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Business Model Innovation of Industry 4.0 Solution Providers Towards Customer Process Innovation

Julian Marius Müller [1,*] and Simon Däschle [2]

1 Logistics and Operations Management, Salzburg University of Applied Sciences, 5412 Puch bei Hallein, Austria
2 School of Business and Economics, Friedrich-Alexander University Erlangen-Nürnberg, 90403 Nürnberg, Germany; simon.daeschle@fau.de
* Correspondence: julian.mueller@fh-salzburg.ac.at

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Abstract: The article investigates the role of business model innovation by Industry 4.0 solution providers and their impact on process innovation of their customers. Industry 4.0 solution providers are hereby seen as the enablers and providers of Industry 4.0 technologies, which provide access to several potentials of Industry 4.0 technologies to their customers. In particular, the role of small and medium-sized enterprises (SMEs) that provide solutions that are based on Industry 4.0 technologies for their customers are investigated, which in turn can improve and innovate their own processes. Frist, the article presents an overview of the current state of research and a brief theoretical background. Second, the article bases its findings on an empirical study of 111 Industry 4.0 providers from Germany that are SMEs. Analyzing the results of questionnaires, correlations between Industry 4.0 solutions and two perspectives are examined: benefits for the solution providers and benefits for process improvements and innovations of the customers. Subsequently, the article discusses these findings, closing the article with both managerial and research implications.

Keywords: Industry 4.0; Industrial Internet of Things; business model innovation; process innovation; solution provider; small and medium-sized enterprises; SMEs; quantitative survey

1. Introduction

Industry 4.0, internationally known as the Industrial Internet of Things, describes an ongoing digitization of industrial value creation, especially relating to aspects such as vertical and horizontal interconnection across humans, machines, and products [1,2]. However, the exact definition of the term Industry 4.0 and its exact implications for different research disciplines need to be clarified in future research [3]. Comparably to Industry 4.0, similar approaches are emerging worldwide, for instance, the "Industrial Internet Consortium" in the United States (US) or "Made in China 2025" in China [4]. Industry 4.0 is expected to generate new business models, as well as increase the efficiency of processes [1,2,5]. Hereby, several characteristics, such as the company size, delineate between the targeted benefits of Industry 4.0 [6].

Current challenges, especially for small and medium-sized enterprises (SMEs), may be reasons for offering or applying Industry 4.0-based services. In sum, SMEs have less been regarded in current Industry 4.0 research [1]. For example, offering or applying Industry 4.0-based services can assist to counteract the required cost reductions and increasing competitive pressure encountered by SMEs for developing such Industry 4.0 services. However, SMEs only have limited financing possibilities as compared to large companies [1,6]. Further, their access to trained personnel in the context of information technology (IT) is limited [7] and the integrations of humans into the concept of Industry 4.0 prove to be challenging [8,9]. In addition to the challenges, there are also many advantages and opportunities for SMEs that result from Industry 4.0. For example, SMEs can react flexibly to changes and implement concepts through a clear and flat organization [1].

In general, for manufacturing companies, industrial services create advantages, such as differentiation from competitors and customer loyalty [10]. Industry 4.0 now enables completely new business models through the combination of technologically perfected production facilities and extended integration of employees, customers and product users. Which of the new or changed business models will be very popular in the industry, however, is largely unclear [1,4]. In order to estimate the potential of the forecasted new service offerings and business opportunities, it is also useful to know the view-point of Industry 4.0 solution providers, since these companies actively participate in innovative business models in Industry 4.0 [1].

Hence, this paper investigates the influences of Industry 4.0 on SME solution providers and which potentials those have to increase process efficiency of their customer. In particular, it is to be found out in this context which service offerings based on Industry 4.0 are reasonable for them in order to increase process efficiency of their customers. Thereby, the paper aims to link the two research streams of efficiency orientation and business model orientation regarding Industry 4.0 [5,6]. Further, the supply chain integration and the associated partnerships between companies is a core aspect of Industry 4.0 [1,2,5]. Another critical aspect concerns the limited interoperability of the systems, standards, and interfaces across several companies in a supply chain [11].

There are a few scientific papers on the topic of business model innovations in connection with IT and in the area of service orientation of manufacturing companies [11–14]. When looking at the literature, it is noticeable that the majority of the scientific articles focus on producing companies. The situation of non-producing companies, such as service providers and IT firms, was very little dealt with in the context of Industry 4.0 [15]. Empirical studies are also rare, since previous studies are often of a theoretical nature or based on specific cases. Therefore, the present paper addresses the following research question in the context of SMEs:

Which kind of services by Industry 4.0 solution providers can help to increase process efficiency of their customers?

The remainder of this paper is organized as follows: Section 2 explains the theoretical background of business model innovation and SMEs. Section 3 gives an overview of the state of research, Section 4 describes the empirical research method. Section 5 presents the results, which are discussed in Section 6 and for which implications are derived in Section 7.

2. Theoretical Background

2.1. Business Model Innovation

A multitude of definitions and frameworks for business models has emerged, whereas the majority of scientific literature agrees on three central elements: Business models show how companies (a) provide value to their customers, (b) how they interact with their suppliers, partners, and customers, and (c) how they are compensated by customers [16,17].

Further, business model innovations are changes to elements within a business model that are significant changes to single elements or a new combination of these elements [18]. Scientific literature increasingly examines technological drivers for business model innovations [19]. Currently, these technological drivers often concern business model innovations as a result of digitization. In the industrial context, these are referred to as business model innovations following Industry 4.0 [1,4].

Business model innovations through industry 4.0 represent both an opportunity and a challenge for companies. On the one hand, they can solve customer problems even more effectively, create new revenue models, and address entirely new customer segments [1,4]. On the other hand, an increasing number of companies are also expressing concerns about the threat to their existing business models. This also includes the danger of cannibalizing one's own well-functioning business model [4].

It can be seen that SMEs in particular are reluctant to develop new business models in the context of Industry 4.0 [1,5]. However, their economic important requires their integration within the concept of Industry 4.0 [1]. The economic importance of SMEs, as well as their characteristics, are described in the next section.

2.2. Small and Medium-Sized Enterprises

In this paper, SMEs are defined following the definition of the European Union, with a maximum of 250 employees and a maximum annual turnover of 50 million Euros. Further, the majority of SMEs is family-owned or even owner-managed [15].

SMEs play an important role for the economy and especially for industrial value creation. In Germany, SMEs represent 99.6% of all enterprises. They generate more than 50% of the gross domestic product and employ about 60 per cent of workforce. Further, about 80 per cent of apprentices are trained by SMEs. Apart from these quantitative key figures, SMEs show specific characteristics. Those relate to, for instance, their resource limitations, restricted bargaining power, often owner-centric decision making, but highly flexible and adaptive nature, which is often seen in niche markets, as so-called "hidden champions" [1].

Existing studies show that SMEs' specific challenges differ from those of large companies regarding Industry 4.0. These challenges stem from their organization nature, foremost including resource limitations, low bargaining power, and concerns that existing business models might be unsuitable for Industry 4.0. Therefore, SMEs require solutions that are tailored to meet their specific challenges, but research has mainly focused on large enterprises rather than on SMEs [1].

As a result of their economic importance, the successful integration of SMEs can be regarded as a key success factor of Industry 4.0. Consequently, research is required to better investigate the role of SMEs within Industry 4.0 and address their specific requirements and concerns regarding the concept [1,5].

3. State of Research

In the following, we present a brief overview regarding the state of research regarding characteristics, challenges, and potentials for Industry 4.0 solution providers (Sections 3.1–3.3). Further, Section 3.4 introduces several forms of business model innovations in the context of Industry 4.0.

3.1. Characteristics of Solution Providers

Solution providers not only offer products, but complete solutions in which products and services are integrated. The services and consulting are adapted to the respective customer needs. Comprehensive solutions that are tailored to customers can strengthen the company's position vis-à-vis competitors and provide insights into customer needs and usage habits [20]. The development of solutions should be driven by the focus on the processes and finances of the customers and not only be based on technological innovations. Solution providers are more likely to develop benefits in long-term partnerships with customers rather than developing purely in-house solutions for customers. This connection with customers brings with it a higher level of cost and risk when compared to the sale of products. Cross-departmental multidimensional interfaces are also very important in the solutions business in order to create a balance between commercialization (e.g., business unit and customer understanding) and industrialization (e.g., standardization and modularization) of the solutions [21–23].

Further, companies that move from being manufacturing manufacturers to offering solutions consisting of products and services have a greater need for the integration of internal functions and a better integration of customers and suppliers [24].

3.2. Challenges for Industry 4.0 Solution Providers

There are several problems that Industry 4.0 solution providers have to face explicitly. Starting with the functionalities of the solutions, care should be taken to ensure that the solutions only contain functions for which customers are willing to pay. Too long waiting to bring the solutions onto the market can also be a mistake. Competitors can already conquer market shares and new competitors can emerge [25]. A further challenge is the high complexity of product development in the context of IT integration into products, which can be very time-consuming and resource-intensive. In addition, IT integration into traditional products can cause high costs [26].

One difficulty with a new business model in which innovative IT-integrated services are offered can be to show customers the benefits, e.g., in the form of cost savings. If companies integrate IT into their products and the business model is not adapted, the new service offering can even fail [26]. Another challenge that is posed by the fact that customer benefits are not always tangible is the question of how the solution provider can capture some of the benefits gained. A change in the business model can be meaningful, because, e.g., traditional billing mechanisms may no longer be advantageous [1]. In the case of billing based on unit prices, the price would have to be increased considerably in order to claim part of the value that is generated. However, this would create a competitive disadvantage. This can be transferred to the topic of Industry 4.0 and underlines the importance of business model innovations. Building on this, sales strategies and channels must be rethought in order to bring the new service offering closer to customers [1,26].

Another problem that affects the service portfolio of a company is that services and products offered can compete with each other. For example, the product life cycle can be extended by services, thus reducing the possibility of selling new products [27]. This is also conceivable in the case of services that are offered with regard to Industry 4.0.

3.3. Potentials for Industry 4.0 Solution Providers

As for the problems that exist with regard to data security, data ownership, and data volumes, this also creates far-reaching opportunities that offer potential for both users and suppliers of Industry 4.0. For example, automated quality controls can be introduced, production data can be used to optimize production processes and shorten production times, resources, inventories, and capacities can be planned, and maintenance measures can be implemented, as required [1]. By integrating IT into products, advantages for users, such as improved product performance, can be created, e.g., in the form of increased capacity utilization and a reduction in operating costs. In addition, the functionality of products can be increased, e.g., by monitoring and remote control of machines [26].

In addition to the extended functionality of machines, machine communication is also changing. A large part of machine-machine communication will become invisible and human-machine communication can be highly interactive [28]. Human-machine interaction and assistance systems offer the possibility of supporting employees, e.g., by means of smart glasses. Work can thus become more ergonomic and the proportion of non-value-adding work processes can be reduced. In addition, errors can be avoided and employees can be trained more quickly [1,5]. Systems that can also be self-organizing and work autonomously go one step further than human-machine interaction systems. This can result in advantages, such as lower control costs, lower energy consumption, higher availability of systems, and shorter throughput times. However, such solutions are usually cost-intensive and especially in medium-sized companies it is therefore very important to take a close look at the cost-benefit ratio [1,6].

Industry 4.0 also offers a high potential for more flexible production with the aim of achieving a batch size of 1. Among other things, this serves to increase customer satisfaction, since a product can be manufactured according to individual customer specifications at the price of a current serial product [1,6].

With regard to complexity costs, which have the highest potential for cost reduction, companies can specifically identify and avoid wastage due to increased transparency through real-time information [1,6]. Real-time information is also the key to reducing inventory costs. This enables safety stocks to be minimized and "Burbidge and Bullwhip effects" to be reduced [5,6]. Maintenance benefits from automatically generated consumption and usage data [1]. Access to quality data in real time can also be used in quality management, especially across the supply chain. This means that multiple inspections of products can be reduced through near-real-time control loops. Production costs should be reduced due to process control loops that are based on real-time information, as this can increase the Overall Equipment Effectiveness (OEE) of machines. Increased automation through, for example, autonomous transport systems can reduce logistics costs [5].

Further, the integration of information and communication technologies is seen by companies as a way to differentiate themselves from their competitors and to achieve greater customer loyalty [5]. In addition, increased customer benefits resulting from IT integration should generate more revenue [26]. Manufacturing companies also expect higher customer loyalty through the development of services and see this as an opportunity for differentiation [7]. IT integration and the development of novel services can be combined by means of Industry 4.0, thus combining the advantages of the two components.

An advantage for manufacturing companies is that through IT integration, data from the products can be transmitted back and it is possible to analyze, among other things, how customers use the products [1,25,26]. In addition, it may be possible for companies to expand their field of activity through Industry 4.0, e.g., by no longer focusing on individual products but on the overall system that is to be optimized. This would amount to an expansion of core competencies and offer customers a different promise of benefit [25]. Above all, there will be opportunities to offer new data-based services that can bring the greatest possible benefit in combination with new business models. The resulting potentials are explained in the following section.

3.4. Business Model Innovations in the Context of Industry 4.0

The technical innovations that are associated with Industry 4.0 offer the possibility of adapting existing business models or developing new ones. In addition, other companies can enter the market and influence the value chain. In order for business models to be adapted, the data must be stored in such a way that suppliers and manufacturers are functionally integrated into the value chain. The resulting integration into business processes is a prerequisite for new business models [5].

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Possible new business models are often related to an extended service orientation of manufacturing companies, because offering services can prove lucrative for manufacturing companies. Thus, integrated knowledge and competences based on service can be dominant components with regard to profitability and additional added value. After the introduction of services to support the most important products, manufacturers have found that services are generally attractive to generate turnover and that product and service sales complement each other [29]. According to Lusch et al., the growth of IT makes it possible to spread entire service provision networks [30]. The authors give seven reasons for this:

- As IT evolves, microprocessors and intelligence are embedded in goods, transforming them into improved platforms for service delivery.
- The further development of IT increases self-service capability.
- The further development of IT increases the ability to serve others.
- The need for transport is reduced by improving the ability to communicate.
- By improving communication skills, the ability to know customers and suppliers better increases.

- By improving communication skills, direct interaction with customers and suppliers increases.
- By improving the ability to communicate at low cost, coordination between companies becomes more efficient and accessible.

IT enables manufacturers to develop new business models through real-time data that makes decision-making processes more efficient and effective. This is particularly valuable for long product life cycles, as customers can be bound by the supply of spare parts and maintenance [18]. With regard to manufacturing companies, the highest sales potential is attributed to after-sales services that directly influence product functionality [27].

Services that are based on embedded IT technologies enable the better monitoring of assets, customer behavior, and supplier commitments. Comprehensive services, such as repair and maintenance services, can be further developed. For example, remote maintenance is made possible, avoiding downtime and providing added value to customers. This is particularly valuable if availability is guaranteed and costs can thus be saved. Overall, manufacturing companies can effectively innovate their business model by offering services, in particular, by improving the value proposition, redesigning the architecture of the value chain and increasing sales [1,17]. In Industry 4.0, the use of data can generate revenue in order to generate a competitive advantage. Because many other types of services are more likely to be regarded as standard services and thus as a necessity than as a means of differentiation, data-based services can therefore have a major influence on the current business models of manufacturing companies and the respective markets [31]. In the following, possible new business models that are based on the above possibilities will be presented.

3.4.1. Intelligent Products and Services

Intelligent products, also described as Cyber-Phsyical Systems (CPS), can be used to enable extended services based on data through the integration of sensors, software, and the Internet [1,25]. For example, downtimes at the customer's site can be reduced by sensors warning of future errors. This can justify higher prices and win new customers with this additional function [32]. With intelligent products, service quality can be improved, as can reactivity with regard to services. In addition, the products can be improved by the integrated intelligence itself, for example, by consuming fewer resources or increasing capacity. The data can also be used to optimize the entire product lifecycle. Data generated from customers helps manufacturers to shorten innovation cycles and can also be used to offer customers upgrades [33].

The data generated can be used to bill services on the basis of consumption or performance. In a consumption-based billing system, for example, the useful life of a system or the compressed air consumed can be used as relevant parameters for billing. In a performance-based settlement, the type of use is decisive, for example, the amount of wear and tear can be used as the settlement value. In addition, the data obtained can be processed and used to identify the optimization potential using models [32].

3.4.2. Availability on Demand

Similar to intelligent products, availability "on demand" is a business model that is based on performance or consumption-based billing. For example, a system remains in the possession of the manufacturer and the customer pays for the use of the system, but not for the system itself. Since the product is not only manufactured, but also operated, this is accompanied by an extension of the value-added chain. The manufacturer is directly responsible for the single-wall-free operation of the plant, so that the availability of the plant is of great importance for this in order to avoid losses in turnover. The condition monitoring and maintenance of the plant is also very important in order to reduce downtimes. By means of this concept, customers can be addressed who prefer a lower capital commitment.

However, there are also additional costs, since an infrastructure must be created to guarantee the operation of the plant. Industry 4.0 particularly supports this business model [32]. This concept is based on the business model pattern "pay-per-use", in which, for example, the period of use serves as the billing variable. Since it is difficult to forecast the exact sales volumes in this model, a minimum purchase quantity is often agreed by means of a usage agreement [22]. "Pay-per-use" is described as a substitute service, since this service replaces the sale of a product [19]. Such replacement services can be particularly helpful in the case of new and, in particular, cost-intensive products in gaining customers who, due to uncertainty, are more likely to wait than buy a product. This means that the customer does not incur any long-term liabilities. However, a higher risk arises for the supplier, because the product remains in the possession of the offering company [19]. A product can also be used by several customers, depending on the period during which the customer has a need [25].

Billing in business models in the "pay-per-use" or "pay-per-feature" area can also be carried out by licensing, based on customer savings [1,26]. Another option with regard to the size that is relevant for billing is the performance of the product, e.g., measured as the availability of a machine [25].

3.4.3. Demand-Oriented Maintenance

Predictive or demand-oriented maintenance is a principle in which maintenance is planned before a malfunction occurs, thus avoiding production downtimes. Data from the machines, such as capacity utilization, temperature, etc., are recorded and processed by sensors. On the basis of these data, which are measured over a longer period of time, prognostic prognoses can be made and maintenance can be carried out accordingly at optimum intervals. As a rule, the plant operator cannot do this without the plant manufacturer, which in turn gives him the opportunity to offer appropriate maintenance and monitoring services [1,2]. Cooperation not only makes sense with customers, but also with suppliers of peripheral systems in order to obtain all relevant information [34].

3.4.4. Location-Related Services and Traceability

Technologies, such as radio frequency identification (RFID) and sensor technology, enable products to be traced. With regard to Product Lifecycle Management (PLM), this means that product information can be tracked and controlled anytime and anywhere. This can also be useful, for example, for product recall campaigns or analyses regarding product origin [33]. This creates opportunities to offer these services to customers. A so-called traceability system can be a guarantee for customers and at the same time increase the efficiency and the profits of the supply chain. In addition, precise information on the quality level of products can be used to decide, for example, whether an alternative market to the main market could be considered instead of simply disposing of the products in question [35].

3.4.5. Individualized and Personalized Products

In addition to the possibility of linking intelligent products with intelligent services individualized and personalized products can be established. The prerequisite for a personalized product that is produced individually in series is a high degree of flexibility in production. Important are the integration of all relevant processes and a high degree of automation. Furthermore, simulations play a decisive role in the feasibility of personalized products. Advantages for providers of this concept can be an extended customer spectrum, higher customer loyalty, and higher product prices [1,2].

3.4.6. Open Source

With the open source concept, product development does not take place in a single company, but in a community that is publicly accessible. In order to generate revenue, this business model often uses revenue models that generate revenue through revenue streams that in turn build on the solution. The advantage of this model is that no investments in product development are necessary. The motivation of the community is e.g., that the current solution should be improved. When setting up this business model, care must be taken to ensure that some of the added value that is created remains in the company's own operations. The business model of "Local Motors" is an example of how vehicles are developed and produced based on Open Source. Thus the first automobile of this type cost only three percent of the usual development costs for a car [22].

Originally, this concept was used in software development. In Industry 4.0, a joint development of software and hardware through an open source concept is conceivable. For this, a closer communication between customer and supplier is expected via new, digital communication channels [36]. The extent to which this concept will spread in German-speaking countries is still unclear [37]. For instance, Martinez et al. [36] show an application example that improves product development and prototyping via open development on an Industrial Internet platform, a concept that is described in the subsequent section.

3.4.7. Platforms

A virtual marketplace or "e-marketplace", e.g., for production capacities, analyses, and applications, can be realized via a cloud. Here, IT companies come into focus and cooperation between IT and product companies seems to make sense in order to develop Internet of Things platforms. The involvement of all market participants is important in order to map value-adding processes through uniform data. This makes it possible for the various participants to work together within the market in real time in order to jointly create value. Such a marketplace can also be seen as an exchange of services [32,38].

3.4.8. New Business Models and Service Offerings for IT Companies

Since some of the possible new business models that are mentioned above focus more on manufacturing companies, we will briefly outline the possibilities for IT and software companies.

Due to fast Internet connections, IT companies can offer cloud services and save users the capital costs of their own software and servers. Billing can be based on the use of the services. A cloud platform can then be used to communicate free machine capacities, among other things. This enables offering companies to increase capacity utilization to solve the problem of capacity bottlenecks [1,2].

Product companies in the IT sector have the opportunity to bundle products and services through innovative business models and thus offer customers benefits. These models include services in the areas of software-as-a-service (SaaS), cloud-based services, IT solutions, and application services. Companies that focus more on software than hardware can generate more revenue through services, as software offerings produce more relevant knowledge to enable a transition to services. Knowledge, which is won by services, can also be used for improvements of products. For example, services can be used to obtain feedback on products or to find out how users utilize products [39].

"Pay-per-use" is also conceivable in the software sector, similar to manufacturing companies. This allows for software solutions to be flexibly adapted and expanded. Due to more favorable conditions, this can be attractive for medium-sized customers [1].

4. Materials and Methods

The investigation of the current state of research has shown that Industry 4.0 cannot only be used to make internal optimizations, but it also has a high potential to offer its own services. In the literature, the user perspective with regard to the potentials of Industry 4.0 is often described or not differentiated between users and providers. The following empirical study shall now exclusively shed light on the situation of solution providers and thus create a differentiation from the user perspective of Industry 4.0. This is to be achieved by means of a quantitative survey using a standardized questionnaire.

Based on the literature research that was carried out, several research questions arise regarding Industry 4.0 solution providers. Since a comparison between producing and non-producing Industry 4.0 solution providers is not available in the current literature, the differences are examined.

The aim is to find out what potential the new business models and service offerings presented in Chapter 3.4 have in the context of Industry 4.0, and how those services help to improve process efficiency for their customers.

4.1. Description of the Questionnaire

At the beginning, the questionnaire asks for general information, such as industry sector and number of employees. This is followed by a detailed survey of the individual subject areas that are the focus of this paper. A five-level Likert scale was chosen for this.

The first part of the questionnaire deals with the general potential of services that are based on the components, technologies and business models of Industry 4.0. The scale ranges from "no potential" to "high potential". Some of the services proposed in the questionnaire, such as intelligent products, open source, availability on demand, and other options, can be traced back to Kaufmann [32]. Other services, such as needs-based maintenance and traceability, were explained in Kroll et al. [40] and Aiello et al. [35]. Further descriptions of service offerings that were used to develop this question can be found in Bischoff et al. [41] or Schröder [42].

In the second part, potentials that Industry 4.0 can offer to solution providers are to be evaluated. The scale again ranges from "no potential" to "high potential". Part three deals with the customer benefit of the solutions offered. Thus, it is asked, which problem definitions of customers are reduced, which customer characteristic numbers are improved, and which customer goals can be supported. For all three questions, the Likert scale ranges from "no potential" to "high potential". The customer trials mentioned primarily refer to current problems, which are mentioned by Bergmann and Crespo [43]. The customer key figures mentioned are based in part on Bauernhansl's list of savings potentials through Industry 4.0 [44]. Further improvements in key figures, such as a reduction in personnel costs in production and a shortening of lead times, were derived from Bischoff et al. [41]. Customer goals that can be supported by Industry 4.0-based solutions are described in, for instance, Björkdahl [26], stating an increase in capacity utilization or Schröder [42] describes the optimization of batch sizes.

Table 1 gives an overview of the three parts of the questionnaire.

Table 1. Overview of survey items.

(1) New Service Business Model Features to Offer to the Customer	(2) Potentials of New Business Model Features for the Provider	(3) Potentials of New Business Model Features for the Customer
Consulting towards digitization	Generation of new customer segments	Reduction of delivery times
Traceability	Generation of international customer base	Reduction of lead times
Product lifecycle optimization	New core competencies	Reduction of storage costs
Predictive Maintenance	Pioneering advantages	Reduction of production costs
Alternative tasks when idle	Competitive advantages for existing products	Reduction of complexity costs
Open-Source product development	Generation of second source of income	Reduction of personnel costs
Availability on demand	Tailor-made solutions	Management of demand volatility
Human-Machine-Interfaces	Less distance to the customer	Autonomous self-organization
Self-optimization of products	Differentiation from competitors	Better interconnection of production facilities
IT Service alongside existing product	Higher vertical integration	Less non-value adding processes
Finding of adequate partners for customer	Increased customer retention	Less fluctuation of quality
Pay-per-Use models		Increased quality within processes
Pay-per-feature models		Reduction of scrap rate

Table 1. *Cont.*

(1) New Service Business Model Features to Offer to the Customer	(2) Potentials of New Business Model Features for the Provider	(3) Potentials of New Business Model Features for the Customer
Knowledge management		Capacity and load balancing
Production software		Better raw material usage
Supply chain management software		Reduction of maintenance costs
Virtual product development		Improved simulations
Production platforms		Increased transparency
Cloud-based production		Less interim storages
Self-optimizing systems		Better usage of existing data
Interconnection of products		Less capital tied up
Process optimization for customer		Redundancy and failure robustness
Increased flexibility of systems		Prediction of customer demands
Integrated quality control		Parallelization of processes
Search for customers		Optimization of lot sizes
Marketing optimization		
Failure analysis		
Simulation software		
Value Stream Mapping		
Analysis of optimization potentials		
Customer integration		
Real-time data availability		
Vendor Managed Inventory		
Process and interface standardization		

The complete questionnaire can be found in the appendix: Table A1 in the appendix shows the list of new business model features to offer to the customer, whereas Table A2 shows the potentials of these new business features for the provider. Further, Table A3 lists the potentials for process improvements or process innovations for the customer.

4.2. Selection of the Sample

In order to gain a holistic understanding of the value creation environment of Industry 4.0 solution providers in medium-sized companies, organizations from many different industries were selected as potential participants. Different solution providers were included, i.e., machine and plant construction companies, system integrators, IT service providers, automation technology companies, etc. Employees or managing directors of companies that see themselves as providers of Industry 4.0 specific solutions are to be surveyed. Another criterion for the survey is the sufficient qualification of participants. The person completing the questionnaire should be able to survey the overall situation and the range of services that are offered by the company in order to be able to provide sufficient answers due to the extensive questions posed by the questionnaire.

4.3. Conduct of the Survey

The questionnaire was created as a Portable Document Format (PDF) document, which can be filled in and saved as a form. The advantage of such a form is that it can be filled out, temporarily stored, and forwarded to the respective expert within the company without great effort. Once the questionnaire had been prepared, it was pre-tested by two Industry 4.0 experts for manageability, content relevance, and comprehensibility and minor changes were made to the questionnaire. Subsequently, the survey was started. Potential survey participants could be addressed personally by visiting the industrial fairs "Hannover Fair 2016", "All About Automation 2016" in Friedrichshafen, and "Automatica 2016" in Munich. The questionnaire could then be sent to the respective persons by e-mail. The websites of the trade fairs mentioned could also serve as a source of information to find further contacts. If the opportunity arose, the company was first contacted by telephone to find out whether the company sees itself as an Industry 4.0 solution provider and, if so, to find out the right contact person for the survey and then to give them an understanding of the survey. Thus, potential survey participants had already been personally informed in advance and the questionnaire was sent by e-mail after the telephone call. Through this approach, which is based on personal conversations, the highest possible response rate should be achieved, since the response rate of written and e-mail surveys is usually rather low. Personal contact can have a motivating effect on the respondent. Further sources for contact acquisition were the Industry 4.0 platform and other clusters or company networks and various industry directories. In this way, solution providers from many different industries were to be contacted in order to be able to comprehensively capture the value-added environment.

4.4. Sample Description

The survey was conducted from April to July 2016. The questionnaire was distributed to 310 potential survey participants. A total of 121 persons took part in the survey, resulting in a response rate of 39%. Of the 121 completed questionnaires, ten were sorted out for evaluation, as these companies are to be classified as multinational corporations and only one questionnaire per company was accepted. Thus, the sample for further evaluation is n = 111.

67 of the 111 respondents (approx. 60%) can be assigned to manufacturing companies and 44 to non-producing companies. There are 33 participants from mechanical and plant engineering, 31 participants from automation, 26 participants from IT and software companies, nine participants from the field of electronics, six participants from service companies, and six further participants. In terms of company size, all companies can be classified as SMEs, i.e., a maximum number of 250 employees and a maximum of 50 million euros in annual turnover [5]. The mean number of employees in the sample is 135.8, ranging from 7 to 245 employees. The mean annual turnover is 26.98 million euros, ranging from 1.3 to 47.8 million euros.

4.5. Data Evaluation

The results of the survey were further investigated using Pearson correlation values and mean values of the individual response options. Pearson's correlation is very common for correlation studies and is also applicable to Likert scales, according to several studies [45,46]. The correlation studies should show correlations between different response options. Random and fictitious correlations are to be excluded, in which a causal and content wise connection was regarded as absurd.

Overall, only correlations from a value of 0.5 were used for further evaluation, as these indicate a strong effect or strong correlation [47]. If a correlation only had a value of 0.5 or more within one of the subgroups (manufacturing enterprises and service enterprises), this correlation was also taken into account, since the differences between the responses of these two groupings are part of the investigation. In addition, all of the correlations included fulfill the condition of p-value < 0.05 and are therefore to be regarded as significant.

An overview of all mean values of the individual questions of the questionnaire and the associated standard deviations can be found in the appendix.

5. Results

In the following, correlations between new business model features with potentials for the Industry 4.0 solution provider are shown in Section 5.1. In Section 5.2, the correlations of new business model features of the Industry 4.0 solution providers with potentials for process improvements and process innovations for their customers are examined.

5.1. Correlations between New Business Model Features and Potentials for the Solution Provider

As explained in Section 4, only those correlations that clearly differ between manufacturing and service enterprises and that are above 0.5 are shown in Table 2.

Table 2. Correlations between new business model features and potentials for the solution provider.

Item Numbers	Item Correlation	Total Sample	Manu-Facturing	Service
1.4/2.3	"Predictive maintenance" AND "New core competences"	0.444	**0.547**	0.206
1.4/2.5	"Predictive maintenance" AND "Competitive advantages for existing products"	0.410	**0.500**	0.128
1.4/2.11	"Predictive maintenance" AND "Increased customer retention"	0.362	**0.575**	−0.177
1.6/2.6	"Open-Source product development" AND "Generation of second source of income"	0.337	**0.509**	0.089
1.8/2.3	"Human-Machine-Interfaces" AND "New core competencies"	0.415	**0.552**	0.137
1.10/2.3	"IT Service alongside existing product" AND "New core competencies"	0.357	**0.553**	0.005
1.10/2.9	"IT Service alongside existing product" AND "Differentiation from competitors"	0.370	**0.544**	0.057
1.30/2.3	"Process analysis and optimization" AND "New core competencies"	0.395	**0.552**	0.086

As Table 1 shows, new business model features are foremost expected to generate potentials for manufacturing enterprises. Hereby, predictive maintenance is seen as a new business model feature that can serve as a new core competence, as creating an additional competitive advantage for existing products, and to increase customer retention. Further, open-source product development is seen by manufacturing enterprises as a tool to generate a second source of income. The provision of Human-Machine-Interfaces is regarded to serve as a new competence. Offering IT service alongside the existing product is also seen to generate a new core competence, as well as a tool for the differentiation from competitors. Last, offering process analysis and optimization is regarded to serve as a new core competence.

5.2. Correlations between New Business Model Features and Potentials for the Customer

As for Table 1, only those correlations that clearly differ between manufacturing and service enterprises and that are above 0.5 are shown in Table 3.

As Table 3 shows, new business model features have higher correlations with generation customer potentials regarding process improvements or process innovation for service enterprises than for manufacturing enterprises. For service enterprises, offering better traceability is expected to generate increased quality within processes of their customer. Comparably, availability on demand shall address capacity and load balancing, whereas knowledge management is intended to better manage demand volatility. Further, process optimization for the customer shall achieve better raw material usage, whereas integrated quality control is intended to archive a reduction of scrap rate for the customer. Failure analysis for the customer shall lead to manifold benefits, including less fluctuation of quality, reduction of complexity costs, increased quality within processes, and a reduction of scrap rate. The latter is also targeted by read-time data availability, whereas the analysis of optimization potentials shall achieve better raw material usage.

For manufacturing enterprises. An increased flexibility of systems is intended to make demand volatility better manageable for the customer. Further, the analysis of optimization potentials shall lead to less non-value adding processes for customers.

Table 3. Correlations between new business model features and potentials for the customer.

Item Numbers	Item Correlation	Total Sample	Manu-Facturing	Service
1.2/3.12	"Traceability" AND "Increased quality within processes"	0.254	0.000	**0.563**
1.7/3.14	"Availability on demand" AND "Capacity and load balancing"	0.296	0.122	**0.515**
1.14/3.7	"Knowledge management" AND "Management of demand volatility"	0.178	−0.013	**0.588**
1.22/3.15	"Process optimization for customer" AND "Better raw material usage"	0.339	0.199	**0.521**
1.23/3.7	"Increased flexibility of systems" AND "Management of demand volatility"	0.432	**0.579**	0.168
1.24/3.13	"Integrated quality control" AND "Reduction of scrap rate"	0.492	0.383	**0.645**
1.27/3.11	"Failure analysis" AND "Less fluctuation of quality"	0.386	0.290	**0.508**
1.27/3.5	"Failure analysis" AND "Reduction of complexity costs"	0.337	0.145	**0.572**
1.27/3.12	"Failure analysis" AND "Increased quality within processes"	0.475	0.358	**0.652**
1.27/3.13	"Failure analysis" AND "Reduction of scrap rate"	0.313	0.134	**0.595**
1.30/3.15	"Analysis of optimization potentials" AND "Better raw material usage"	0.260	0.041	**0.553**
1.30/3.10	"Analysis of optimization potentials" AND "Less non-value adding processes"	0.452	**0.508**	0.371
1.32/3.13	"Real-time data availability" AND "Reduction of scrap rate"	0.285	0.153	**0.511**

6. Discussion

The fact that customer benefit is one of the most important topics for Industry 4.0 solution providers from non-manufacturing industries underscores the strong customer focus of these service-driven companies [26]. For them, from the perspective of solution providers, Industry 4.0 is actually perceived, as a solution to counteract the challenges that are described in 3.2 and in particular the challenges of SMEs.

With regard to the key figures of customers to be improved, it is noticeable, that on the one hand the improvement potentials predicted by Bauernhansl [32] with regard to inventory costs, production costs, and complexity costs can be confirmed. However, on the other hand, the potential to reduce production costs was rated higher than that of complexity costs and inventory costs. This does not correspond exactly with Bauernhansl's theory, which, however, does not distinguish between Industry 4.0 suppliers and users and rather estimates general savings potentials [32]. Further, SMEs have proven to focus on operational and production-related benefits of Industry 4.0 rather than the strategic benefits or such benefits that unfold across the supply chain [10].

Further, the results show the difficulty of estimating generally valid savings potentials, which can vary greatly depending on the application or solution [1,10]. The finding that solution providers rated the potential for reducing their customers' production costs the highest is a further indication that a strong production focus of the solutions exists. This explanation is also supported by the fact that those customer goals can be most strongly supported by Industry 4.0-based solutions [10].

Perceived benefits of Industry 4.0 are for the most part related to production, but not yet to other disciplines, such as supply chain management [1,3]. However, horizontal and vertical interconnection in real-time represent a core characteristic of Industry 4.0 [1,2]. The benefits across the supply chain are still less regarded in the sense that Industry 4.0 might also stem from the difficulty to interconnect several systems and interfaces that do not possess unified standards, especially across several supply chain partners [11].

The fact that the potential to solve the customer problem of an increasing variety of products was rated as higher by non-producing companies could be due to the fact that certain IT companies in particular can make a direct contribution to this through, e.g., Manufacturing Execution Systems [1].

The large number of correlations between new business model elements and customer benefits indicate the strong links between the individual topics. However, this is more the case with non-producing solution providers. The reason for this could be the holistic view of service companies [16,26]. In addition, service-oriented IT firms can offer solutions that can address many of the proposed topics, as well as the production, development, sales, and other departments of customers from different industries simultaneously [17].

In contrast, solutions from manufacturing companies, for instance, can be very industry-dependent and customer-specific [1], and therefore not allow for a generalization of the benefits. Hence, those solutions may not cover the entire portfolio of customer benefit options at the same time. However, the mean values, which in most cases have similar characteristics in manufacturing companies as those of nonproducing companies, suggest that the solutions of manufacturing companies were classified as similarly effective in terms of customer benefit. However, since there exist hardly any recognizable correlations, the assumption seems logical that the solutions of different producing enterprises are very individual regarding the customer use and differ correspondingly.

A further reason for correlations within comparable items could be that there are many options that complement each other in terms of content or are very similar. Hence, for instance, the correlation of "Failure analysis" with "Increased quality within processes" can be explained. A further example is that the complexity costs can be reduced by reducing non-value-adding operations.

However, as already mentioned, the correlations primarily reflect the perspective of nonproducing companies, whereas manufacturing companies do not show correlations regarding new business model elements in order to generate benefits for the customers, but for themselves.

7. Conclusions

7.1. Managerial Implications

From a managerial perspective, the paper has shown a variety of possible business model features that can be offered to the customer, based on Industry 4.0-technolgoies. Moreover, it is shown which own benefits for the solution provider are targeted by introducing new business model features following Industry 4.0-technologies. It is found that these benefits are foremost intended by manufacturing enterprises in contrast to service enterprises. Further, it is shown which business model features are targeting what potentials for process improvements or process innovation for their customers. Hereby, it is shown that mainly service enterprises target their customers' benefits with new business model features. Therefore, this paper offers both an insight as well as a recommendation to better target both potentials, for the company and for the customer, at the same time when introducing new business model features.

7.2. Theoretical Implications

From a theoretical perspective, the paper adds to the state of research regarding business model innovation in the context of Industry 4.0. Hereby, the delineation of the user and provider perspective represents a well-proven concept [1]. Exploring the motives for SMEs to introduce new business model features remains a topic that is scarcely investigated, which the paper adds to [5].

Further, the differentiation between manufacturing and service enterprises, especially regarding the challenges of integrating the offering of services for manufacturers [16,17,26], is a research stream that is extended in the context of Industry 4.0.

7.3. Limitations and Suggestions for Future Research

However, the paper has several limitations that must be considered. First of all, by only investigating the solution providers, the generation of customer benefits can only be assessed, but not definitely be determined. Hence, a dyadic approach, also including an investigation among the customers and users of such solutions offered, is the logical next step for future research.

Second, the paper is limited to German enterprises. In response, an international comparison would offer interesting insights and opportunities for comparison in future research.

Third, the paper is limited to SMEs, which on the one hand assists to fill a research gap, but on the other hand should be extended in a comparison with larger enterprises in future research.

Fourth, some of the business model features do not definitely or necessarily relate to Industry 4.0-technologies. Those can, at least partly, also be achieved using less advanced technology. Consequently, research regarding the extent to which Industry 4.0-technologies are included in those approaches is required.

Last, the paper can only derive antecedents, i.e., what the solution providers intend, but not what they will achieve by introducing the new business model features. This should also be investigated in future research.

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Appendix A

Table A1. New service business model features to offer to the customer.

Item Number	Item	Mean Value	Standard Deviation
1.1	Consulting towards digitization	3.670	1.248
1.2	Traceability	3.945	1.195
1.3	Product lifecycle optimization	3.642	1.067
1.4	Predictive Maintenance	4.200	1.065
1.5	Alternative tasks when idle	2.661	1.132
1.6	Open-Source product development	2.440	1.126
1.7	Availability on demand	3.266	1.199
1.8	Human-Machine-Interfaces	3.818	1.077
1.9	Self-optimization of products	3.874	1.080
1.10	IT Service alongside existing product	3.739	1.126
1.11	Finding of adequate partners for customer	2.725	1.096
1.12	Pay-per-Use models	2.815	1.305
1.13	Pay-per-feature models	2.916	1.175
1.14	Knowledge management	3.349	1.003
1.15	Production software	3.455	1.201
1.16	Supply chain management software	3.685	1.036
1.17	Virtual product development	3.183	1.248
1.18	Production platforms	2.826	1.275
1.19	Cloud-based production	3.028	1.249
1.20	Self-optimizing systems	3.431	1.257
1.21	Interconnection of products	3.928	1.110

Table A1. *Cont.*

Item Number	Item	Mean Value	Standard Deviation
1.22	Process optimization for customer	4.091	1.028
1.23	Increased flexibility of systems	3.826	1.153
1.24	Integrated quality control	3.917	1.081
1.25	Search for customers	2.727	1.141
1.26	Marketing optimization	2.694	1.118
1.27	Failure analysis	3.908	1.050
1.28	Simulation software	2.927	1.186
1.29	Value Stream Mapping	2.880	1.166
1.30	Analysis of optimization potentials	3.836	0.924
1.31	Customer integration	3.292	1.195
1.32	Real-time data availability	4.138	0.907
1.33	Vendor Managed Inventory	2.848	1.142
1.34	Process and interface standardization	3.385	1.105

Table A2. Potentials of new business model features for the provider.

Item Number	Item	Mean Value	Standard Deviation
2.1	Generation of new customer segments	3.718	1.158
2.2	Generation of international customer base	3.239	1.276
2.3	New core competencies	3.927	0.940
2.4	Pioneering advantages	3.477	1.003
2.5	Competitive advantages for existing products	3.771	1.077
2.6	Generation of second source of income	3.345	1.222
2.7	Tailor-made solutions	3.873	1.150
2.8	Less distance to the customer	3.174	1.216
2.9	Differentiation from competitors	3.881	0.988
2.10	Higher vertical integration	3.339	1.188
2.11	Increased customer retention	3.909	1.010

Table A3. Potentials of new business model features for the customer.

Item Number	Item	Mean Value	Standard Deviation
3.1	Reduction of delivery times	3.682	1.226
3.2	Reduction of lead times	3.862	1.205
3.3	Reduction of storage costs	3.523	1.216
3.4	Reduction of production costs	3.881	1.230
3.5	Reduction of complexity costs	3.694	1.156
3.6	Reduction of personnel costs	3.541	1.175
3.7	Management of demand volatility	4.185	1.120
3.8	Autonomous self-organization	3.481	1.081
3.9	Better interconnection of production facilities	4.138	1.084
3.10	Less non-value adding processes	4.266	1.015
3.11	Less fluctuation of quality	4.009	1.131
3.12	Increased quality within processes	3.907	1.170
3.13	Reduction of scrap rate	3.648	1.248
3.14	Capacity and load balancing	3.710	1.221
3.15	Better raw material usage	3.306	1.234
3.16	Reduction of maintenance costs	4.120	1.074
3.17	Improved simulations	3.167	1.172
3.18	Increased transparency	3.731	1.181
3.19	Less interim storages	3.065	1.270
3.20	Better usage of existing data	4.092	1.068
3.21	Less capital tied up	2.509	1.189
3.22	Redundancy and failure robustness	3.458	1.238
3.23	Prediction of customer demands	2.785	1.281
3.24	Parallelization of processes	3.028	1.240
3.25	Optimization of lot sizes	3.271	1.343

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