Business model innovation in small- and medium-sized enterprises

Strategies for industry 4.0 providers and users

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Abstract

Purpose – Industry 4.0 is expected to significantly transform industrial value creation. However, research on business models affected through Industry 4.0, and on small- and medium-sized enterprises (SMEs), remains scarce. In response, the purpose of this paper is to address both aspects, further elaborating on the role that SMEs can take toward Industry 4.0 as provider or user.

Design/methodology/approach – The paper used an exploratory research design based on 43 in-depth expert interviews within the three most important German industry sectors, mechanical and plant engineering, electrical engineering and automotive suppliers. Interviews were conducted with leading personnel of the respective enterprises, including 22 CEOs. They assign business model implications through Industry 4.0, referring to the Business Model Canvas, while the paper delineates between Industry 4.0 providers and users.

Findings – The paper finds that key resources and value proposition are among the most affected elements of the business model, whereas channels are the least affected. Furthermore, distinct characteristics between Industry 4.0 providers and users can be delineated. In general, Industry 4.0 providers' business models are significantly more affected than users, except for key partners and customer relationships.

Research limitations/implications – Industry 4.0 remains at its early stages of implementation. As a result, many interviewees' answers remain at a rather general level.

Practical implications – Strategies for the further alignment of the business models are provided for Industry 4.0 providers and users.

Originality/value – The paper is among the few that investigate Industry 4.0 in the context of SMEs and business models.

Keywords Manufacturing industry, Case studies, Small- and medium-sized enterprises, Industry 4.0

Paper type Research paper

1. Introduction

Industry 4.0 is a concept initiated by the German government that intends to introduce a paradigm shift toward a digital future in industrial production. It is an attempt to ensure future competitiveness for German industry (Kagermann *et al.*, 2013; Lasi *et al.*, 2014). Industry 4.0 attempts to address two developments for German industry within a common program, changing environmental conditions and relevant technological developments (Lasi *et al.*, 2014). Examples of changing environmental conditions include globalization, increased market volatility, abbreviated innovation cycles, intensified competition and increasing complexity (Lasi *et al.*, 2014). Relevant technological developments in industrial production include increasing automation, digitalization and interconnection between machines, products and users. These developments are based on the concept of the Internet of Things, which will be introduced into the German manufacturing industry (Kagermann *et al.*, 2013; Lasi *et al.*, 2014).

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In addition to securing Germany's industrial position in the world through efficient value creation, Industry 4.0 intends to provide flexibility and customization of products and services (Kagermann *et al.*, 2013). Ecological and social benefits, such as reduced energy consumption, waste reduction and new, adaptive work environments, also will be achieved through Industry 4.0 (Kagermann *et al.*, 2013; Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017; Müller, Kiel and Voigt, 2018). Along with technical challenges, organizational conversions must be faced regarding Industry 4.0 (Loebbecke and Picot, 2015). One of the main elements within these conversions is the business model, where highly profitable new or changed models are predicted (Arnold *et al.*, 2016; Kagermann *et al.*, 2013; Loebbecke and Picot, 2015). In contrast to research in technical fields regarding Industry 4.0, economic challenges and potential, especially relating to business models, thus far have been examined less (Arnold *et al.*, 2016; Brettel *et al.*, 2014; Loebbecke and Picot, 2015). Therefore, this paper attempts to support research in the field of Industry 4.0 and correlated effects on business models.

Further, leading personnel of small- and medium-sized enterprises (SMEs) can understand and describe changes for the entire business model (Müller, Buliga and Voigt, 2018). Therefore, investigating the user and provider perspectives of Industry 4.0 regarding business model innovations is especially suitable in SMEs. SMEs have major significance in the German economy, encompassing 99.6 percent of enterprises, 59.4 percent of employees, 54.8 percent of value added and 35.9 percent of annual turnover (German Federal Ministry of Economic Affairs and Energy, 2014). However, research in the field of SMEs and Industry 4.0 remains rare (Müller, Buliga and Voigt, 2018). Conclusively, this paper addresses the following research question:

RQ1. Which specific characteristics regarding user and provider perspectives of Industry 4.0 exist in SMEs toward Industry 4.0-triggered business models?

In response to rare research in this field, this paper applies an exploratory research design that is based on 43 in-depth expert interviews. These were conducted within the three most important German industry sectors: mechanical and plant engineering, electrical engineering and the automotive industry. Interviews were conducted with leading officials of the respective enterprises, including 22 chief executive officers (CEOs). These interviews were used as primary sources, whereas archival data were used as secondary sources. By analyzing the interviews, obtained statements were allocated to the elements of the Business Model Canvas by Osterwalder and Pigneur (2010). Subsequently, those were analyzed regarding the user and provider perspectives of Industry 4.0.

In essence, this paper addresses the research topic of the appropriate design of companies' business models in order to extract value from new technologies (Chesbrough, 2010). Technologically triggered business model innovation remains an acknowledged but comparatively less researched stream in business model research (Baden-Fuller and Haefliger, 2013). In response to technological developments, such as Industry 4.0, companies need to correspondingly adapt their business model, fostering opportunities and meeting challenges that arise (Saebi *et al.*, 2016). The topic of new or changed business models that are enabled or challenged through Industry 4.0 remains a relatively new topic that few studies have investigated so far (Arnold *et al.*, 2016; Ehret and Wirtz, 2017; Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017). Especially addressing their unique characteristics regarding Industry 4.0, SMEs require research that supports them on redeveloping or extending their existing business models. However, SMEs' business models considering Industry 4.0 have been neglected thus far (Müller, Buliga and Voigt, 2018). Therefore, this paper addresses the topic of business model innovation through Industry 4.0 in SMEs. It delineates the user and provider perspectives toward Industry 4.0 that play a vital role in how companies approach the concept (Kagermann *et al.*, 2013).

2. Theoretical background

2.1 Industry 4.0

The term Industry 4.0 encompasses the expectations of politics and corporate practice that industrial manufacturing is heading toward a fourth Industrial Revolution (Kagermann *et al.*, 2013; Liao *et al.*, 2017; Maynard, 2015). The previous three Industrial Revolutions have achieved high productivity increases driven by a few fast-spreading general-purpose technologies, such as mechanization, electricity and information technology (Veza *et al.*, 2015). These general-purpose technologies resulted in strong technical improvements and initiated complementary developments (Bresnahan and Trajtenberg, 1995). For Industry 4.0, the underlying technology is represented by cyber-physical systems, whose technological infrastructure is based on the concept of the Internet of Things (Kagermann *et al.*, 2013; Lasi *et al.*, 2014; Xu, 2012). Together with cloud computing, cyber-physical systems and the Internet of Things are regarded as the central technological foundations of Industry 4.0 (Zhong *et al.*, 2017).

In Industry 4.0, cyber-physical systems establish an interconnection between the physical world and cyberspace (He and Xu, 2015; Ren *et al.*, 2013). The systems create mechanisms for human-to-human, human-to-object and object-to-object interactions along the entire value-added chain (Kagermann *et al.*, 2013). The task of integrating humans into this concept remains a challenge as it faces employees' resistance, including fear of being replaced or having inadequate skills (Frazzon *et al.*, 2013; Gorecky *et al.*, 2014; Hirsch-Kreinsen, 2016; Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017).

The integration of cyber-physical systems into industrial production leads to the creation of cyber-physical production systems (Schlechtendahl *et al.*, 2015). These can fulfill their potential when interconnected across the entire supply chain (Haddud *et al.*, 2017). Cyber-physical production systems enable several data-based services, such as predictive condition monitoring and balancing and reducing energy consumption within production (Shin *et al.*, 2014; Tao *et al.*, 2011). Those features are established along the entire lifecycle of machinery and products (Lennartson *et al.*, 2010).

Aside from cyber-physical production systems, Industry 4.0 is driven by technological developments such as service-oriented architectures (Guinard *et al.*, 2010; Mikusz, 2016; Raja *et al.*, 2013; Vogel-Heuser *et al.*, 2015). These enable the creation of new services and product-service utilities (Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017; Ehret and Wirtz, 2017). Those developments result in the concept of smart production, also termed smart manufacturing (Davis *et al.*, 2012; Radziwon *et al.*, 2014; Wang *et al.*, 2016; Zuehlke, 2010). Smart production is characterized by manufacturing of intelligent, personalized products and by high levels of collaboration through production networks (Lasi *et al.*, 2014; Veza *et al.*, 2015; Xu *et al.*, 2014).

Besides the German Industry 4.0 initiative, similar initiatives have been developed worldwide (Liao *et al.*, 2017). The European Union has started a public-private partnership under the title "Factories of the Future" to achieve sustainable and competitive production (European Commission, 2016). In the USA, similar efforts are underway through the Industrial Internet Consortium. In China, the "Internet Plus initiative" and "Made in China 2025" represent programs comparable to Industry 4.0, and are among several approaches worldwide (Liao *et al.*, 2017; Müller and Voigt, 2018).

2.2 Small- and medium-sized enterprises

In Germany, the term SME refers to companies with less than €50m in sales and fewer than 500 employees (German Federal Ministry of Economic Affairs and Energy, 2014). For this paper, SMEs represent a fruitful research context for various reasons.

First, prospects for Industry 4.0 can primarily be expected because of the horizontal and vertical interconnection of the value chain. In German industrial value creation, SMEs represent an essential part, as they represent 99.6 percent of all enterprises, generating more than 50 percent of the GDP. In turn, integrating SMEs is perceived as a key success factor of Industry 4.0 (Müller, Buliga and Voigt, 2018).

Second, existing studies reveal that SMEs' specific challenges differ from those of large companies regarding Industry 4.0. These challenges include resource limitations, low bargaining power and concerns that existing business models might be unsuitable for Industry 4.0 (Müller and Voigt, 2016; Müller, Kiel and Voigt, 2018). SMEs also tend to have distinct characteristics regarding the introduction of information technologies in general (Sharma and Bhagwat, 2006). Therefore, SMEs require solutions tailored to meet their specific challenges, but research has mainly focused on large enterprises rather than on SMEs (Müller, Buliga and Voigt, 2018).

Third, the upper management of SMEs is able to supervise the whole enterprise. The managers' knowledge reveals information about Industry 4.0 that affects the whole enterprise and the entire business model. They may possess knowledge of key aspects within their enterprise and can therefore provide both an external and internal perspective (Müller, Buliga and Voigt, 2018).

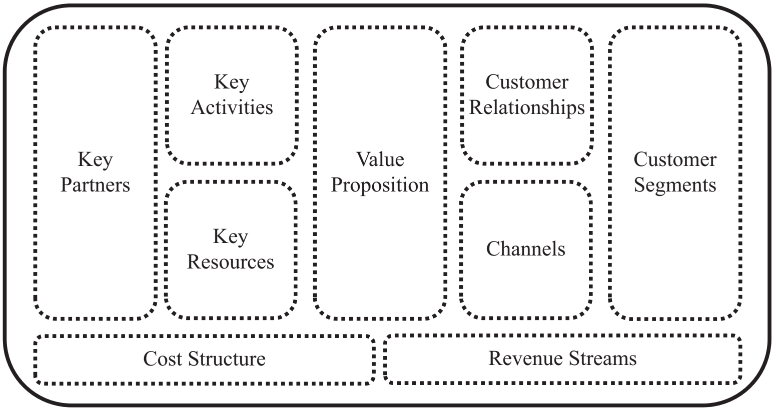
2.3 Business model innovation

Companies can extract value from new technologies only through suitable business models (Chesbrough, 2010). Technological innovation therefore is a key driver for business model innovation (Baden-Fuller and Haefliger, 2013). In response, companies must adapt their business models to external threats and opportunities (Saebi *et al.*, 2016). By introducing Industry 4.0, manufacturers are able to develop new customer value (Arnold *et al.*, 2016; Ehret and Wirtz, 2017; Müller, Buliga and Voigt, 2018). This is expected through new services and product-service systems. Manufacturers can take two roles, the user or the provider perspective of Industry 4.0 (Kagermann *et al.*, 2013).

Whereas different approaches describe business models, most of the current literature agrees on central aspects: creating and capturing value by providing a value proposition to customers (Casadesus-Masanell and Ricart, 2010; Zott *et al.*, 2011; Zott and Amit, 2013). This paper used the Business Model Canvas by Osterwalder and Pigneur (2010). It originates from the Business Model Ontology by Osterwalder *et al.* (2005). The Business Model Canvas is used in current literature to analyze business models from a practitioner's perspective. It has proven to be a comprehensive approach to business models, as its nine building blocks assist in generating a holistic and nuanced view on business models (Wirtz *et al.*, 2016).

The following description offers a brief summary of the building blocks within the Business Model Canvas. The value proposition provides an overview of a company's bundle of products and services. Customer segments describes the groups of customers that a company wants to offer value. Channels describe the various means that the company utilizes to contact its customers. Customer relationships explains the types of links that a company establishes between itself and its different customer segments. Key activities describes the arrangement of activities and resources. Key resources outlines the competencies necessary to execute the company's business model. Key partners portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value. Cost structure summarizes the monetary consequences of the means employed in the business model. Revenue streams describes the ways that a company makes money through a variety of revenue flows (Osterwalder and Pigneur, 2010). Figure 1 illustrates the nine building blocks within the Business Model Canvas.

Several authors in business model research address the capabilities and impacts of digital technologies on business models. However, the specific impact of Industry 4.0 on business models remains a field scarcely investigated (Arnold *et al.*, 2016). Furthermore, empirical investigations of business models in context of the Industrial Internet of Things



Source: Osterwalder and Pigneur (2010)

Figure 1. Business model Canvas

mostly have not focused on the special requirements of SMEs (Arnold *et al.*, 2016; Echterfeld *et al.*, 2016; Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017; Müller, Buliga and Voigt, 2018).

3. Research design

This qualitative empirical study aims to present the impacts of Industry 4.0 on business models of manufacturing SMEs. First, the study generates an overview of business model changes brought from Industry 4.0 for manufacturing SMEs. Changes in the nine building blocks are highlighted, supported by exemplary expert statements. Further, the paper attempts to differentiate between several business model changes that are specific for the user or provider perspective upon Industry 4.0. Therefore, relative frequencies of affected building blocks are used to show differences and similarities. The perspective of providers encompasses manufacturing cyber-physical systems and selling them to customers. Users of Industry 4.0 apply cyber-physical systems in production and services. This delineation presents an important categorization that companies can take regarding Industry 4.0 (Kagermann *et al.*, 2013). The delineation between providers and users of Industry 4.0 investigation is especially suitable in the context of SMEs. SMEs often have a focused and often single business model that can be overseen by top managers, in contrast to larger enterprises (Müller, Buliga and Voigt, 2018). The paper thereby also attempts to overcome the limitation of single key informants not being able to report complex organizational phenomena (Glick *et al.*, 1990; Hughes and Preski, 1997).

Because of scarce prior research on Industry 4.0-related effects on business models of manufacturing SMEs, an exploratory qualitative research design was chosen. This is appropriate in exploratory research as rich data can be obtained, allowing the investigation of concrete managerial problems and extending the existing state of research (Yin, 2009; Eisenhardt and Graebner, 2007). Except for single-case studies, empirical research on business models in the context of emerging technologies remains scarce (Demil *et al.*, 2015). Multiple-case studies enable contextualization, allowing the comparison of distinct findings and increasing the reliability of obtained data (Eisenhardt and Graebner, 2007). Furthermore, case study research has been used successfully in information systems research (Dubé and Paré, 2003).

To conduct the qualitative survey, a representative sample was chosen (Yin, 2009; Eisenhardt and Graebner, 2007; Demil *et al.*, 2015). According to Kagermann *et al.* (2013), mechanical and plant engineering, the automotive industry and the electrical industry would be primarily affected by Industry 4.0. Therefore, those three industry sectors were chosen for the study. Case firms were selected to have one predominant business model, as competing business models within a single enterprise are difficult to include in research design (Markides and Charitou, 2004). To ensure these aspects, SMEs were preselected using publicly available data for classification before requesting an interview. Furthermore, a competent interview partner in a leading position, preferably the CEO, was required (Kumar *et al.*, 1993).

Using semi-structured interviews, an interview guideline representing the research question was developed. Publicly available data and internal data provided by the interviewees for triangulation to validate the research were used as secondary sources (Yin, 2009; Gibbert *et al.*, 2008; Huber and Power, 1985). The interview guideline consists of two parts, obtaining information about the interviewee and the enterprise, and then about business model changes from Industry 4.0. The interviews were conducted via telephone and recorded on audio files in accordance with the interview partners. Subsequently, the interviews were transcribed from the audio files, and then subjected to a qualitative content analysis (Miles and Hubermann, 1994). During this process, the initial categories were defined inductively and then aligned to existing research, intending to develop theoretical knowledge (Edmondson and McManus, 2007; Holsti, 1968). In the next step, the final categories were condensed from the initial categories using a frequency analysis (Holsti, 1968). This process was conducted independently by two researchers. Subsequently, the categories were checked for consistency and compared to derive inter-coder reliability (Holsti, 1969), thereby validating the coding process.

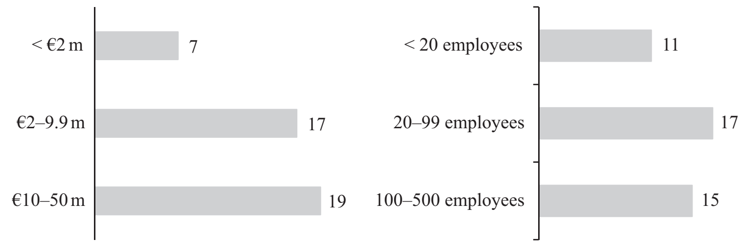
All surveyed enterprises fulfill the criteria of SMEs according to the definition of the German institute of SME research: a maximum number of 500 employees and a maximum annual turnover of €50m (German Federal Ministry of Economic Affairs and Energy, 2014). In all, 43 interviews with lengths between 25 and 60 min were conducted and 22 of the 43 interview partners are CEO of their respective enterprises. The others are among the top officials of their enterprises, and all are members of their management board. Within the 43 enterprises, 24 are mechanical and plant engineering enterprises, 13 are automotive suppliers and 6 are from the electrical industry sector. The average number of employees is 91.02, whereas the average annual turnover is €16.09m. Figure 2 reveals the detailed distribution within the empirical sample.

4. Findings

4.1 Changes of business model elements through Industry 4.0

Table I provides an overview for the nine building blocks within the Business Model Canvas, including exemplary changes of the respective building blocks through Industry 4.0.

Key resources is the most named building block within the sample (58.14 percent of interviewees). The interviewees mainly mention two aspects. First, production facilities and equipment need to be altered or especially purchased according to the specifications of Industry 4.0. As one interviewee mentions: "Industry 4.0 will require [us] to either adapt existing machinery, also known as "retrofitting," or to purchase new machines. Especially the



Note: $n = 43$

Figure 2.
Annual turnover and number of employees within sample

Building block	Total ratio (%)	Exemplary changes through Industry 4.0
Key resources	58.14	New or altered production equipment New personnel, especially with IT competencies Retraining of existing personnel
Value proposition	53.49	New, data-driven products or services More flexible and individual production New product features, e.g., predictive maintenance, self-optimization or energy savings “Retrofitting” of existing production equipment
Key partners	48.84	New partners with IT or data expertise Especially SMEs will require partners in areas such as data expertise
Customer relationships	48.84	More long-term oriented partnerships Intensified partnerships between customer and supplier
Customer segments	41.86	New customer segments can be addressed through new data-based value propositions New competitors address existing customers
Revenue streams	41.86	New payment models, e.g., pay-per-use Automation of revenue streams
Cost structure	37.21	Large investments necessary Cost savings through increased productivity
Key activities	23.26	New activities that build upon data analysis Data analysis enables, e.g., optimization
Channels	18.61	Digital channels for efficient communication Automation of communication through machine-to machine communication

Table I. Business model building blocks and exemplary changes through Industry 4.0

second will inflict high costs on SMEs” (Interviewee No. 21). Second, the interviewees describe the need for new personnel or required retraining of existing personnel. An SME representative states: “Industry 4.0 technologies require especially trained experts in the field of IT. SMEs cannot afford those easily, as such competencies are rare on the market. Currently, such experts mainly go to larger enterprises” (Interviewee No. 2). Another expert says “[…] it will be a challenge that existing personnel might become obsolete because we can’t train them accordingly” (Interviewee No. 30). This is confirmed by another interviewee, who states: “An SME has a limited workforce. The retraining required for Industry 4.0 is manageable for a larger enterprise. But who runs the daily business in an SME if the workforce is being trained? No SME can easily acquire adequate backup here” (Interviewee No. 14).

Value proposition is the second most named building block (53.49 percent of interviewees). The interviewees mainly describe new products, services or a combination of both to be offered to the customer. As one interviewee explains: “Our machines can produce more individually and tailored to customer demands. The ultimate goal here is often described as ‘batch size one.’ However, it remains questionable if this is really required for each and every product” (Interviewee No. 23). A manufacturer of machinery and equipment states: “We can offer new features with our machines, e.g., predictive maintenance, self-optimization, or reduction of energy consumption” (Interviewee No. 8). New services through Industry 4.0, which are often mentioned together with new products, are mostly described as “data-driven.” As another representative explains: “It is our goal to not only produce the machine, but set it up and connect it with other machines in the factory. We want to produce ‘turnkey’ solutions for our customer, especially regarding the integration in existing production plants” (Interviewee No. 39). Another interviewee describes the aforementioned retrofitting of machines: “As an SME, we can hardly keep up to build the newest equipment everywhere. But our strength is individual service. And this is something that you need if you want to make a 30-year-old machine ready for Industry 4.0” (Interviewee No. 6).

Key partners is tied for the third most named building block (48.84 percent of interviewees). In this context, the SMEs' representatives primarily name partners that are experts in IT-related aspects. One interviewee states: "An SME cannot be an expert in machines and in IT easily. But it can look for the right partner, for me preferably another SME, that it can work together with" (Interviewee No. 11). Another interviewee mentions that "data security is a task that requires the right partners for us, but those partners are rare" (Interviewee No. 27).

Customer relationships is also tied for the third most named building block (48.84 percent of interviewees). Most interviewees agree that Industry 4.0 will lead to long-term relationships that include working closer together: "I experience that customers and suppliers are trying to solve these issues regarding Industry 4.0 together. You cannot achieve new technological developments in a short time, or if you only worry about costs in the short run" (Interviewee No. 27).

Customer segments is tied for the fifth most named building block (41.86 percent of interviewees). Here, the interviewees explain that new data-based products and services can lead to new customers being addressed. As one expert mentions: "Industry 4.0 rewrites the rules of the game to a certain extent. Also, the smaller [SMEs] are trying to address new customers, but also other players from abroad or from the IT industry try to enter the market" (Interviewee No. 28).

Revenue streams is also tied for the fifth most named building block (41.86 percent of interviewees). In this regard, all experts state that new pricing and revenue models will be available through Industry 4.0: "Pay per use, pay per feature, or other payment methods like this become possible. But before, this would just have been too hard to supervise. In Industry 4.0, this can be done automatically to a large extent" (Interviewee No. 13).

The Cost structure (37.21 percent of interviewees) is third least named by the interviewees, but still significantly more than key activities and channels. Most statements in this regard relate to investments required for Industry 4.0. As one interviewee mentions: "SMEs have a hard time facing the costs that come with Industry 4.0 implementation" (Interviewee No. 5). Cost savings through increases in productivity are also mentioned: "We will get more flexible and efficient in value creation, decreasing our variable costs through Industry 4.0" (Interviewee No. 26).

Key activities is second least named from all building blocks within the Business Model Canvas (23.26 percent of interviewees). Most interviewees name data-based activities through Industry 4.0: "We will be able to do things like data analysis and thereupon optimize our processes" (Interviewee No. 12). Another SME representative offers a possible explanation for the low number of SMEs naming key activities in the context of Industry 4.0: "SMEs tend to stick to what they did. They just want to do it better and especially more efficiently. For me, Industry 4.0 also includes the chance to do something completely new, even for an SME" (Interviewee No 40).

Channels is the least named building block (17.65 percent of interviewees). The few interviewees who mention this element of the Business Model Canvas relate to digital channels to communicate with their customers. One interviewee explains: "Industry 4.0, from my point of view, is able to save a lot of time in communication. One can now communicate digitally, or even the machines take over that job as they communicate among themselves" (Interviewee No. 17). Another interviewee offers a possible explanation for the lowest naming of this building block: "SMEs' key asset, at least for many of them, is talking personally to each other and knowing the person you talk to. As such, they won't easily turn to new ways of communication, although they should find a form to enter these new ways of communication" (Interviewee No. 40).

4.2 User and provider perspectives on Industry 4.0

In general, the present study finds that SMEs regarding Industry 4.0 from a provider perspective name the highest ratio of building blocks affected within their enterprise. Five out of nine building blocks are predominantly mentioned from a provider perspective. Two building blocks are stated comparably often from the user perspective and the provider perspective. The building block that both perspectives agree to be least affected by Industry 4.0 is channels, whereas key resources is mentioned by the majority of both perspectives as most affected by Industry 4.0. Key activities is named comparably seldom by the providers and the users, indicating a small impact on this building block for both perspectives on Industry 4.0. Only two building blocks are named by a higher percentage of Industry 4.0 users than from Industry 4.0 providers: key partners and customer relationships. These findings are summarized in Table II.

Figure 3 illustrates the ratio of building blocks affected from the perspectives of Industry 4.0 users and Industry 4.0 providers.

Within the sample of this study, most SMEs perceive themselves as users rather than as providers in the context of Industry 4.0. Only three enterprises regard themselves as both users and providers regarding Industry 4.0. Overall, the findings for both perspectives on Industry 4.0 can be summarized as follows: the providers of Industry 4.0 generally expect a significantly higher impact on their respective business models through Industry 4.0, except for the building blocks of key partners and customer relationships. However, this group

Perspective	Total ratio (%)	Building blocks regarded predominantly
Industry 4.0 user	76.74	Key partners, Customer relationships
Industry 4.0 provider	23.26	Value proposition, key resources, key activities, cost structure, revenue streams

Table II. Total ratio of perspectives and their predominant naming of building blocks

Figure 3. Ratio of building blocks affected for provider and user perspectives of Industry 4.0

constitutes the smaller portion of SMEs surveyed. The users of Industry 4.0 expect less impact on their business models through Industry 4.0 than providers, except for key partners and customer relationships.

5. Interpretation

Key resources is named predominantly by the providers of Industry 4.0-based solutions. This can be explained as manufacturing firms having to obtain competencies regarding IT. This in particular affects human resources, as data analysis experts and associated hardware are required (Müller, Buliga and Voigt, 2018; Rachinger *et al.*, 2018). Fewer changes are expected for employees in production itself, but "creative problem-solvers" are increasingly required (Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017). Both developments are logical in respect to the providers of Industry 4.0-based products and services, as the new value propositions especially will require new key resources. Still, the task of integrating existing workers into Industry 4.0 remains a challenge that requires further investigation. This encompasses the need for training and qualification of the existing workforce that could be especially challenging for SMEs.

Value proposition is named predominantly by the providers of Industry 4.0-based solutions. This seems reasonable, as new value propositions, such as individualized products meeting customer requirements specifically with batch size one products, are expected through Industry 4.0 (Kagermann *et al.*, 2013; Oesterreich and Teuteberg, 2016; Rachinger *et al.*, 2018). Furthermore, individual and customer-oriented services, making use of digital technologies and data analysis, are predicted through Industry 4.0. These include condition-based monitoring and predictive maintenance along with optimization of production systems and value chains (Kagermann *et al.*, 2013; Müller, Buliga and Voigt, 2018). Conclusively, the providers of Industry 4.0-based predominantly mention value proposition, as providers of those solutions and products will primarily generate new value propositions.

Key partners is named predominantly by the users of Industry 4.0. This is confirmed in current literature, which states that key partners is considered to be especially important for operation and control of Industry 4.0-based systems (Kagermann *et al.*, 2013; Porter and Heppelmann, 2014). Due to their limited size, SMEs as providers will most likely require key partners in order to develop new Industry 4.0-based solutions (Müller, Buliga and Voigt, 2018).

Customer relationships is named predominantly by the users of Industry 4.0. Long-term, intensified relationships with manufacturers and providers of products and services are predicted, especially for usage of products and services (Kagermann *et al.*, 2013; Müller, Buliga and Voigt, 2018). The findings are therefore in line with current research but should be extended with further investigation regarding the customer relationships of users and providers in Industry 4.0.

Customer segments is named comparably often by the providers and the users of Industry 4.0. This finding questions the assumption that providers would address new customer segments to a greater extent. Also in literature, no differentiation between provider and user perspectives of Industry 4.0 can be found thus far. However, new customer segments are predicted through Industry 4.0 (Arnold *et al.*, 2016; Kagermann *et al.*, 2013; Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017; Müller, Buliga and Voigt, 2018). This differentiation should be addressed in detail in further research.

Revenue streams is named predominantly by the providers of Industry 4.0-based solutions. New revenue models, such as dynamic pricing and pay-per-use payment models, are expected through Industry 4.0 (Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017; Müller, Buliga and Voigt, 2018). This can be explained as providers might foresee these new possibilities, as they will provide new revenue streams.

Cost structure is named predominantly by the providers of Industry 4.0-based solutions. Large investments are expected for Industry 4.0 to obtain required key resources. However, reductions in fixed and variable costs are predicted through increased quality and productivity (Arnold *et al.*, 2016; Kagermann *et al.*, 2013; Müller, Buliga and Voigt, 2018). For obtaining new key resources, this evaluation seems logical, as providers will require large investments in this respect. For possible savings, those might not yet be seen for users in industry, especially in SMEs (Müller, Buliga and Voigt, 2018).

Key activities is named predominantly by the providers of Industry 4.0-based products and solutions. In general, new key activities are expected through data management, data analysis and data mining to enable knowledge-based decision making (Brettel *et al.*, 2014; Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017). The low estimation for key activities from SMEs can be reasoned as manufacturing SMEs are not as far developed in terms of data management and handling so far. Therefore, they might not regard this topic as important yet (Müller, Buliga and Voigt, 2018). However, the estimation of the providers of Industry 4.0-based solutions is in line with the state of research, as the provision of smart products and services will especially require new key activities.

Channels is the least named for all perspectives (17.65 percent of interviewees), and no differentiation between providers or users of Industry 4.0 can be found. Collaborative ways of value creation are predicted regarding Industry 4.0 that include co-creation between the providers and the users of Industry 4.0-based solutions, based on new communication technologies (Kiel, Arnold and Voigt, 2017; Kiel, Müller and Voigt, 2017; Müller, Buliga and Voigt, 2018). As a result of this co-creation process, individual products can be created, understanding customer needs in detail (Kagermann *et al.*, 2013; Müller, Pommeranz, Weisser and Voigt, 2018). However, the results do not reveal a differentiation between provider and supplier perspectives and offer a low evaluation of channels in general. This can be explained as direct, personal and highly individual Channels are already present in SMEs and provide a highly valuable characteristic of SMEs (Müller and Voigt, 2016).

The finding that providers consider more changes in terms of impacts on their respective business model through Industry 4.0 seems logical. The provision of products and services from design to market affects more elements within a business model than using them. This becomes especially obvious for the low evaluation of key activities from a user perspective. The evaluation of key resources regarded as most important and channels regarded as least important from both perspectives is mostly in line with current research for larger enterprises (Arnold *et al.*, 2016).

6. Managerial implications

Besides presenting the key findings, this paper separates managerial implications for the perspectives of both providers and users of Industry 4.0. Providers in respect to Industry 4.0 are recommended to investigate necessary key activities and required key partners regarding Industry 4.0. Especially for the latter, SMEs as providers will definitely require adequate partners for the provision of Industry 4.0-based solutions due to their limited size. Addressing new customer segments could provide new Industry 4.0-based solutions to a broader group of potential customers. New customer relationships should also be considered, also in respect to the mentioned new relationships that could emerge through digital channels. Furthermore, this paper recommends the possibilities of new channels in terms of Industry 4.0. This includes new technologies for communication in collaboration with existing and well-established channels. For the users of Industry 4.0, it can be suggested to especially regard the value of key partners and customer relationships, thereby finding suitable key partners for the provision of Industry 4.0-based solutions. In addition, the users of Industry 4.0 are advised to foster customer relationships in terms of Industry 4.0.

Extending these recommendations, special challenges of SMEs toward Industry 4.0 must be regarded: lack of financial resources, low production numbers, low degrees of standardization and a lack of understanding of integration, which are major concerns for German SMEs (Müller and Voigt, 2016). Furthermore, access to skilled employees and concerns regarding data security and privacy concerns are among major challenges for German SMEs that plan to implement Industry 4.0. Conjointly with these findings, this paper presents the following recommendations for users and providers of Industry 4.0.

For users, the reduction of capital commitment regarding Industry 4.0-based solutions that are cost-intensive is essential. Pay-per-use contracts and leasing of machinery could provide ways to reduce capital commitment. This approach could also include financing by customers, especially larger enterprises possessing larger financial resources, relating to the high importance of new customer relationships. Furthermore, finding compound effects with other enterprises regarding Industry 4.0 is recommended, relating to the high importance of new key partners for users regarding Industry 4.0. This approach could assist in reducing costs, establishing standards and gaining access to trained personnel and expertise. Potential solutions could be platforms among SMEs or partnerships with larger enterprises.

For providers, this paper proposes business models building on new value propositions, key activities and revenue streams, such as provision of services, complete product-service systems and payment methods. Thereby, providers of Industry 4.0-based solutions could address the concerns of SME users of Industry 4.0, such as lacking expertise toward Industry 4.0 or insufficient financial resources. Offering complete solutions, such as service provision and hardware conjointly, could assist in generating compound effects and offering new value propositions to customers. Addressing the requirement of new key resources in terms of Industry 4.0, compound effects could be found within platforms among SMEs or partnerships with larger enterprises. These could also assist in developing new cost structures required in terms of Industry 4.0, relating to new key resources required.

Overall, it can be concluded that a provider role toward Industry 4.0 creates larger impacts on SMEs' business models. Therefore, companies need to decide if this poses a threat toward their established business models, and whether they should therefore avoid the provider role toward Industry 4.0. However, taking a provider role toward Industry 4.0 could also enable SMEs to fully grasp the potentials of Industry 4.0, which remain out of reach of Industry 4.0 users. SMEs are therefore advised to consider both roles but encouraged to take the risks to become an Industry 4.0 provider.

7. Conclusion

This paper attempts to provide insights for manufacturing SMEs and how Industry 4.0 affects their business model, leading to specific integration strategies. Thereby, this study contributes to the current body of knowledge regarding business models and Industry 4.0. It presents findings that are especially focused on SMEs as one of the few studies in this context. The detailed differentiation among the nine building blocks for Industry 4.0 providers and users is unique and unseen in literature thus far. This approach is especially suitable regarding SMEs due to their focused and mostly singular business model.

Furthermore, the approach of differentiating between the perspectives of a provider and a user of a technology has scarcely been conducted thus far. It is expandable to other technologically triggered business model innovations and provides an insightful field for future research. The results show that distinct characteristics between these two perspectives exist, whereas providers of Industry 4.0-based solutions expect the most changes in their business models in regard to Industry 4.0. Notably, a significantly larger proportion of SMEs in this study can be characterized as Industry 4.0 users, with Industry 4.0 providers only constituting about one quarter of the sample. This information can be extended for the Industrial Internet of Things and comparable concepts to Industry 4.0 outside of Germany.

Because of the exploratory qualitative research design, the study also inherits several limitations. Exploratory research in this case has the difficulty that Industry 4.0 might be at its start of implementation for many of the surveyed SMEs. A generalization to other research settings without verification using different research methods is considered critical. However, as the study follows a replication sampling logic (Yin, 2009) and encompasses 43 interviews, the results can present general patterns about impacts on business models regarding Industry 4.0. As a further limitation, this study mainly relies on qualitative results and uses case materials exclusively for validation. Future research could include case material in order to extend the empirical results obtained.

Further recommendations for future research include quantitative research methods in order to verify the qualitative research results. A comparison to larger enterprises, if those can be condensed to a single business model referring to Industry 4.0, would present further valuable insights for this topic. The interdependence between different elements within a business model is of particular interest, also in connection with reasons for the adoption of new or changed business models and their implementation processes. An investigation regarding the implementation of business model adaptions over time should be considered, investigating the interplay with partners, suppliers and customers. The managerial implications proposed must be verified in practice, whereas their effectiveness needs to be addressed in future research.

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