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Industry 4.0 – The Evolution of Business Models

by

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Abstract

Business models need to change over time if companies want to sustain their value creation and value capture. Examples such as Kodak and Nokia, which have failed in digitisation, have shown that companies need dynamic capability incorporating the adaption and renewal of their business models to stay competitive. German companies, especially those forming the backbone of the German economy – small- and medium-sized enterprises (SME) – are confronted by more volatile as well as competitive markets and suffer as a result of pressure from abroad. According to a large number of scientific authors and all types of consultancies, SMEs need to adapt their digitisation strategies to stay competitive in future.

However, previous academic literature has neglected to examine how such technological developments, such as Industry 4.0 (I4.0), impact German SMEs business models (BMs). This dissertation is therefore not only interesting for academic research but also for business practice.

For this reason, a cross-case analysis enabled the author to analyse I4.0-related BM changes in six German SMEs from different industries. These findings from the data analysis demonstrate how I4.0-related technologies influence SME BMs in the German manufacturing industry. With the help of the Business Model Canvas (BMC) ontology, the empirical findings demonstrate how such SME BMs change if SMEs implement I4.0-related technologies. Furthermore, similarities and differences in such changes across various industries were included in the specific findings of the data analysis.

The empirical findings demonstrate that each of the German SMEs has already implemented I4.0-related technologies. After the implementation, these German SMEs have dealt with incremental BM changes more than BM innovations. No German SME has changed its entire

BM, but could improve at least one BM component because of I4.0. In particular, all these SMEs are influenced in the following BM components: customer relationships, key resources and cost structure.

Table of Contents

Table of Figures

List of Abbreviations

I4.0	Industry 4.0
AR	Augmented Reality
B2B	Business-to-Business
BM	Business model
BMC	Business Model Canvas
BMI	Business model innovation
CEO	Chief executive officer
CPPS	Cyber-Physical Production Systems
CPS	Cyber-Physical Systems
CVP	Customer value proposition
EPP	Expanded polypropylene
EPS	Expanded polystyrene
ERP	Enterprise Resource Planning
EU	European Union
GmbH	Gesellschaft mit beschränkter Haftung (legal form)
IfM	Institut für Mittelstandsforschung
IoT	Internet of Things
IoTS	Internet of Things and Services
KfW	Kreditanstalt für Wiederaufbau
MES	Manufacturing Execution System
R&D	Research and development
SME	Small- and medium-sized enterprise
VR	Virtual Reality

1. Introduction

1.1 Problem outline

"*Industry 4.0*" (I4.0) is a term which was first introduced at the Hanover Fair in 2011 (Kagermann *et al.*, 2013). A fourth industrial revolution is happening in global manufacturing, and intends to ensure the competitiveness of German industry. According to Lasi *et al.* (2014), German industry must deal with changes to environmental conditions on the one hand, and, on the other, with technological developments. While the changes in environmental conditions result from globalisation, increasing market volatility, shorter innovation cycles, intensive competition and increasing complexity, technological developments include the introduction of the Internet of Things (IoT), Cyber-Physical Systems (CPS), big data analytics and cloud computing, with the aim of shaping manufacturing lines.

German industry is highly dependent on small- and medium-sized enterprises (SMEs). "Approximately 99 percent of all German enterprises are SMEs employing 60 percent of all employees in Germany. These SMEs and their employees generate 34 percent of the total turnover of all German enterprises" (Sommer, 2015).

"Many SMEs need to identify future growth markets" (Ganzarain and Errasti, 2016). However, Ganzarain and Errasti (2016) outline that SMEs often have no idea where to start generating new growth opportunities or do not know how to face the challenge of I4.0. "In Germany, industries are evaluating their readiness towards implementing I4.0. At least 41 percent of German firms are aware of the theme and have started some concrete initiatives. But it is a long way to go and for some industries the topic is still unknown" (Sanders, Elangeswaran and Wulfsberg, 2016, p. 816). Moreover, Maier and Student (2015) point out that SMEs are aware that action needs to be taken, but do not know how to go about this and where to start.

To achieve growth opportunities as are mentioned above, and to defend their international competitiveness, SMEs in the manufacturing sector should use the increasing range of technological possibilities available (Schröder, 2016). Established companies need to not only reshape their products, but innovate their business models (Markides, 2006; Chesbrough, 2010; Teece, 2010; Zott and Amit, 2010; Schneider and Spieth, 2013; Thoben, Wiesner and Wuest, 2017). Schröder (2016) underlines that SMEs should develop new strategies in order to improve the value chain and to develop new business models. Furthermore, Kagermann *et al.* (2013) confirm that manufacturers would be well-advised to reflect upon and innovate their business models to stay competitive.

Thus far in academic literature, there is no consensus on a clear and consistent definition of business models (Zott, Amit and Massa., 2011). Nevertheless, Teece (2010) describes business models as a management hypothesis that shows the necessary customer requirements, methods and organisational approach for a company to achieve its needs whilst making a profit. In previous academic literature, some business model ontologies have been introduced, such as the "Business Model Canvas", by Osterwalder and Pigneur (2010), and the "Magic Triangle", by Gassmann, Frankenberger and Csik (2013), demonstrating different characteristics that describe the opportunities to capture value for a company.

However, existing academic literature on I4.0 is mostly technology-oriented, while there is a lack of insight into the strategic and operational effects of I4.0 within manufacturing firms. "Business model research is relatively silent with regard to how the relationship between industry dynamics and business models can be characterized" (Hacklin, Björkdahl and Wallin, 2017, p. 2). Furthermore, because of the extent and complexity of the I4.0 concept, understanding of the adoption of I4.0 components in business models is lagging behind among manufacturing firms.

1.2 Research question

Existing academic literature does not offer detailed insights into the impact of I4.0 on the business models of manufacturing SMEs. This research addresses the issue of linking business models with I4.0 concepts. In order to address this gap, German SMEs will be studied using the following research question: "How does Industry 4.0 influence the business models of SMEs in the German manufacturing industry?"

In this context, this dissertation aims specifically to:

(i) identify the I4.0-related business models changes

(ii) demonstrate the differences and similarities in such business model changes

1.3 Structure

To respond adequately to the above-mentioned research question, this study is structured in six chapters. The first three comprise theoretical background information and the final three are concerned with a qualitative cross-case research study regarding the I4.0-related impacts on the business models of German SMEs in different manufacturing industries.

More specifically, the first chapter provides the reader with a brief introduction to the topic of I4.0 and additionally elaborates on this dissertation`s relevance and purpose.

The following chapter comprises a review of the previous academic literature. To provide a valuable broad overview for the reader, the author has separated the literature review chapter into three subchapters that will describe in detail the following key issues relating to the research question respectively: “small- and medium-sized enterprises”, “Industry 4.0” and “business models”.

The qualitative research methodology is presented in chapter three, including a brief description of the methodological background and the data collection process as well as the proceedings relating to the analysis.

Chapter four then sets out the data analysis, including a brief introduction to each research participant, the general findings included in the business model canvas ontology and the specific findings where changes to the business model canvas component will be outlined.

Chapter five discusses these empirical findings, drawing from the data analysis and critically examining these findings in the light of previous academic literature, as outlined in the introduction and in the literature review.

Lastly, this dissertation concludes with underlying limitations and provides suggestions for further research.

2. Literature review

2.1 Introduction

The purpose of the following chapter is to provide a review and critical analysis of the previous academic literature. In order to tackle the research question, this chapter should provide background information about the key issues relating to the research question. For this reason, “small- and medium-sized enterprises”, “Industry 4.0” and “business models” (BM) should be considered in more detail.

2.2 Small and medium-sized enterprises

This chapter will precisely define small- and medium-sized enterprises (SMEs) to provide the reader with an overview of different kinds of enterprise sizes. The definition of SMEs and their importance to the locations of German industry should be further discussed.

2.2.1 Definition of SMEs

No common view of SMEs is apparent in academic literature. “The term SME covers a wide range of definitions and measures, varying from country to country and varying between the sources reporting SME statistics. Some of the commonly used criteria are the number of employees, total net assets, sales and investment level” (Ayyagari, Beck and Demirguc-Kunt, 2007, p. 416).

As a result of the focus of this work on the German manufacturing industry, only German SMEs are considered here. To understand what SMEs are, a definition is needed. This will be provided by the European (EU) Commission, the “Institut für Mittelstand” (IfM) Bonn and the “Kreditanstalt für Wiederaufbau” (KfW).

According to Liikanen (2003), the SMEs are enterprises that are classified into the following categories, as seen Figure 1:

1. Companies which employ fewer than ten employees and with a maximum annual turnover of 2 million euros are classified as “micro” enterprises.
2. Companies which employ fewer than fifty people and generate a turnover of less than 10 million euros are defined as “small” enterprises.
3. Companies with a limit of 250 employees and generating a turnover of 50 million euros and/or with an overall balance sheet amount under 43 million euros are classified as “medium-sized” enterprises.

Enterprise classification	Number of employees	and	Annual turnover in mio. euros	or	Balance sheet amount in mio. euros
Micro	Up to 10		max. 2		max. 2
Small	Up to 50		max. 10		max. 10
Medium	Up to 250		max. 50		max. 43

Figure 1: European Commission’s classification of SMEs. Source: Derived from Liikanen (2003)

On the other side, the IfM Bonn has set up its own definition of SMEs, which differs slightly from the EU Commission’s definition. The IfM Bonn defines SMEs through the unity of property and management.

According to the IfM Bonn (2016), “Mittelstand” enterprises overlap with SMEs in Germany. Mittelstand enterprises are large medium-sized enterprises. In a medium-sized enterprise, up to two natural persons or their family members hold at least 50% of the shares of a company and these natural persons belong to the company (IfM Bonn, 2016).

Furthermore, as part of IfM Bonn's definition, distinguishing SMEs from large companies on the quantitative size criteria, enterprises with 500 or more employees or more than 50 million euros in turnover also belong to the middle class if they meet the above criteria.

To achieve a harmonisation with the SME definition of the EU Commission in the micro- and small enterprise segment, micro and small enterprises are now defined in line with the EU definition (IfM Bonn, 2016). For medium-sized enterprises, however, the threshold of the IfM Bonn's definition remains 499 employees.

The German government-owned development bank "KfW Bankengruppe", formed after World War II as part of the Marshall Plan, also extends this SME classification and underlines the concept of a "large medium-sized enterprise". These enterprises should be majority-owned by private individuals and do not exceed a group turnover of 500 million euros (KfW, 2016).

Enterprise classification	Number of employees	Annual turnover in mio. euros
Micro	Up to 10	Up to 2
Small	Up to 50	Up to 20
Mittelstand	More than 50	Up to 500

Figure 2: SMEs classification for this dissertation

As a result of the range of definitions in existence, the author of this dissertation will use magnitude, as seen in Figure 2. This magnitude has been essential for this research, which used magnitude to determine a wide variety of SMEs from different industries for qualitative analysis.

2.2.2 Importance of SMEs for the German economy

Such SMEs form the backbone of the German economy. While there are only 1,800 large enterprises in Germany, 3.67 million enterprises are classified as small- and medium-sized (KfW, 2015). Of these enterprises, 690,000 belong to the manufacturing industry. SMEs thus represent 99.95% of all German companies and employ 29.1 million people, or 68% of the working population (KfW, 2015).

The German economy is in good shape. However, such good shape requires growth rates of well above 2%, requiring a significantly faster productivity growth (KfW, 2016). This productivity is the Achilles heel for SMEs. However, according to KfW (2016), the labour productivity growth rate of SMEs fell by a significant 3,3% in 2015. Productivity is, for such enterprises, essential for survival in international competition. New developments in digitisation provide new opportunities to increase the overall efficiency and productivity of such enterprises. Nevertheless, according to Schröder (2016), only 5% has already been invested in such a digitisation strategy. KfW (2016) states that overall SME investment in digitisation projects was around 10 billion euros in 2015, a figure which can be expected to rise to around 13 billion euros annually up to 2018.

This digitisation strategy, which is also includes key components of I4.0, will be an essential part of this dissertation and for business models of SMEs. For this reason, the terms I4.0 and BM will be clarified in the next two subchapters.

2.3 Industry 4.0

"Germany has one of the most competitive manufacturing industries in the world and is a global leader in the manufacturing equipment sector" (Kagermann *et al.*, 2013, p. 5). According to Sendler (2016), the processes of German industry have been digitised over the last forty years.

However, Germany has not been a pioneer in terms of digitisation over this time, because huge American multinational technology companies, such as Apple, Microsoft, Google, Facebook and Amazon, are dominating the global market. Since the first introduction of I4.0 at the Hanover Fair in 2011, Germany has taken on a leading role in this area (Sendler, 2016). I4.0 is the "focal part of the high-tech strategy of the German government" (Bochman *et al.*, 2015, p. 270).

"In the words of German Chancellor Angela Merkel, Industry 4.0 is the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with convention industry" (Davies, 2015, p. 2). After the introduction of mechanical production facilities with the help of water and steam power (first industrial revolution), the introduction of division of labour and mass production with the help of electrical energy (second industrial revolution) and the development of electronic and IT systems, further automating production (third industrial revolution), I4.0 represents the fourth industrial revolution and is characterised by the introduction of the "Internet of Things" (IoT) (Thoben, Wiesner and Wuest, 2016).

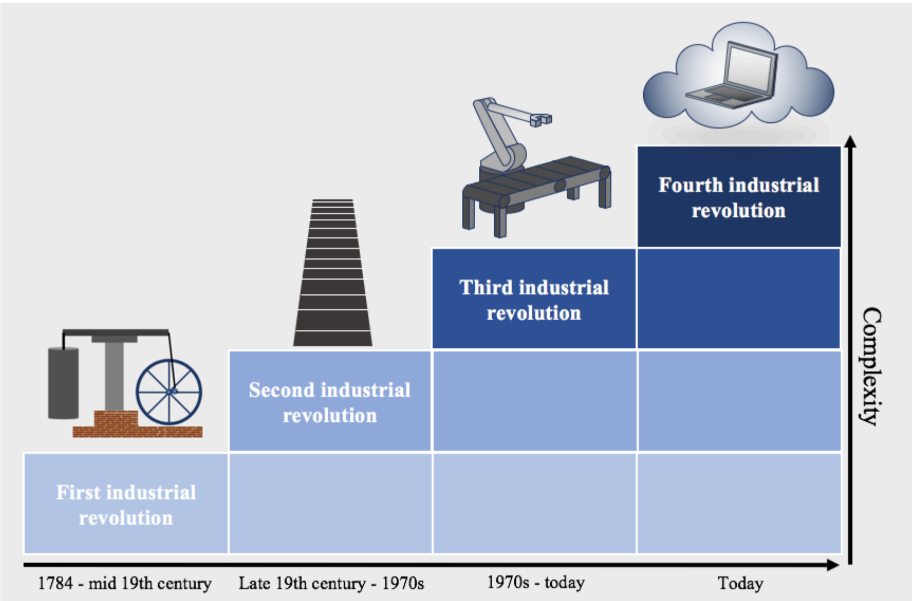

Figure 3: Historical development of the industry

2.3.1 Components of I4.0

I4.0 depends on a number of new and innovative technological systems. To ensure that the reader understands the logic and the idea behind I4.0, the most important components of I4.0 should be described in the following chapter. The goal of this chapter is therefore to provide a brief and concise overview of I4.0.

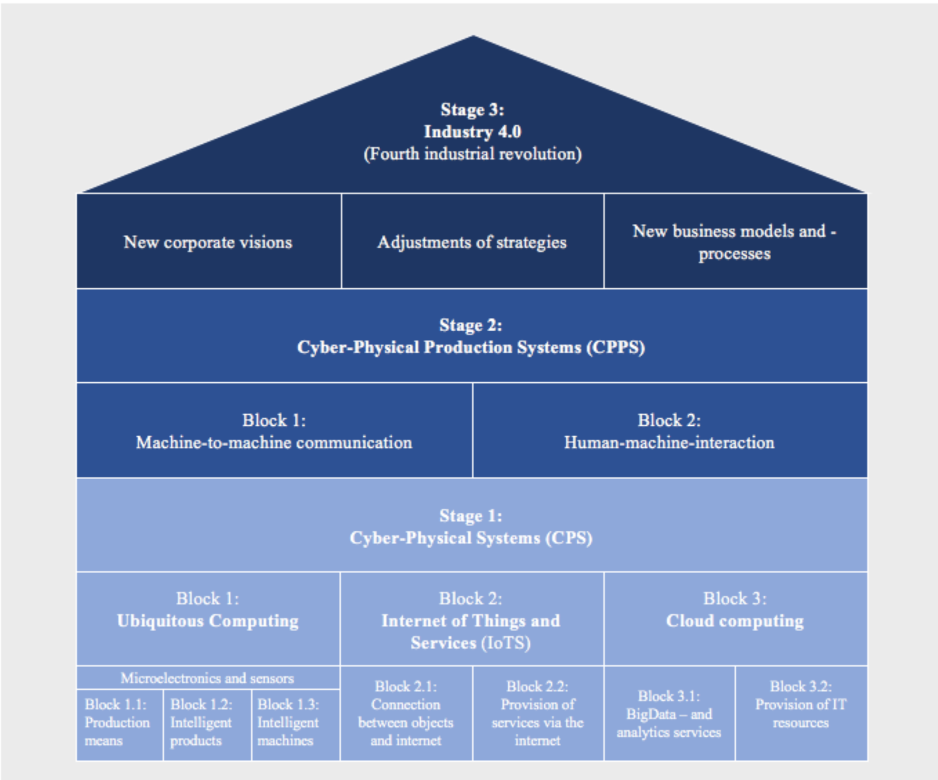

Figure 4: Industry 4.0 components. Source: Derived from Roth (2016)

As is apparent in Figure 4, the first stage of I4.0 is described by "Cyber-Physical Systems" (CPSs). CPSs are a combination of software and hardware systems (Roth, 2016). CPS consists of physical entities, such as machines, vehicles and work pieces equipped with technologies (Bauernhansl, 2014; Thoben, Wiesner and Wuest, 2016). Roth (2016) separates such technologies into three blocks: "ubiquitous computing", the "Internet of Things and Services"

(IoTS) and, lastly, “cloud computing”. *Ubiquitous computing* gives all objects in a system the ability to process and send information and data by providing appropriate microelectronics, sensors, communication modules and computer power. These objects, which are provided with information technology and a certain intelligence, are used, for example, in the formation of intelligent production means, intelligent product means or entire intelligent production machines. In the second block, *IoTS*, ubiquitous computing objects are equipped with necessary communication capabilities. The IoTS serves primarily as a link between intelligent physical objects of ubiquitous computing and the internet. For this reason, production resources in I4.0 can be addressed directly via the internet and the necessary data can be collected, processed and returned to the machines in the form of control data (Roth, 2016). This digitisation of production requires a correspondingly expanded IT infrastructure, provided in the form of so-called *cloud computing*. The maintenance and control of such CPSs is supported by real-time evaluations, requiring services such as BigData and Analytics (Sendler, 2016). According to Porter and Heppelmann (2014), such CPSs have been connected along the value chain of companies.

The second stage of I4.0 describes the use of a CPS called a “Cyber-Physical Production System” (CPPS), able to control the production decentral and context-adaptive across the company’s borders. However, in order to enable fully functional networking and communication between the systems and components of a CPPS and humans, the use of suitable interfaces is necessary (Roth, 2016). One the one hand, the use of a suitable syntax of machine-to-machine communication is necessary. Machines can increasingly be linked together in systems and are fully automated and optimise production (Porter and Heppelmann, 2015). According to Porter and Heppelmann (2015, p. 9), “a production machine can detect a potential malfunction, shut down other equipment that could be damaged and direct maintenance staff to the problem”. Creation of a standard is indispensable for the actual realisation of a decentralised and automated production system. On the other hand, appropriate technologies for human-machine interaction are essential to monitor and control the production facilities. According to Roth (2016), Virtual Reality (VR) or Augmented Reality (AR) can represent interfaces between the employee and the machine and make it possible to involve people as final decision-making authorities in production planning and control.

Implementation of such technology in the manufacturing environment is the beginning of a completely new approach in production – the “smart factories” (Kagermann *et al.*, 2013; Bauernhansl, 2014). “The embedded manufacturing systems are vertically networked with business processes within factories and enterprises and horizontally connected to dispersed value networks that can be managed in real time – from the moment an order is placed right through to outbound logistics” (Kagermann *et al.*, 2013, p. 5). Resource efficiency in terms of material usage, energy consumption and human work, are therefore significantly enhanced (Spath *et al.*, 2013; Kaufmann, 2015). Kagermann *et al.* (2013) further points out that I4.0 allows individual customer requirements to be met, as well as dynamic business and engineering processes, which enables last-minute changes to production, continuous resource productivity, efficiency and better transparency in the manufacturing process, which improving decision-making.

The implementation of such a CPPS in a company requires not only basic technological components but also visionary ways of thinking at management level (Roth, 2016). I4.0 is not only the technological development of production, but rather a future for the entire company, for which strategies and BM adjustments have to be made (Davies, 2015; Roth, 2016). Kagermann *et al.* (2013) also mentions that I4.0 results in new ways of creating value and novel BMs. Such BMs will be discussed in more detail in the next chapter.

2.4 Business models

In this section, the expression and concept of BMs should be outlined. A broad definition of a BM is as a management hypothesis about what customers want, how they want it, and how the enterprise can organise itself to meet these needs, be paid for doing so, and make a profit (Teece, 2010). Moreover, Osterwalder, Pigneur and Tucci (2005, p. 3) provide a more detailed definition: "A business model is a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm. Therefore, we must consider which concepts and relationships allow a simplified description and representation of what value is provided to customers, how this is done and with which financial aspects."

A distinction must be made between the company's strategy and a BM. The difference between strategy and BMs is much less clear (Osterwalder, Pigneur and Tucci, 2005). "A business model isn't the same thing as a strategy, even though many people use the terms interchangeably today" (Magretta, 2002, p. 90). The two terms are linked but the distinction is more common (Magretta, 2002). Magretta (2002) further describes BMs as a system that shows how the pieces of businesses fit together, while strategy also includes competition. Figure 5 shows this issue in three distinct layers. This figure provides insights into BM as a translation of a company's strategy into a blueprint for money-earning logic (Osterwalder, Pigneur and Tucci, 2005). Subsequently, a BM can be implemented into the process layer, where the logic will be operationalised.

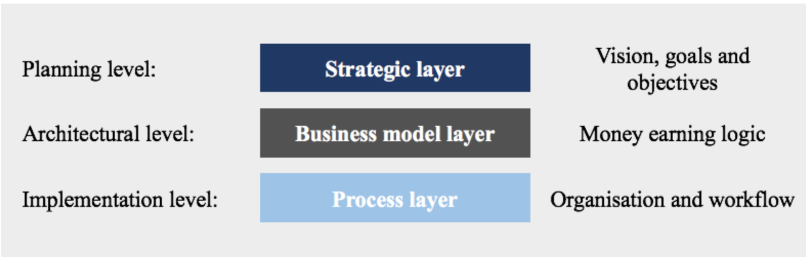

Figure 5: Business layers. Source: Derived from Osterwalder (2004)

A great BM can reshape industries and drive spectacular growth (Magretta, 2002; Johnson, Christensen and Kagermann, 2008). To achieve such growth, a company needs to understand the components of a BM. According to Osterwalder, Pigneur and Tucci (2005), a BM is composed of different elements or components. Such components can be differentiated into "value proposition activities", "activities of value creation" and "models for value capture" (Johnson, Christensen and Kagermann, 2008; Casadesus-Masanell and Ricart, 2010; George and Bock, 2011; Zott, Amit and Massa, 2011; Baden-Fuller and Haefliger, 2013). First, the customer value proposition (CVP) is a promise of value to be delivered and will help customers to perform a job. "The more important the job is to the customer, the lower the level of customer satisfaction with current options for getting the job done […], and the better your solution is than existing alternatives at getting the job done, the greater the CVP" (Johnson, Christensen and Kagermann, 2008). Second, these value creation activities include resources (e.g. people, technology and facilities), capabilities, specific resources working together, and processes (e.g. training of staff, manufacturing and services) of companies. Third, models of value capture describe the underlying cost structure and revenue formula, which decide on profitability and economic sustainability.

Nevertheless, some strategic circumstances often require BM changes (Johnson, Christensen and Kagermann, 2008): for example, the opportunity to capitalise on a brand-new technology by wrapping a new BM around it, the opportunity to leverage a tested technology by bringing it to a whole new market or the opportunity to bring a job-to-be-done focus where one does not yet exist (Johnson, Christensen and Kagermann, 2008). This is also confirmed by Afuah and Tucci (2001) that industry-level factors such as technological developments impact BM. Furthermore, Johnson, Christensen and Kagermann (2008) provide as a further circumstance the need to respond to a shifting basis for competition. This might be a reason, why SMEs need to change their models; because they are faced with increasing international competitiveness (Sommer, 2015).

In relation to changes, academic literature often mentions these as BM innovations (BMI). According to Koen, Bertels and Elsum (2011), this can be regarded as a problem because BM changes can be differentiated into “BM development” and “BMI”. While a BM development is described as an incremental (evolutional) change, a BMI results in a disruptive (revolutional/radical/fundamental) change. Stähler (2002) argues that at an incremental change will only influence some partial part of a BM. Teece (2010) describes the latter from a dynamic capabilities perspective as the sensing, seizing and reconfiguration skills that are necessary to adapt to changing business environments. BMIs represent the discovery of fundamentally different BMs in an existing business that enlarges a company market by attracting new customers or increasing competition (Christensen and Overdorf, 2000; Markides, 2006, Björkdahl, 2009, Casadeus-Masanell and Tarijan, 2012). Furthermore, Casadeus-Masanell and Tarijan (2012) added that companies may use such distinct BMs in order to make more efficient use of resources or develop new income streams. To provide an example of such an BMI, the author uses the “magic triangle” ontology, which was developed by scholars of the University of St. Gallen:

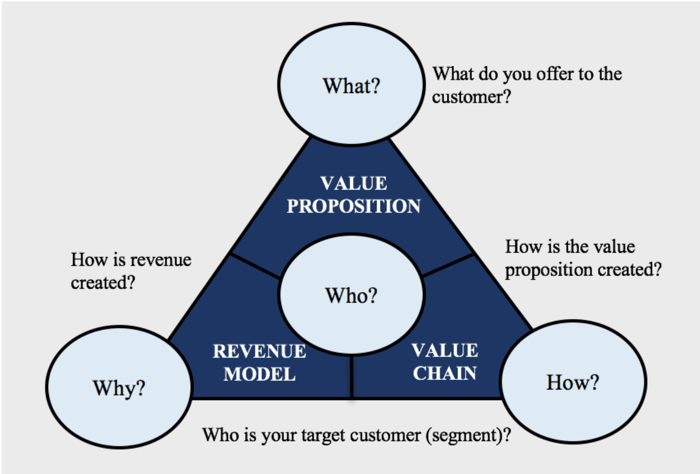

Figure 6: Magic Triangle. Source: Derived from Gassmann, O.; Frankenberger, K. and Csik, M. (2014)

Figure 6 illustrates the magic triangle. The reduction to four dimensions makes the concept easy to use and exhaustive enough to provide a clear picture of BM architecture (Gassmann, Frankenberger and Csik, 2013). This BM ontology is divided into four distinct dimensions: "Who", "What", "How" and "Why?" (Gassmann, Frankenberger and Csik, 2014). "*Who* refers to the target customer, *What* is the value proposition that is offered to the customer, *How* is the value chain to deliver the value proposition to the customer, and *Why* describes the underlying economic model to capture value" (Chan, 2015, p. 553). According to Gassmann and Sauer (2016), a company deals with a disruptive BMI if at least two of four elements of a BM change.

However, one study determined that no more than 10% of innovation investment in global companies is focused on developing new BMs (Johnson, Christensen and Kagermann, 2008). They argue that established companies should not undertake BMI lightly. They can often create new products that disrupt competitors without fundamentally changing their own BMs. Christensen and Overdorf (2000) already indicate that such innovations represent "sustaining innovation", making a product or service better in ways so that customers in the mainstream market already have value. Sendler (2016) confirms that, while American start-ups change the markets with disruptive innovations, German SMEs stand for a continuous improvement process which will merely improve some components of BMs.

However, academia has not been able to agree on one clear and consistent definition of BM (Zott, Amit and Massa, 2011; Gassmann, Frankenberger, and Csik, 2013). Johnson, Christensen and Kagermann (2008) underlines that "very little formal study has been done into the dynamics and processes of BM development". To proceed further, it is necessary to agree on one definition. Osterwalder and Pigneur (2010), as representatives of an architectural approach, compared the most frequently mentioned BM definitions and identified nine blocks constituting BMs. The BM framework is widely spread in academic literature. The "business model canvas" (BMC) is a tool for describing, analysing and designing BMs. Figure 7 shows the similarities between the magic triangle ontology and the BMC. Both ontologies have very similar elements in their BM structure:

		Ontology	
		Magic Triangle	Business Model Canvas
Elements	Value Proposition	What?	Offer
	Value Creation	Who?	Customer
		How?	Infrastructure
	Value Capture	Why?	Financial viability

Figure 7: Similarities between these BM ontologies.

While the magic triangle provides a rather more general view of a BM, the BMC gives an in-depth view and connection between the different BM components. What is more, according to Osterwalder and Pigneur (2010), the BMC was originally developed with respect to information systems, upon which I4.0 is based. Weiner *et al.* (2010) further pointed out that this ontology is most widely used in BM research, which is also often used in corporate practice (Gassmann *et al.,* 2013, p. 25). For these reasons, the BMC ontology should be applied in this dissertation.

According to Osterwalder and Pigneur (2010), their framework shows these nine blocks and includes the logic of how a company indents to make money. “The nine blocks cover the four main areas of a business: customers, offer, infrastructure, and financial viability. The business model is like a blueprint for a strategy to be implemented through organisational structures, processes and systems” (Osterwalder and Pigneur, 2010, p. 15).

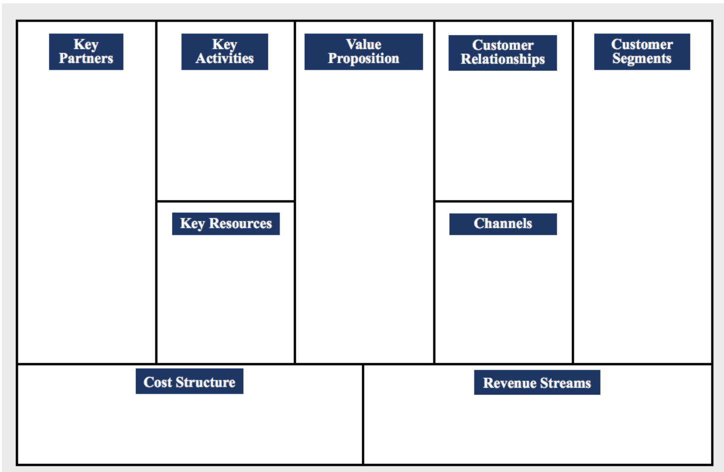

Figure 8: Business Model Canvas (BMC) ontology. Source: Derived from Osterwalder and Pigneur, 2010

Figure 8 illustrates the nine building blocks: “customer segments”, “value proposition”, “channels”, “customer relationships”, “revenue streams”, “key resources”, “key activities”, “key partners” and “cost structure”. The centre of the ontology is formed by the value proposition, which promises value delivered through the products and services to the customer segments, as mentioned before. These customers represent the different groups of customers the company wants to address. The channels describe how companies communicate with and reach their customer segments to deliver a value propositions (Osterwalder and Pigneur, 2010). The fourth block customer relationship describes the type of relationship companies want to establish with their customers. While the key resources describe the most important asset required, the key activities characterise the most important activities a company must undertake in order to make BMs work (Osterwalder and Pigneur, 2010). Furthermore, the key partnerships of a BM define the network of suppliers and partners that are essential for a BM. Finally, while the revenue streams represent the cash a company generates from each customer segment, the cost structure describes all costs incurred (Osterwalder and Pigneur, 2010). Both blocks represent the financial viability of a BM, as is evident in Figure 7.

This kind of ontology and its nine components provide a comprehensive view of a BM. Thus, to answer the research question, the author will include each of the nine components in interviews undertaken and will describe, using this data, the I4.0-related impact on the BMs of German SMEs.

2.4 Conclusion

Extensive study of the literature reveals that no investigation into I4.0-related BM changes to German SMEs has yet been carried out. As a result of the importance of SMEs for the German economy, the similarities and differences between BM changes must be examined to demonstrate the advantages of I4.0. Furthermore, the author's intention is to motivate SMEs to implement some parts of high-tech strategy, staying competitive in the future.

3. Methodology

3.1 Introduction

The objective of the following chapter is to provide a greater understanding of the author's methodological approach in this research, including the rationale and justification for using these methods.

3.2 Research design

This research is qualitative in nature. According to Eisenhardt (1989b), this research approach is especially appropriate for new topics to develop theory in organisational research.

Furthermore, two approaches describe the correlation between research and theory: "deductive" analysis and "inductive" analysis (Bryman and Bell, 2015). "Deductive analysis refers to data analysis that sets out to test whether data are consistent with prior assumptions, theories, or hypotheses identified or constructed by an investigator" (Thomas, 2006, p. 237). On the other hand, in inductive analysis, "the researcher begins with an area of study and allows the theory to emerge from the data" (Strauss and Corbin, 1998, p. 12). Edmonson and McManus (2007) also underline this concept as contributing to developing theoretical knowledge. These are the reasons why the author of this dissertation analysed the interviews inductively.

Eisenhardt (1989b) notes that building theory from case studies is a research strategy that involves using one or more cases to create theoretical constructs, propositions and empirical evidence. Case studies are appropriate in exploratory research as the author can obtain valuable data, allowing investigation of concrete managerial problems (Eisenhardt and Graebner, 2007; Yin, 2009). Moreover, Edmonson and McManus (2007) highlight the need for case studies because they typically answer research questions that address “how” and “why” in unexplored research areas particularly well.

Owing to the lack of academic literature in the field of I4.0-related impact on SMEs business models, the author of this dissertation used a multiple case design, also known as cross-case analysis. According to McGuiggan and Lee (2008), cross-case analysis is a qualitative methodology which is widely used in social science. Case studies are suitable for exploratory, descriptive and explanatory research (Yin, 1994). Yin (1984) further points out that this research method is well suited for contemporary and complex phenomena to be studied within their real-life contexts. Eisenhardt and Graebner (2007) have also stated that each case serves as a distinct experiment that stands on its own as an analytic unit.

For this reason, the author will conduct interviews in different industries to provide valuable information about SME BM changes and the differences and similarities in these changes across various industries. To analyse SMEs in the German manufacturing industry, the author has decided to include following five German manufacturing industries: medical technology-, printing-, electronic-, machine and plant engineering- and glass industry.

3.3 Data collection

According to Blaxter *et al.* (2010), many methods can be used to achieve suitable data collection. However, it is essential to understand the theory of methodology and therefore to identify appropriate methods which should be applied to this analysis. A researcher uses two collection methods to gather data. Primary data is collected by the researcher, while secondary data already exists and is freely available for everyone (Kolb, 2008). Furthermore, McDaniel and Gates (2013) describe secondary data as data that consists of information already gathered and which might be relevant to the problem, while primary data includes surveys, observations and experimental data collected to solve the particular problem under investigation. Both collection methods have been used in this study and will be further outlined in the following subchapters.

3.3.1 Primary data collection

The primary data was collected through interviews. The research participants were selected based on the implementation status of I4.0-related technologies in their companies. In total, six interviews were conducted with chief executive officers (CEOs) and other leadership team members of German SMEs across various industries.

The method used to answer the research question incorporated semi-structured, in-depth interviews. According to Yin (2009), this type of interview allows structured data collection to gather new knowledge. This type of interview meets the objective in a more in-depth way than any other type of interviews, thereby allowing the interviewer to gain more knowledge about I4.0-related impacts on SME BMs.

In-depth interviews are often mentioned to as a form of conversation (Ritchie and Lewis, 2003), but there are clear distinctions between a conversation and an in-depth interview, such as the goal, the role of the interviewer and that of the participant (Ritchie and Lewis, 2003), given that the interviews were carried out on a one-to-one basis between the interviewer and the participant.

To provide the research participant with an overview of the structure and themes of the interview, an information sheet ("Information for Participants") and a questionnaire were given to each research participant in advance of the interview - attached in Appendix 1 and Appendix 2 respectively. This questionnaire was divided into three parts. The first part deals with general information about the enterprise, part two discusses questions relating to whether the enterprise had already implemented I4.0 and the last part discusses whether I4.0 impacted on SME BMs. One example of such an interview transcript is shown in Appendix 3.

The interviews took place within one month because of the time needed for checking answers and verifying the information obtained. The interviews consisted of eighteen open-ended questions. They began with a request for an introduction of the role of the research participant at the company in question, before moving to the first question. The interviews with experts had a duration between thirty and seventy-five minutes, allowing time for questions and answers on both sides. Bloor and Wood (2006) stated that piloting is important to conduct preliminary research prior to the main study. The author therefore decided to conduct one pilot interview before the other interviews were conducted to make sure that questions were clear and participants understood the structure and meaning of the questions (Saunders *et al.*, 2012; McDaniel and Gates, 2013). This was helpful because the pilot interviews showed that some questions could be combined and some should be added to gain more information.

As suggested by Miles and Huberman (1994), these interviews with experts were conducted by telephone and recorded on audio files in accordance with the research participants. To avoid any misunderstandings, each interview was conducted in German. Finally, the author applied the “24-hours rule” (Eisenhardt, 1989a). The interviews were therefore transcribed in English from the audio files by the author within one day of the interview taking place.

3.3.2 Secondary data collection

Secondary data has been collected from a wide variety of sources, such as books, journals and other databases, to gain a varied knowledge and insight into already existing literature. This study involved a detailed discussion of secondary research, helpful when planning and analysing primary research (Kolb, 2008). As a result of the lack of academic research relating to the issue being examined in this study, secondary data is most appropriate to this study as a base of knowledge on which to build primary research and the later data analysis stage.

Secondary data collection involved the collection of information relating to the topics, SMEs, I4.0 and BMs. Scientific databases such as Google Scholar, ProQuest and EBSCO were therefore surveyed for high-ranked theoretical academic literature to gain valuable information for the following relevant key words: SME, Industry 4.0, Industrie 4.0, Internet of Things, Business Models and Business Model Innovation.

3.4 Data analysis and presentation

The data was analysed as follows. To analyse the data, the author used a qualitative content analysis, as suggested by Miles and Huberman (1994).

After transcription of the audio recordings, because of the large amount of data, the data from the third part of the questionnaire, which includes the nine components of the BMC ontology, was reduced and organised. The author read the data carefully and identified all statements essential to the research question. These codes were then noted and each relevant statement organised under an appropriate code. This is referred to as "open coding" (Miles and Huberman, 1994). According to Miles and Huberman (1994, p. 56), "codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study. Codes are usually attached to 'chunks' of varying size – words, phrases, sentences or whole paragraphs".

Data displays, organises, compresses and assembles information, because qualitative data are typically voluminous, bulky and dispersed (Punch, 2009). Miles, Huberman and Saldana (2014,

p. 108) argue that, “you know what you display”. For this reason, the author of the dissertation created an Excel sheet, enabling data to be organised and summarised, as shown in Appendix 4 as an example. The key messages of each interview were listed side by side for an accurate overview of the codes and their different key messages in the various interviews.

After coding all the interviews, the author could see any BM changes and similarities as well as differences between such changes.

3.5 Research limitations

The limitations of using interviews for primary data collection was that the author could only conduct interviews with highly competent and knowledgeable research participants (Kumar *et al.,* 2013), as are mentioned above, who have an overall view of business activities. Moreover, to provide clear BM changes, because of I4.0-related technologies, it was essential to conduct interviews only with representatives of companies that had already implemented such technologies as mentioned in the previous chapter. Lastly, enterprises were preselected using publicly available data for classification to ensure that these companies were in the SMEs classification magnitude.

3.6 Conclusion

To sum up, this chapter has provided a greater understanding of the methodology used by the author for this dissertation. While the primary data collection, with its semi-structured in-depth interviews, was quite essential to gather valuable information from the research participants, the secondary data provides data that already exists in academic literature. In using a cross-case analysis, the author intends to demonstrate how BMs have changed and show the similarities and differences in I4.0-related BM changes for SMEs.

The next chapter will show the findings of the empirical research, gathered through the in-depth interviews, to address the research question.

4. Data analysis

4.1 Introduction

This chapter will provide an insight into the companies which meet the SME criteria and which are mentioned in section 2.2.1, their market structures and their I4.0 implementations. The general findings provide the reader a broad overview about BM changes. Finally, the specific findings, as well as similarities and differences in BM changes are set out.

4.2 Overview of the research participants

“Company A” (medical technology industry):

Company A is a German family-owned medium-sized enterprise that develops, produces and sells weighting scales and measuring instruments. While the company employs 250 employees in its headquarters, the whole group has roughly 500 employees.

“Company B” (printing industry):

Company B is a SME that operates in the German printing industry and manufactures printing products especially for B2B-customers. The enterprise employs forty-eight people and generated revenues between eight and ten million of euros in 2016.

“Company C” (electrical industry):

Company C is a medium-sized company. It is a manufacturing service provider which produces electronic assemblies and complete systems. The company has 165 employees and generated a revenue of 21 million euros in 2016.

“Company D” (electrical industry):

Company D manufactures standardised energy management and energy controlling systems. The company has seventy employees and generated a revenue of 14 million euros in 2016.

“Company E” (machinery and plant engineering):

Company E is a medium-sized enterprise which operates in the mechanical engineering industry. It manufactures and distributes complete plants and special machines such as foam machines for the processing of foam particles such as “expanded polystyrene” (EPS) and “expanded polypropylene” (EPP). The company has 420 employees and generated a revenue of 71 million euros in 2016.

“Company F” (glass industry):

Company F is a medium-sized enterprise which operates in the glass industry. It processes flat glass panels, such as insulating glass panes, and distributes these throughout Germany. The company employs eighty-one people and generated revenues of 10 million euros in 2016.

4.3 General findings

In the following subchapter, the author of this dissertation shows the results of his analysis into how I4.0 influences the BMs of German SMEs. As mentioned in the research methodology, the author therefore uses the nine components of the BMC to demonstrate such I4.0-related BM changes.

Figure 9 shows the BMC as outlined in section 2.4. The author has added the empirical findings into this ontology. To clarify that the reader can recognise such findings, the author has included a pie chart into each BM component. Each pie chart should demonstrate whether a BM component has changed as a result of I4.0. While the colour green demonstrates that a BM component has changed, the colour red makes clear that I4.0 has no influence on the BM component. Furthermore, the percentages should show how many German SMEs are affected by I4.0-related BM change.

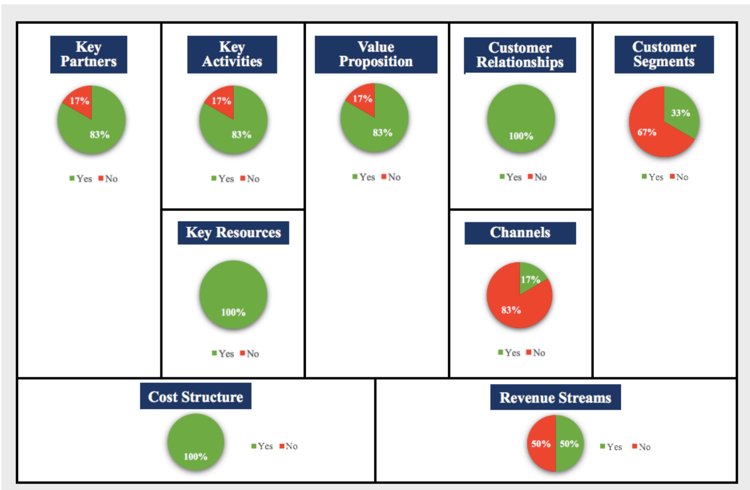

Figure 9: Changes of BM components

As the reader can see in Figure 9, the BM components most influenced by I4.0 are customer relationships, key resources and cost structure. It has been found that all companies in these BM components have noticed change instigated by I4.0. Components such as key partners, key activities and value proposition represented the second most influenced component, with 87% of the companies seeing an impact of I4.0. For revenue streams half of the research participants recognised such a change. I4.0-related impact on customer segments was confirmed by two companies. Finally, the component least affected by I4.0 incorporated the channels of a BM.

Only one company noticed such a change to the communication between the company and its customers.

Arguably, all BM components of German SMEs noticed an I4.0-related impact. The next subchapter will demonstrate with more in-depth insights how these BM components have changed and show the similarities and differences in such changes.

4.4 Specific findings

In the following subchapter, the author demonstrates the more specific details of such a BM component change. Additionally, similarities and differences in such changes to each component should be outlined. As mentioned in the research methodology, the author uses codes to structure such empirical findings.

Customer segments:

In two of six cases, there are component changes to German SMEs BMs (**Code 1**: "Changes in customer segment"). There are some changes, because "I4.0 is suitable for industrial customers", as mentioned by Company B. Second, the CEO of Company D, further pointed out that I4.0 has helped significantly in expanding the customer segment. As a result of I4.0, more orders were placed because customers are of the opinion that the very high degree of automation improves the quality and availability of Company D's products. Before the implementation, the company was not trusted to be able to produce such a product volume. Overall, most companies arguably do not recognise such a change in this BM component.

Customer relationships:

As mentioned in the general findings above, the BM component customer relationship belongs to the components with the most I4.0-related impacts. What is similar for all companies from different industries is that all companies have recognised a positive change in this relationship

(**Code 2**: “Improved customer relationships”). Company A clarified this as follows: “By shorter running times or by an improved product with a higher benefit, we are able to extend our customer relationships”. Furthermore, as mentioned by Company C, I4.0 simplifies this relationship because the company can tell the customer when its product is finished, whether it is already underway or whether there are any problems with it. This notion is also supported by Company E, who pointed out that more intensive relationships exist because the company receives more requests from its customers to solve any maintenance issues via the new service of Company C. Here, it is valuable to obtain insights into different I4.0-related outcomes, such as shorter running time, better transparency and better maintenance services, leading to improved customer relationships.

On the other hand, “customer relationships have become more complicated” (**Code 3**: “Insights into customer system”). This was mentioned by Company B. This company is directly connected with the customer system which enables Company B to select necessary data from the customer in order to serve its products. Finally, both CEOs of Company B and Company F mentioned that the implementation leads to an improved customer loyalty (**Code 4**: “Customer loyalty”).

<u>Value proposition:</u>

In 87% of cases, value proposition is affected by I4.0. While there are some similarities in such changes across different industries, most changes are more individual.

According to Company C, the implementation of I4.0 technologies benefits customers with more precision in meeting delivery deadlines (**Code 5**: “Better predictability”). With the system of Company C, the company can predict its manufacturing status better than it could in the past.

Furthermore, implementation leads to a reduction of customers costs (**Code 6**: "Reduction of costs"). This was confirmed by three companies and supported by the I4.0 implementation at Company B: "It has a tremendous reduction in quality costs and rework for the customer." The CEO of Company D also mentioned cost cuttings for its customers: "The lower material costs will positively influence the product costs for the customer because the customer should also get something from these benefits." Furthermore, the CEO of Company E supported this: "With the new technology, there are lower service costs for the customers".

Moreover, customers benefit from better service which has a direct impact on the value proposition. This is confirmed by the two companies (**Code 7**: "Better maintenance service"). The customers of Company E also benefit from faster reaction times. Before the implementation, for example, a customer from Mongolia had to wait approximately a week for a Company E´s serviceman to fix a machine problem. After the implementation of an I4.0-related application, the customer only needed to download an online ticket to be assigned a serviceman from Germany to give advice via the internet on how to fix such a problem. On the other hand, 9,000 switchgears and lighting systems are used throughout the world. These customers are connected to the head office – for each customer there is a virtual twin in the computer. With this system, servicemen can quickly solve problems and even recommend replacing parts before they fail. Furthermore, Company B's employees are able to evaluate, for example, the energy demand of the customers and cover potential savings, which is a new service. These services of the two German SMEs increased the value proposition to the customer.

Furthermore, three research participants confirmed that customers are able to request individual products (**Code 8**: "Individual product"). With such a "craft production character" and this technology, the customer can now wish for something individualised. As a result of this technology, B2B customers no longer order huge lot sizes but rather are able to order just one product.

What is more, because of the I4.0 technologies, customers are now able to be more flexible in terms of changing product information relating to an order (**Code 9**: “More flexibility”). Two research participants have confirmed that their customers now have more time to change any desires before delivery because of the lower lead times of their manufacturing processes. This is supported by Company B: “The customer changes the product information in his system. If an information packet is changed in the morning, it is already physically changed in the evening at the customer's physical site.” Additionally, the CEO of Company D noted that: “In the past, we have a lead time of three weeks for a control cabinet. Now we are building the plants within six hours. This means that the customer has the possibility to change the system by the previous day.”

Finally, three research participants were, after the implementation, better able to provide product quality (**Code 10**: “Better quality”). This is supported by Company B: “We have 35,000 to 40,000 different material numbers which will be processed to assemblies. Our own goal was to deliver a 0 error rate.”

<u>Channels:</u>

The channels play a subordinate role in the context of I4.0. Just one company noticed a change in this BM component (**Code 11**: “Change of channels”). Company E has observed that personal communication is receding. However, because of the implementation of the online maintenance service, digital communication with customers has increased significantly. The conclusion can be drawn that the similarity for most industries is that such communication methods are not influenced by I4.0-related technologies.

Key resources:

Key resources are also one of the components affected by I4.0 for all companies. In particular, half of the cases noticed that they need better IT know-how (**Code 12**: “IT know-how”). This is supported by Company C: “Data becomes an increasingly important resource. We have a huge amount of data points and lines. From our own production data, we are able to make new decisions and draw conclusions.”

Another aspect which can be associated with key resources incorporates raw materials (**Code 13**: “Raw materials”). Just one company saw an I4.0-related impact on raw materials. As mentioned by Company D, the purchase of such raw materials became more conscious: “Robotics permanently reports which material parts are often installed by us. Parts that are not often used are replaced by parts that we often use. This means we are constantly reducing the amount of components we purchase.” This quote underlines that the variance of raw materials decreased in this case.

Finally, staff are influenced by the implementation of I4.0 technologies (**Code 14**: “Staff”). In Company A’s point of view, it is important for him to deal with the employee mind-set and the desire to engage with such technology. Furthermore, Company B pointed out that a company needs employees who can really think very logically in processes. This is also supported by Company D: “There is a major restructuring process taking place. Current employees need the willingness to retrain. If we have 20% of business informatics today, I assume that we have 80% of such informatics in 2020.”

Overall, it can be said that this BM component has been influenced at all companies and therefore in five different German industries by I4.0-related impacts. While two of these changes were recognised by more research participants, the change in raw materials was argued only by Company D.

<u>Key activities:</u>

Key activities are affected by I4.0 in 87% of cases (**Code 15**: "Process changes"). Only one company did not recognise such a change in this BM component. However, there are no similarities between these changes in the different industries. Instead, the companies have dealt with more individual changes.

For example, Company B changed its whole manufacturing process from off-set printing to digital printing. Before the implementation of this change, the company needed to have printing plates in order to print a limited number of products. High setup costs have arisen in this procedure.

Other companies have changed some parts of their processes. With the implementation of I4.0-related technologies, companies are now able to shape their processes more efficiently. This is supported by Company D: "We used to look at the manufacturing process. Today, we are looking to optimise these processes." Furthermore, the control of such processes has changed. Company C noted that: "The processes are the same, but they are controlled differently. […] The way in which the processes are addressed and controlled has changed." A further example of such efficiency enhancements is the case of Company F. As the CEO further pointed out, the company has implemented software which has automated the intake of orders. Before this, the company had received such orders via fax. Afterwards, an employee would manually add these into its system. These customer orders are now transferred directly into the system.

Key partners:

Key partners, which plays an important role for companies, changed in 87% of cases (**Code 16**: "Changes of key partners"). The author found some similarities between the cases in the data analysis.

On one hand, four research participants have developed new cooperations with institutes such as the Fraunhofer Institute and research projects at universities, such as TU Munich and Stanford University, to keep up to date with new developments.

On the other hand, some research participants have noted that IT partners have become more important. This is argued by Company E: "New cooperation have emerged in the fields of cloud computing, artificial intelligence and big data." This is also supported by Company C: "The company that has developed and implemented this software comes as a new key partner."

From this, it can be concluded that different industries have experienced similar changes in this BM component, as clarified above.

Revenue streams:

Half of the research participants mentioned that I4.0 had an impact on SMEs' BMs (**Code 17**: "Changes in revenue streams"). As a result of the implementation of I4.0 technologies and resulting better services, companies are now able to charge higher prices, as noted by Company F. Furthermore, the introduction of new services leads to "new sources of income", as mentioned by the CEO of Company E. However, he continued that such revenue streams will cannibalise existing ones. Nonetheless, "the profit margins in the digital maintenance service are significantly higher than when I send a serviceman to the customer, because all additional costs such as non-productivity time are eliminated". Finally, Company B has outlined that something has changed in the payment process: "Each of these items sold have a price. The customer has a goods receipt scanner and of course he furthermore knows from his ERP system which materials must have been in there. Afterwards, the payment is triggered fully automatically."

Cost structure:

Changes in cost structure were mentioned more by research participants than changes in revenue streams. All the research participants observed such I4.0-related impacts on this BM component.

The research participants noted the most impact on research and development costs (**Code 18**: "R&D costs") and costs arising within supply chains (**Code 19**: "Supply chain costs"). On one hand, three research participants pointed out that investment costs will rise if a company strives for such an implementation. The CEO of Company A supported this as follows: "You need money to make money. First, you have to invest in order to harvest the fruits later." On the other hand, because of the efficiency enhancement of the process, a company can save a lot of lead time and therefore reduce a great deal of costs arising within supply chains. Included in these costs are costs arising from the inventory. An example of this kind of reduction is provided by Company B: "We have completely changed the technology to digital print. This means that we have the possibility to print directly from the data stock. For this reason, the warehouse and these 500 pallet spaces have been reduced to zero. The warehouse was simply virtualised."

Another cost component mentioned by three research participants was labour costs (**Code 20**: "Labour costs"). For the reason that these companies have lower manpower, they are able to save a substantial amount of labour costs. A clear illustration is provided by the CEO of Company D: “The company has labour cost savings of 38%.”

Further costs are saved in the field of expenditure on materials (**Code 21**: “Material costs”). Just one company realised such a change in this cost type. This is illustrated by Company D: “We have also material cost savings of 5%.”

Lastly, if a company provides any services for its customers, it can significantly reduce its costs (**Code 22**: “Service costs”). This is supported by the CEO of Company E: “It is noticeable that the service costs, such as travel expenses and working hours of such servicemen, go significantly down.”

4.5 Conclusion

This chapter has provided deeper insights into the author’s empirical analysis, exploring six interesting cases from five different industries, including their markets and the implementation status of their I4.0-related technologies. Furthermore, with the help of the nine components of the BMC and the valuable research findings presented, the reader has gained a better understanding of how I4.0-related changes have affected the BMs of German SMEs. Moreover, the reader should be able to recognise similarities and differences in such changes across different industries and observe the associated benefits for such companies.

The following chapter will critically examine the most important research findings in a broader context, making use of previous academic literature and practice.

5. Discussion of findings

5.1 Introduction

The previous chapter has outlined the valuable findings of the six research participants regarding SME BM changes as a result of I4.0. This chapter will critically examine these findings in the light of the previous state of academic literature, as outlined in the second chapter of this dissertation.

5.2 Discussion

German SMEs are obliged to constantly develop to stay competitive in times of globalisation or increasing market volatility. Previous academic literature has mentioned that SMEs need to use an increasing range of technological possibilities (Schröder, 2016) and to innovate their BMs (Markides, 2006; Chesbrough, 2010; Teece, 2010; Zott and Amit, 2010; Schneider and Spieth, 2013; Thoben, Wiesner and Wuest, 2017). However, how these BMs will change as a result of I4.0-related technologies is clarified by this dissertation. With the help of the BMC ontology developed by Osterwalder and Pigneur (2010), the empirical findings demonstrate how such SME BMs will change if they implement I4.0-related technologies.

The introduction to this dissertation and also the interviews with the six research participants have clarified that German SMEs have to operate in quite competitive and fragmented markets where certain price wars prevail and deal with changes to environmental conditions. On the question of what companies expected from I4.0 implementation, most of the research participants responded that they hoped for better efficiency, transparency and traceability of processes and a closer relationship to the customer. However, most of them also mentioned that they hoped for survival within quite competitive markets and thus also crisis-proof status. As a result of these answers, it can be said that the research participants have already thought about which way they need to go to stay competitive in future. This confirms the statement by Sommer (2015) in the introduction that SMEs need to change their BMs because they are faced with increasing international competitiveness. All the companies interviewed have already implemented different I4.0 technologies. As these companies operate in five different industries, I4.0 is arguably no longer an unknown topic, as outlined in the introduction. Furthermore, the author asked each research participant about the future plans of their companies. More than the half of the companies are currently working on I4.0 projects that they want to implement in the future. It can therefore be said again that the SMEs know exactly what action needs to be taken and what they have to do, contrary to the arguments of Maier and Student (2015), also mentioned in the introduction.

At the end of each interview, all the research participants were asked how they would evaluate the I4.0-related changes on their BMs in future. In the short term, most companies answered that such implementation does not have much impacts on them. This is supported by the CEO of Company A: “It has no impact on us. We take care of this. This is nice. This is what the competition does.” However, in the long term, it will have a substantial influence and will change markets. This is highlighted by the CEO of Company E: “I believe that I4.0 has a big influence. I think you have to do it. If you do not, there are a lot of small software companies that take this business away because it has a huge benefit for the customer. So it is a major change that happens in our BM.”

Such changes were also mentioned in the literature review of this dissertation. As expected before and recognised in the data analysis, the companies are dealing more with BM developments, as mentioned by Stähler (2002) in the literature review, than any disruptive BM innovations. This is also supported by the findings discussed in detail in the previous chapter. As mentioned by Sendler (2016), German SMEs stand for a continuous improvement process which will merely improve some components of BMs. The findings of the empirical analysis underline this statement. Arguably, all the companies have realised such an incremental change in at least one or more BM components. All the statements of the research participants have this in common. Also, if the reader takes the magic triangle of Gassmann, Frankenberger and Csik (2014) into consideration, it can be said that the companies have merely changed one of the four triangle components. Thus, no company has changed its whole BM, rather changing at least one BM component as a result of I4.0.

Nonetheless, how these SMEs' BMs have changed because of I4.0 is the special ingredient of this dissertation. The reader can recognise in the data analysis an increased focus on the interface between the company and its customers. This is a major result of this dissertation and is confirmed by the majority of research participants. As the author has interviewed representatives of companies from different industries, the reader can also deduce that most German industries have to deal with this topic. The two changes in the customer segments, and also the changes in the customer relationships, are meant. The low change in such customer segments found in this analysis is supported by Porter and Heppelmann (2014), who pointed out that I4.0 technologies do not merely change existing customer segments, but rather create new markets. As the companies are dealing with incremental BM changes and not with BM innovations, as mentioned in the literature review, the author might argue that such incremental changes do not create any new markets nor attract any new customer segments except as exceptions. However, one of the key learnings from these BM components changes is that relationships between companies and customers have improved and intensified more than before implementation. As mentioned in the data analysis section, each research participant outlined that something had changed in their BM components. As a result of these enhancements and intensifications, companies benefit from increased customer loyalty.

A further aspect that the findings clarify is the change in the BM component value proposition. As mentioned in the literature review, a BM creates and delivers value for its customers (Johnson, Christensen and Kagermann, 2008). The findings of the data analysis demonstrate that, through the implementation of I4.0, companies are able to deal with customers' individual challenges and offer tailor-made solutions which should represent this value. For this reason, these findings are also in line with Kagermann *et al.* (2013), emphasising that I4.0 allows individual customer requirements to be met. Furthermore, Kagermann *et al.* (2013) predicted particular significant opportunities for SMEs to develop B2B services. This prediction proved to be correct and was also supported by the valuable insights given by the CEOs of Company D and Company E. Porter and Heppelmann (2014) also note that service orientation entails opportunities in terms of novel business concepts and income sources. However, to achieve such a value proposition, the findings of this dissertation highlight that a company need to identify customers' needs and the necessary technology for these.

As expected, all the companies have already implemented some technologies, as mentioned in the literature review, within their horizontal or vertical business processes. However, the findings clarify that there is no uniform solution to implementation of such I4.0 technologies. This is supported by Company B: "There are no recipes for I4.0. Point A, point B and point C you have to make, then you have I4.0, but it is actually an individual customer solution." Some company representatives mentioned that the implementation of such technologies has been a problem because they did not know which system they needed to buy and who the right partners were to implement these I4.0-related technologies. This finding would slightly strengthen the argument about the initial difficulties, as mentioned in the introduction. Thus, it is essential that a company needs to make the right decisions when implementing such I4.0 technologies. The results of the interviews have also clarified that most companies have needed a certain decision-making period to think about which technologies they want implement in future.

The findings also highlight how the BM component key resources have changed because of I4.0 technologies. The manufacturers previously dealt with hardware development and production, but have recently become required to deal with software-related activities. Thus, the companies need to develop competencies regarding IT. Data plays a new key role in the resources of a company, as confirmed by Company C. This is also supported by Roth (2016) in the literature review. According to these findings, five of six company representatives also mentioned that something is changing, especially in human resources. This is confirmed by the CEO of Company D, who outlines that workers need to be retrained to have jobs in the future. To be able to operate such I4.0 technologies, such as CPS or CPPS, as mentioned in the literature review, employees must be trained and companies need more highly qualified people, such as computer scientists, than ever before. Spath *et al.* (2013) also emphasise that human beings need to assume important responsibilities in the context of I4.0. However, the research participants mentioned that there are some issues with employees during the implementation stage. Most research participants support this assertion. On the one hand, Company B outlined that employees need to be convinced that new technology will help the company: “The scepticism to something new is definitely there”. On the other hand, the CEO of Company E mentioned that the service personnel are afraid that they will lose their jobs when certain functions happen digitally. These issues with employees were not identified by the author in academic literature. Consequently, companies need to be aware of such interactions in human resources.

According to Porter and Heppelmann (2014), I4.0 influences key partners with regards to changing established supply relationships. This is in line with the results of the data analysis. The author believes that I4.0 has a strong impact on the cooperation between company and raw material suppliers. However, this has not been the case for these six SMEs. The empirical analysis therefore demonstrates that most of the SMEs now cooperate with research institutes and have developed stronger relationships with their IT partners. These new partnerships clarify that German SMEs are looking into the future to keep up to date with new developments and remain in closer contact with scientists.

Furthermore, the empirical findings display a wide variety of cost changes. As the author expected, investment costs in R&D have increased at most companies. These resulting efficiencies reduce costs in, for example, staff and materials. This is also in line with Bauernhansl (2014), who stated that cost savings are possible. For example, just one German SME has noticed such decreases in material costs or another research participant could reduce service costs. These findings clarify that such savings depend to some extent on which industry the companies operate in. As companies that deal with higher quantities of materials, they have greater opportunity to reduce these than companies with low quantities of materials. Furthermore, not every manufacturing company in Germany is able to provide such a service as Company D and Company E. Most German SMEs are therefore unconcerned with such service costs because they are not able to provide the services in question. However, all companies have in common that they are benefiting from a steady income with a higher margin.

After looking through the academic literature as well as the empirical findings from the cross-case analysis, the author can set out the following practical and theoretical implications:

Implications for practice:

1. The reader can see how the BMs, especially the nine components of them, of German SMEs have changed. Thus, companies facing the challenge of adapting I4.0-related technologies can see how such technologies would influence their BMs. They can thus take preventive measures to exploit associated potentials.

2. This dissertation demonstrates how essential it is for German SMEs to make closer contact with their customers to understand their future needs. Before the implementation of I4.0-related technologies, German SMEs have to approach customers and proactively ask them for individual solutions that bring higher value or benefits. Only then is it possible for SMEs to provide the most efficient means of implementation of I4.0-related technologies to achieve competitiveness in Germany and internationally.

3. The noticeable change in the staff which has taken place in most industries clarifies that German SMEs need to retrain their employees to tackle the demographic change towards computer scientists. Furthermore, SMEs need to empower and train their employees to clarify why I4.0-related technologies will be an advantage for companies in future.

4. To be profitable and also competitive in future, the reader might see that such implementation also has a positive impact on the profit formula of German SMEs. Although I4.0-related technologies require large investments in the initial phase, these investments will pay off in terms of lower costs for staff and materials and also in increased efficiency within horizontal and vertical business processes.

5. This dissertation also demonstrate that all German SMEs have reached a certain operational excellence. With the help of the real-time access via mobile phones, tablets and software, the SMEs are able to convert large amount of operational data into usable information and thus to improve their efficiency decisively.

6. In addition to the empirical findings, the author could address the problems that might arise when companies implement I4.0-related technologies. These problems, which exist in different industries, are now visible and the reader or manager of SMEs who is thinking about implementation can see what is coming.

Implications for research:

1. Distinguishing from previous papers that focus on technical and production-oriented issues, this dissertation specifically addresses the question of how I4.0 influences the BMs of German SMEs. The author of this dissertation has therefore analysed the BMs of German SMEs with the instrument BMC. This has never been done before.

2. The author of this dissertation has conducted a cross-case analysis with six German SMEs from five industries, demonstrating the similarities and differences in these BM changes in the different industries. In the academic literature, it is not clear that this has been done before.

3. This dissertation also provides insights into the clear differentiation between incremental changes of BMs and disruptive BMI. The empirical findings clarify that established German SMEs generally adjust their BMs rather than innovates them.

5.3 Conclusion

The chapter has critically analysed the empirical findings and examined whether they are in line with the literature review in the dissertation. Furthermore, implications for practice and theory were added into the discussion to demonstrate what this dissertation contributes for the reader.

6. Conclusion

6.1 Reiteration of the purpose of the study

The purpose of this dissertation was to provide in-depth insights into how I4.0 influences German SMEs. In particular, the aim of the dissertation is to demonstrate how I4.0-related technologies influence SME BMs in the German manufacturing industry. With the help of the BMC ontology of Osterwalder and Pigneur (2010), the empirical findings should demonstrate how such SME BMs will change if they implement I4.0-related technologies. For this reason, representatives from six German SMEs from five different industries were interviewed to gather valuable in-depth insights into BM changes. Furthermore, similarities and differences in such changes across various industries were included in the specific findings of the data analysis. Thus, the reader can see whether these changes are industry-specific or represented in more industries.

6.2 Summary of findings

The interviews with the research participants confirmed that German SMEs now have to deal with changes in environmental conditions. Previous academic literature and the statements of research participants have also confirmed that these changes are related to why German SMEs need to ask themselves what the future of their companies looks like.

The key findings of this dissertation, which are separated into general and specific findings, demonstrate that each of the German SMEs has already implemented I4.0-related technologies – some more, some less so. The author was willing to describe how these technologies have impacted on German SME BMs. This impact was displayed with the help of the nine BM components of the BMC ontology.

Overall, the general findings of the data analysis demonstrate that each SME BM is influenced by I4.0-related technologies. The reader can assume that all German SMEs are influenced in customer relationships, key resources and cost structure. In 87% of cases, the SMEs recognised changes in key partners, key activities and the value proposition. While the revenue streams were influenced in half of the cases, the smallest BM components of all German SMEs were customer segments and channels.

The specific academic findings answer the research question "How does Industry 4.0 influence the business models of SMEs in the German manufacturing industry?" in more detail. In particular, similarities and differences in BM changes are outlined to demonstrate important correlations between industries.

After the implementation of I4.0-related technologies, SMEs benefits from better connection to their customers. While just one SME recognised that it could increase the customer segment, all companies benefited from improved customer relationships. Such relationships intensified and customers became more loyal than before the implementation.

In addition, to ensure this customer loyalty, 87% of these German SMEs enhanced their value proposition with the help of I4.0-related technologies. While better predictability of the manufacturing process or a predictive maintenance service might now provide the customer with in-depth insights into the manufacturing process or deliver warnings that a customer machine needs maintenance, individual product manufacturing, more flexibility and better product quality enables the customer to order products in a lot size of one in high quality with a quick processing time. Furthermore, on the value proposition side, the customer has the advantage of lower costs incurred. Three research participants confirmed that customers benefit from cost cuttings in, for example, disposition or rework. On the other hand, the BM component cost structure influenced all German SMEs. While investment costs increased in the initial phase, costs, such as supply chain costs, labour costs, material costs and service costs, decreased significantly.

Moreover, German SMEs have recognised changes in key resources. While the raw material purchase has become more conscious, SMEs benefit from data as a key resource arising from the manufacturing processes. With such data, SMEs can make decisions and draw conclusions. This highlights how important IT know-how is in a firm. German SMEs therefore face challenges on the employees' side, such as restructuring processes and IT-related trainings of employees at all levels.

Furthermore, BM component key partners have changed over time. While no collaborations have been disappearing, partners such as institutes, universities and IT partners are now in close contact with German SMEs to ensure that they are up to date for future developments.

As a result of these findings, the author of this dissertation has concluded that German SMEs deal with incremental BM developments more than disruptive BM innovations. No German SME has changed its entire BM, but could improve at least one BM component of their BMs because of I4.0. For this reason, the author has named the dissertation "Industry 4.0 – The Evolution of Business Models".

Finally, because of these valuable findings, the author can derive practical as well as theoretical implications and recommendations for further research.

6.3 Limitations

To make this dissertation as credible and reliable as possible, it is essential for the reader to understand and acknowledge the limitations which have affected the author. According to Miles and Hubermann (1994), one limitation occurs automatically because the research was carried out by one person. This leads to a "vertical monopoly", because the researcher reduces data, analyses and writes up material through personal approaches. In this regard, the author tried to reduce possible bias with different data collection tools, which led to greater reliability, as mentioned by Bloor and Wood (2006) and Yin (2014). However, possible bias cannot be fully excluded in the primary data.

The empirical analysis is based on five different German manufacturing industries. However, because there are more German manufacturing industries, the results cannot be fully generalisable for all industries. Furthermore, because the author has interviewed just one research participant from four different industries and two research participants operating in the same industry, changes, similarities and differences cannot generalised for each industry.

Furthermore, issues regarding primary data include incorrect interpretation, credibility of sources used and the fact that the researcher might have missed material or not taken it into consideration (Blaxter, Hughes and Tight, 2010). Qualitative research has the limitation that a large population was not involved and the answers of the interviewees cannot be generalised to a wider population. According to Opdenakker (2006), another limitation is that, because the interviews were conducted on the telephone, the author of the dissertation could not look at body language during the interviews. Thus, the author cannot guarantee that the research participants told the truth.

The design of this dissertation is of an explorative nature and thus provides a cross-case analysis. It therefore derives conclusions from qualitative information and relies on research participants' insights and experiences from their own companies.

6.4 Recommendations for further research

Recommendations are based on consideration of the research methodology, empirical data analysis and limitations.

With respect to the research methodology, one potential recommendation for future research is to carry out a quantitative empirical analysis to demonstrate any correlations between the revenue invested directly in I4.0-related technologies and any efficiencies, such as lower lead time or any cost savings.

For the empirical data, it would be interesting for further research to examine I4.0-related SME BMs changes in other countries, such as Great Britain, to contrast these findings.

Furthermore, it would be interesting for further research to carry out a long-term study. The researcher might accompany representatives of various SMEs from different industries and analyse whether any patterns exists in changes during the implementation process.

Finally, it is essential for further research, especially for company-based dissertations, that the researcher and the SMEs investigate what it looks like if SMEs innovate (BM disruption) their BMs. Both need to ask the following question: What does this BM look like if we build this SME on a "green field"?

References

Books:

Afuah, A. and Tucci, C.L. (2001), *Internet Business Models and Strategies*, McGraw-Hill, Chicago.

Bauernhansl, T. (2014), *Die Vierte Industrielle Revolution - Der Weg in ein wertschaffendes Produktionsparadigma*, Springer, Wiesbaden.

Blaxter, L., Hughes, C. and Tight, M. (2010), *How to research*, Open University Press / McGraw-Hill Education, Maidenhead.

Bloor, M. and Wood, F. (2006), *Keywords in qualitative methods*, Sage Publications, London.

Bryman, A. and Bell, E. (2015), *Business Research Methods*, 4th edition, University Press, Oxford.

Chesbrough, H. (2006), *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press, Boston.

Kaufmann, T. (2015), *Geschäftsmodelle in Industrie 4.0 und dem Internet der Dinge – Der Weg vom Anspruch in die Wirklichkeit*, Springer, Wiesbaden.

Kolb, B. (2008), *Marketing research*, SAGE, Los Angeles.

McDaniel, C. and Gates, R. (2013), *Marketing Research International Student Version*, 9th edition, John Wiley & Sons Inc., Hoboken.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative Data Analysis: an expanded sourcebook*, 2nd edition, Sage Publications, Inc., Thousand Oaks.

Miles, M.B., Huberman, A.M. and Saldana, J. (2014), *Qualitative Data Analysis: A Methods Sourcebook*, Sage Publications, Inc., Thousand Oaks.

Osterwalder, A. and Pigneur, Y. (2010), *Business Model Generation - A Handbook for Visionaries, Game Changers, and Challengers*, John Wiley & Sons Inc., Hoboken.

Punch, K.L. (2009), *Introduction to Research Methods in Eduction*, Sage Publications Ltd., London.

Ritchie, J. and Lewis, J. (2003), *Qualitative research practice*, Sage Publications Ltd., London.

Roth, A. (2016), *Einführung und Umsetzung von Industrie 4.0. Grundlagen, Vorgehensmodell und Use Cases aus der Praxis*, Springer Gabler Verlag, Wiesbaden.

Saunders, M., Lewis, P. and Thornhill, A. (2012), *Research Methods for Business Students*, 6th edition, Pearson Education Limited, Essex.

Stähler, P. (2002), *Geschäftsmodelle in der digitalen Ökonomie: Merkmale, Strategien und Auswirkungen*, 2nd edition, Josef Eul Verlag, Lohmar, Köln.

Strauss, A., and Corbin, J. (1998), *Basics of qualitative research*, 2nd edition, Sage, Newbury Park, CA.

Weiner, N., Renner, T. and Kett, H. (2010), Geschäftsmodelle im "Internet der Dienste": Aktueller Stand in Forschung und Praxis, Fraunhofer-Verlag, Stuttgart.

Yin, R.K. (1994), *Case Study Research: Design and Methods*, Sage Publications, California.

Yin, R.K. (2009), *Case Study Research: Design and Methods*, Sage, Thousand Oaks.

Yin, R.K. (2014), *Case Study Research: Design and Methods*, 5th edition, Sage, Thousand Oaks.

Articles in books:

Gassmann, O., Frankenberger, K. and Csik, M. (2013) “Geschäftsmodelle aktiv innovieren” in Grichnik D. and Gassmann, O., *Das unternehmerische Unternehmen*, pp. 23–41. Wiesbaden: Springer Fachmedien Wiesbaden.

Gassmann, O.; Frankenberger, K. and Csik, M. (2014) “Revolutionizing the Business Model” in Gassmann, O and Schweitzer, F., *Management of the Fuzzy Front End of Innovation*, pp. 89-97. Switzerland: Springer International Publishing.

Articles in journals:

Ayyagari, M.; Beck, T. and Demirguc-Kunt, A. (2007), “Small and Medium Enterprises Across the Globe”, *Small Business Economics*, Vol. 29, pp. 415-434.

Baden-Fuller, C. and Haefliger, S. (2013), “Business Models and Technological Innovation”, *Long Range Planning*, Vol. 46 No. 6, pp. 419-426.

Björkdahl, J. (2009), “Technology cross-fertilization and the business model: the case of integrating ICTs in mechanical engineering products”, *Research Policy*, Vol. 38 No. 9 , pp. 1468-1477.

Bochmann, L., Gehrke, L., Böckenkamp, A., Weichert, F., Albersmann, R., Prasse, C., Mertens, C., Motta, M. and Wegener, K. (2015), “Towards Decentralized Production: A Novel Method to Identify Flexibility Potentials in Production Sequences Based on Flexibility Graphs”, *International Journal of Automation Technology*, Vol. 9 No. 3, pp. 270-282.

Casadesus-Masanell, R. and Ricart, J.E. (2010), “From Strategy to Business Models and onto Tactics”, *Long Range Planning*, Vol. 43 No. 2-3, pp. 195-215.

Casadesus-Masanell, R. and Tarzijan, J. (2012), “When one business model isn't enough”, *Harvard Business Review*, Vol. 90 No. 1-2, pp. 132-137.

Chan, H.C.Y. (2015), “Internet of Things Business Models”, *Journal of Service Science and Management*, Vol. 8, pp. 552-568.

Christensen, C.M. and Overdorf, M. (2000), “Meeting the Challenge of Disruptive Change”, *Harvard Business Review*, Vol. 78 No. 2, pp. 66-76.

Edmondson, A.C., and McManus, S.E. (2007), “Methodological Fit in Management Field Research”, *Academy of Management Review*, Vol. 32 No. 4, pp. 1155-1179.

Eisenhardt, K.M. (1989a), “Making fast strategic changes decisions in high-velocity environments”, *Academy of Management Journal*, Vol. 32 No. 3, pp. 543-576.

Eisenhardt, K.M. (1989b), “Building theories from case study research”, *Academy of Management Review*, Vol.14, pp. 532–550.

Eisenhardt, K.M. and Graebner, M.E. (2008), “Theory Building from Cases: Opportunities and Challenges”, *Academy of Management Review*, Vol. 50 No. 1, pp. 25-32.

Ganzarain, J. and Errasti, N. (2016), “Three Stage Maturity Model in SME’s towards Industry 4.0”, *Journal of Industrial Engineering and Management*, Vol. 9 No. 5, pp. 1119-1128.

George, G. and Bock, A.J. (2011), “The Business Model in Practice and its Implications for Entrepreneurship Research”, *Entrepreneurship: Theory & Practice*, Vol. 35 No. 1, pp. 83-111.

Hacklin, F., Björkdahl, J. and Wallin, M.W. (2017), “Strategies for business model innovation: How firms reel in migrating value”, *Longe Range Planning*, pp. 1-29.

Johnson, M., Christensen, C. and Kagermann, H. (2008), “Reinventing Your Business Model”, *Harvard Business Review*, Vol. 86 No. 12, pp. 50–59.

Koen, P.A., Bertels, H.M.J. and Elsum, E.R. (2011), “The three faces of Business model innovation: Challenges for established firms”, *Research Technology Management*, Vol. 54 No. 3, pp. 52-59.

Kumar, N., Stern, L.W., and Anderson, J.C. (2013), “Conducting interorganizational research using key informants”, Academy of Management Journal, Vol. 36 No. 6, pp. 1633–1651.

Lasi, H., Kemper, H.G., Fettke, P., Feld, T., and Hoffmann, M., (2014), “Industry 4.0”, *Business & Information Systems Engineering*, Vol. 6 No. 4, pp. 239-242.

Liikanen, E. (2003), “Commission recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises”, *Official Journal of the European Union*, (2003/361/EC), pp. 36-41.

Magretta, J. (2002), “Why Business Models Matter”, *Harvard Business Review*, Vol. 80 No. 5, pp. 86-92.

Markides, C. (2006), “Disruptive innovation: In need of better theory”, *Journal of Production Innovation Management*, Vol. 23 No. 1, pp. 19-25.

McGuiggan, R. and Lee, G. (2008), “Cross-case analysis: An alternative methodology”, *Proceedings of Australian and New Zealand Marketing Academy Conference*, Sydney 2008, pp. 1–7.

Opdenakker, R. (2006), “Advantages and disadvantages of four interview techniques in qualitative research”, *Forum Qualitative Sozialforschung = Forum: Qualitative Social Research*, Vol. 7 No. 4, pp. 1-14.

Osterwalder, A., Pigneur, Y. and Tucci, C.L. (2005), “Clarifying Business Models: Origins, Present, and Future of the Concept”, *Communications of the Association for Information Systems*, Vol. 15, pp. 1-25.

Porter, M. and Heppelmann, J.E. (2014), “How Smart, Connected Products Are Transforming Competition”, *Harvard Business Review*, Vol. 92 No. 11, pp. 1-23.

Porter, M. and Heppelmann, J.E. (2015), “How Smart, Connected Products Are Transforming Companies”, *Harvard Business Review*, Vol. 93 No. 10, pp. 96-114.

Sanders, A., Elangeswaran, C. and Wulfsberg, J. (2016), “Industry 4.0 Implies Lean Manufacturing: Research Activities in Industry 4.0 Function as Enablers for Lean Manufacturing”, *Journal of Industrial Engineering and Management*, Vol. 9 No. 3, pp. 811-833.

Schneider, S. and Spieth, P. (2013), Business Model Innovation: Towards an integrated future Research Agenda, *International Journal of Innovation Management*, Vol. 17 No. 1, pp. 1-34.

Sommer, L. (2015), “Industrial Revolution – Industry 4.0: Are German Manufacturing SMEs the First Victims of the Revolution?”, *Journal of Industrial Engineering and Management*, Vol. 8 No. 5, pp. 1512-1532.

Teece, D.J. (2010), “Business Models, Business, Strategy and Innovation”, *Long Range Planning*, Vol. 43, pp. 172-194.

Thoben, K.D., Wiesner, S. and Wuest, T. (2017), “Industrie 4.0 and Smart Manufacturing – A Review of Research Issues and Application Examples”, *International Journal of Automation Technology*, Vol. 11 No. 1, pp. 4-16.

Thomas, D.R. (2006), “A General Inductive Approach for Analyzing Qualitative Evaluation Data”, *American Journal of Evaluation*, Vol. 27 No. 2, pp. 237-246.

Zott, C. and Amit, R. (2010), Business Model Design: An Activity System Perspective, *Long Range Planning*, Vol. 43 No. 2-3, pp. 216-226.

Zott, C., Amit, R. and Massa, L. (2011), “The Business Modell: Recent Developments and Future Research”, *Journal of Management*, Vol. 37 No. 4, pp. 1019-1042.

Online resources:

Davies, R. (2015). “Industry 4.0 Digitilisation for productivity and growth”, European Parliament Research Service. Dowloaded it from http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf as 15th July 2017

Gassmann, O., Frankenberger, K. and Csik, M. (2013). “The St. Gallen Business Model Navigator”, Working Paper by University of St. Gallen. Downloaded it from https://www.alexandria.unisg.ch/224941/1/St.%20Gallen%20Business%20Model%20Navigator.pdf as 22th May 2017.

Gassmann, O. and Sauer, R. (2016). “Kreative Zerstörung 4.0: Trends und neue Geschäftslogik”. Downloaded it from: https://www.wko.at/site/WirtschaftspolitischeBlaetter/008_Gassmann-Sauer.pdf as 24th June 2017.

IfM Bonn (2016). “SME-definition of IfM Bonn”. Downloaded it from: https://en.ifm-bonn.org/definitions/sme-definition-of-ifm-bonn/ as 20th September 2017.

Kagermann, H., Wahlster, W., Helbig, J., Hellinger, A., & Stumpf, V. (2013). “Recommendations for Implementing the Strategic Initiative INDUSTRIE 4.0 - Final Report of the Industrie 4.0 Working Group”, Frankfurt am Main: Industrie 4.0 Working Group. Downloaded it from http://www.irishmedtechassoc.ie/Sectors/IMDA/IMDA.nsf/vPages/Key_themes~Manufacturing~manufacturing-4.0-and-additive-manufacturingreports/$file/Final_report__Industrie_4.0_accessible.pdf as 22th May 2017.

KfW (2015). “Profile The SME Sector in Germany”. Downloaded it from: https://www.kfw.de/migration/Weiterleitung-zur-Startseite/Homepage/KfW-Group/Research/PDF-Files/The-SME-sector-in-Germany.pdf as 11. July 2017.

KfW (2016). “Merkblatt Unternehmen erweitern”. Downloaded it from: https://www.kfw.de/Download-Center/Förderprogramme-(Inlandsförderung)/PDF-Dokumente/6000000188-Merkblatt-037-047.pdf as 9th July 2017.

Maier, A., and Student, D. (2015). Industrie 4.0 - der große Selbstbetrug. Downloaded it from http://www.manager-magazin.de/magazin/artikel/digitale-revolution-industrie-4-0-ueberfordert-deutschen- mittelstand-a-1015724.html. as 21th May 2017.

Osterwalder, A. (2004). “The business model ontology: A proposition in a design science approach”, PHD thesis, l’Ecole des Hautes Etudes Commerciales de l’Université de Lausanne, Lausanne. Downloaded it from http://s3.amazonaws.com/academia.edu.documents/30373644/thebusiness-model-ontology.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1497782436&Signature=EVpIC6YY5OkXhguGAj85TTzcl9M%3D&response-content-disposition=inline%3B%20filename%3DThe_Business_Model_Ontology_a_propositio.pdf as 18th June 2017.

Senders, U. (2016). “Die Chance von Industrie 4.0 – Vernetzung und Durchgängigkeit als Faktoren einer erfolgreichen Industriepolitik”. Downloaded it from https://www.boell.de/sites/default/files/web_161010_e-paper_bb_grordnpol_2_industrie_4_0_v100.pdf as 13th June 2017.

Schröder, C. (2016). "Herausforderungen von Industrie 4.0 für den Mittelstand." Research paper. Downloaded it from http://library.fes.de/pdf-files/wiso/12277.pdf as 21th May 2017.

Spath, D., Ganschar, O., Gerlach, S., Hämmerle, M., Krause, T. and Schlund, S. (2013) "Produktionsarbeit der Zukunft – Industrie 4.0." Downloaded it from https://www.iao.fraunhofer.de/images/iao-news/produktionsarbeit-der-zukunft.pdf as 5th August 2017.