents) respectively.

Based on our study, we are able to outline some managerial implications that are worthy of attention by organizations. First, as a result of the increasing digitalization and interconnectedness of production, new core competencies are emerging and, consequently, new work requirements will arise for the workforce. Employees need more knowledge in software development as well as in data analysis as this is one of the core activities in new BMs (Arnold et al. 2016). Second, the same software coding is being used for all products, which increases the vulnerability to piracy - as the markets for apps or digital programs illustrate. This is the reason for the so-called "all-or-nothing markets", in which one provider has a monopoly position, are increasing (Wildemann 2016). Especially in the case of platforms, where network effects are an essential characteristic, it is important to reach the critical mass in a short period of time. Third, the creation of new organizational structures is required to support new BMs. To stay competitive in the IIoT context, established companies have to adapt or innovate their organizational structures. Current organizational structures are often not suitable for the new business environment. Production companies are becoming a mixture of hardware and software companies due to the increasing integration of information and communication systems and the resulting intelligent, connected products (Porter and Heppelmann 2015). Finally, we see a need for the formation of strategic partner networks. Particularly, established companies in the field of plant construction and engineering need to build up competencies in the area of data aggregation and analysis to offer new, data-driven services in addition to their products. Therefore, they should cooperate with ICT companies, who have experience and knowledge in this area.

Conclusions, Limitations, and Future Research

This article explores IIoT BMs in practice intending to identify their IIoT specific components and overall BM archetypes. By analyzing 1043 publications in trade magazines and newspaper articles published during 2011-2017, we were able to explore the main categories of BMs in use in the context of IIoT, i.e. IIoT Digical, IIoT Service-centered, IIoT Data-driven, and IIoT Platform. Using a fine-grained analysis based on the Business Model Canvas, and considering incumbent and start-up companies, we were also able to provide specific characteristics of each BM archetype. Our results add to the limited body of empirical evidence of BMs in the context of IIoT. We provide insights for researchers by highlighting existing practice. Our results are useful for practitioners by providing a consolidation of commonly used BMs and their characteristics, which can help organizations, determine what BMs might be suitable at a given point of time.

Our study, however, is not without limitations. First, as with any qualitative research, there is a risk of bias in the coding of our data. To mitigate this risk, we used a dual-coder approach. Second, we recognize that a large proportion of the publication outlets were German. However, the scale of publications identified (over 1000) and our inclusion also of international outlets, as well as business magazines, reduces the risk of relying on a particular country context. Nevertheless, future research could validate or extend our findings by using outlets from other countries. Second, our study focuses on BM classification but does not address challenges and barriers of each BM archetype. This, however, is an interesting avenue for further research in this area. Third, our findings are limited to the IIoT context. Future research could validate the identified archetypes in other areas, such as smart cities, agriculture, energy, or environment protection. Finally, we did not discuss further differentiations or variations of BM types within the particular BM archetypes such as the "IIoT platform BM". Thus, future research could address these aspects to extend insights on the identified archetypes.
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