Business Model Innovation for Industrie 4.0: Why the "Industrial Internet" Mandates a New Perspective on Innovation

Christian Burmeister, Dirk Lüttgens and Frank T. Piller

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Industrie 4.0 (I40), i.e. the implementation of cyber-physical systems along the entire value chain and a far reaching digitalization of products and processes, is regarded as a significant agent of change in our current industrial system. While the previous discussion of I40 has been centered on technologies and standards, our focus is on business models (BM) for and enabled by I40. Having the right I40 BM will ultimately decide about companies' market positions and profitability. This calls for a systematic process for business model innovation (BMI). The previous academic literature has offered mostly conceptual reviews to date. Empirical analyses of management approaches and processes applied for BMI are scarce. Based on an exploratory research design, we present the results of a comparative interview study with large companies and industry associations. We analyze I40 business model characteristics, provide an in-depth perspective of companies' processes, structures and tools for BMI and derive upcoming practices as well as key competencies for BMI in the course of I40. Our results indicate a diverse picture. While some companies have dedicated BMI structures in place and lead I40 BMI, others could benefit from complementing existing product and service development with a systematic approach to BMI, building the fundamental capability to exploit the opportunities of I40.

1. Introduction

Over the last few decades, practice and academic research alike have gained substantial experience of how to master new product and service development successfully. However, recent technological advances and economic challenges demand that established companies increasingly need to reshape not just their products (or continuously improve their processes), but innovate their business model (BM) (*Markides*, 2006; *Chesbrough*, 2010; *Teece*, 2010; *Zott/Amit*, 2010; *Schneider/Spieth*, 2013).

A core facilitator of the latter perspective is "*Industrie 4.0*", a technology-enabled trend promising to fundamentally change the way in which we organize production and value creation. The term Industrie 4.0 (I40) was popularized in Germany around 2013 and refers to a fourth industrial revolution, after the steam engine, conveyor belt, and programmable controllers (*Evans/Annuziata*, 2012; *Kagermann et al.*, 2013). In the U.S. literature, the terms *Industrial Internet* (*Iansiti/Lakhani*, 2014) or *Internet of Things* (IoT) (*Porter/Heppelmann*, 2014; *Simonite*, 2014) are used with a similar connotation. It is a subset of the general digital transformation of existing businesses and processes, in which previously analogue or even manual operations in business processes are replaced by digital computer structures (*Iansiti/Lakhani*, 2014). A core idea of I40 is the implementation of cyber-physical systems (CPS) for industrial production i.e., networks of microcomputers, sensors and actuators embedded in materials, machines or products that have been connected along the value chain (*Porter/Heppelmann*, 2014; *Rudtsch et al.*, 2014). At the same time, I40 also captures the digital enhancement or even re-engineering of products and services. The global availability of real-time data enables sophisticated analysis and intelligent control of the industrial production environment, which significantly extends today's possibilities and may represent a disruptive technological change. More specifically, I40 yields new value propositions for highly customized or differentiated products, well-synchronized product-service combinations, and value-added services (*Iansiti/Lakhani*, 2014; *Rudtsch et al.*, 2014). At the same time, new supply chain structures with flexible processes and high equipment efficiency deliver not just cost savings, but enable a range of strategic benefits such as the better handling of complex products, short time-to-market, and manufacturing on-demand. While differentiation and cost leadership have conventionally been considered as contradictory strategies, I40 promises to enable both simultaneously (*Fleisch et al.*, 2014; *Olschewski/Weber*, 2014).

All these changes have profound implications for a firm's value proposition, its competitive strategic positioning, and hence its BM. Up to now, BM development has been seen as the task of a start-up, as illustrated with the rise of digital technology in the *dotcom* era. In this context, BMs were used to analyze new forms of value creation enabled by emerging digital technologies (*Aziz et al.*, 2008). Today, the need to be innovative with products and BMs on a continuous basis is not just a task for start-ups, but for established companies as well. This change is not just trigged by the demand side. Based on increasing digital capabilities, roles like software developers and network operators are gaining importance, and new roles like data aggregators and platform operators are emerging. Following these changes, the BMs of incumbent companies are under threat of being undermined by data-driven companies such as Google, Amazon, and Apple. Perhaps even more alarming are recent accounts that show a traditional industrial powerhouse like Germany already lagging behind America and China in implementing this new paradigm (*Zühlke*, 2015). While German stakeholders started a long and burdensome process of setting up norms and public standards for I40, the U.S. followed a more pragmatic approach to developing de-facto standards and applying them quickly to new industrial BMs. Forming the meta-level of ecosystem, industry and BM considerations beyond the digitalization and CPS technology, I40 provides a higher-level ground for the discussion of BMI approaches and company conduct.

While BM literature has been developing over the past decades, analyses of BMI processes and best practices as well as BM-related discussions of I40 are scarce. The objective

of our paper is, therefore, to discuss the peculiarities of I40 BMs and evaluate how companies approach BMI in the course of I40 i.e., which processes, structures, and tools they use to take advantage of the opportunity. We identify challenges as well as best practices and mirror these with I40 BM characteristics (or "requirements" in reverse). While showing how a systematic BMI process can complement existing processes for product or service development, we give indications of how a dedicated BMI process contributes to innovation performance in the course of I40 and beyond. Finally, we propose that the future market position and profitability of companies will be the result of having the right (innovative) BM in place, building on opportunities offered by I40 *in time,* and using *appropriate* BMI structures to exploit them. Our paper contributes to the emerging literature on BMI (*Chesbrough*, 2010; *Osterwalder/Pigneur*, 2010; *George/Bock*, 2011; *Gassmann et al.*, 2013) by providing an exploratory in-depth perspective on how European companies address the challenge of systematically developing new BMs in the age of I40, and what these BMs will look like.

Methodologically, our paper is of a qualitative nature, utilizing data from semi-structured interviews with senior managers from 14 leading companies and industry associations in the high-tech and engineering space. This is complemented by an analysis of recent academic and trade literature, industry reports, and other materials on I40. Our study provides a broad insight into current activities, concepts, and emergent BMI practice in the context of I40, which we use to propose a set of implications for theory and management.

2. Literature Review and Technical Background

Following suggestions by *Webster/Watson* (2002), we used a concept-centered approach and first identified key contributions and recent literature reviews in the field (e.g. *Zott et al.*, 2011; *Höflinger*, 2014; *Spieth et al.*, 2014); we used references listed in this work. Afterwards, we tracked their subsequent citations and searched common databases, platforms, and search engines (EBSCO, OPAC, SSRN, Google Scholar) for relevant key words ("business model", "business model innovation", "Industrie 4.0", "internet of things", "industrial internet", "cyber-physical systems") to achieve saturation. The results of this analysis are presented in the following in two parts: we start with a brief review of the term "Industrie 4.0", followed by a review of the literature on BMI.

2.1 Technical Background: Industrie 4.0

The term "Industrie 4.0" (I40) has become a widely used synonym for ongoing and recent efforts to establish cyber-physical (production) systems (CP(P)S) and appropriate new BMs, which are seen as the foundation of a new "industrial revolution". After the steam engine, the conveyor belt and programmable logic controllers, the implementation of CPPS and complementary devices in the "Internet of Things" (IoT), along with a unifying network infrastructure, is expected to open up significant disruptive potential (*BMBF*, 2013; Kagermann et al., 2013; Westerlund et al., 2014).

Cyber-physical systems are networks of microcomputers, sensors, and actuators that can be embedded in materials, devices or machines, and are connected through the internet (*BMBF, 2013)*. The technology stack consists of a classical device layer i.e., the physical device and the added logical capability of embedded sensors and actuators, a network

layer for the transmission and transport of information, a content layer that contains the data and meta data, and a service layer for the application functionality (*Fleisch et al.*, 2014; *M. Porter/Heppelmann*, 2014). Global availability of real-time data will enable new linkage and precise alignment of processes beyond company boundaries (*Geisberger/Broy*, 2012; *BMBF*, 2013). This enables flexible integration across multiple companies along the value chain, thereby establishing highly flexible and dynamic value creation networks. The real-time data stream can be analyzed for decision-making purposes and to control devices throughout the entire value generation process flexibly (BMBF, 2013; BITKOM/Fraunhofer IAO (Ed.), 2014).

The technological possibilities of I40 have also created the potential for innovative offerings, too. Product and service innovations may be based on highly differentiated and customized products, synchronized product/service combinations, or value-added services (*BMBF*, 2013; *Kagermann et al.*, 2013; *BITKOM/Fraunhofer IAO (Ed.)*, 2014; *Olschewski/Weber*, 2014; *M. Porter/Heppelmann*, 2014; *Rudtsch et al.*, 2014). At the same time, dynamic value chain configurations will facilitate higher resource and equipment efficiency and, therefore, cost reductions driven, for example, by the opportunity for a flexible and dynamic reconfiguration of production capacities, shorter time-to-market, higher scalability, lower scrap rates, or preventive maintenance (*BMBF*, 2013; *Kagermann et al.*, 2013; *BITKOM/Fraunhofer IAO (Ed.)*, 2014; *Rudtsch et al.*, 2014).

While the current discussion of I40 has been mainly technology focused, conventional roles and capabilities of equipment and plant engineering, producers, and logistics providers will also be extended as new layers of technological infrastructure come into play e.g., by CPS suppliers, software providers, platform operators, network operators, data collectors/analysts, CPPS integrators or even an open community (*Fleisch et al.*, 2014; *Olschewski/Weber*, 2014; *Westerlund et al.*, 2014). Subsequently, to achieve these growth opportunities, companies need to innovate their BMs, which again is likely to foster a further shift of company and industry boundaries (*Geisberger/Broy*, 2012; *MFW BW/Fraunhofer IPA*, 2014).

2.2 Business Models and Business Model Innovation (BMI)

Following *Teece* (2010), we define a business model *(BM)* as a management hypothesis about what customers want, how they want it, and how the enterprise can organize itself to best meet these needs, get paid for doing so, and make a profit. A BM is composed of different elements or components (*Osterwalder et al.*, 2005), which have been conceptualized at different levels of aggregation. A common starting point is differentiating the value proposition, activities of value creation, and models for value capture (*Johnson et al.*, 2008; *Casadesus-Masanell/Ricart*, 2010; *George/Bock*, 2011; *Zott et al.*, 2011; *Baden-Fuller/Haefliger*, 2013). The value proposition describes the drivers of customer value as well as the unique features of the firm's offering. The value creation layer includes the resources, capabilities and processes required to deliver the offering – starting from partner/supplier relationships to sales channels. Value capture comprises the underlying cost structure and revenue formula, which decide on profitability and economic sustainability.

On a more granular level, *Shafer et al.* (2005) have defined 20 BM components in four categories similar to those mentioned before. Frequently cited and commonly applied in practice is work by Osterwalder and Pigneur (2004; 2005; 2010), who divide a BM canvas into nine more specific elements following the four categories of a balanced scorecard:

product (value proposition), customer interface (target customers, distribution channels, relationships), infrastructure (resources, core competencies, partner network), and financials (cost structure, revenue model). Recent categorizations propose a more dynamic view of the BM as a constantly evolving system (*Casadesus-Masanell/Ricart*, 2010; *Cavalcante et al.*, 2011). Still, for the purpose of this study, we regard a BM as a predefined and intrinsically static set of parameters about a business's value- creation mechanism.

I40 business models are expected to be designed around customer centricity, value creation networks and, of course, the data that is generated. When using data from the customer side, offerings can be better tailored, priced and delivered to customer or segment needs along the entire lifecycle of the product (*BMBF*, 2013; *Kagermann et al.*, 2013; *MFW BW/Fraunhofer IPA (Ed.)*, 2014; *M. Porter/Heppelmann*, 2014). When using data from the value chain, processes can be more adaptive and automated, allowing companies to optimize their value creation structures and networks (*Kagermann et al.*, 2013). CP(P)S or IoT platforms will consolidate data and services to support collaborative value-creation processes and the networks behind them (*Kagermann et al.*, 2013; *Simonite*, 2014). Lastly, data can also become a main element of the revenue model, if users pay with their data instead of money.

Recently, the notion of a systematic *process for developing new BMs ("business model innovation (BMI)")* has been established, often following the logic of a product development process. *Teece* (2010) describes BMI from a dynamic capabilities perspective as the "sensing, seizing and reconfiguration skills" that are necessary to adapt to changing business environments. In Schumpeter's (1934) classic distinction of innovation types (new products, new methods of production, new sources of supply, exploitation of new markets, new ways to organize business), the outcome of this process – *a* BMI – would refer to the latter: the search for new logic and new ways to create and capture value (*Casadesus-Masanell/Zhu* 2013; *Massa/Tucci* 2013). *Zott/Amit* (2007) describe BMI as creating a new market or innovating transactions in existing ones. Similarly, *Markides* (2006) frames BMI around the "discovery of a fundamentally different BM in an existing business" that enlarges a firm's market by attracting new customers or increasing consumption. He distinguishes BMI clearly from product innovation: BMI has a different object at its core, follows different ways of emergence methods, and has different implications for managers. Overall, following Schröder's (2008) general definition of innovation, we define BMI as the (dynamic) generation process and initial implementation of a (static) BM, which is *new* from the perspective of the company or target market.

Opportunities for BMI can arise both within and outside a company (*Demil/Lecocq*, 2010). Environmental dynamism (market and technology turbulence), intra-industry threats (competitive forces), extra-industry threats (factor conditions, complementarities) and regulatory changes (taxation, product-related regulation etc.) are common triggers that demand BMI initiatives (*Ansoff*, 1975; *Christensen*, 1997; *Zott*, 2003; *Demil/Lecocq*, 2010; *Sosna et al.*, 2010; *Cavalcante et al.*, 2011; *Saritas/Smith*, 2011; *Höflinger*, 2014). In the past decade, BMIs have increasingly been motivated by advances in information technology (*Zott/Amit*, 2007; *Aziz et al.*, 2008; *Chesbrough*, 2010). The resulting BM changes are multi-faceted and cover all BM layers.

Little academic research, however, has so far been published on the *process* of innovating a BM (*Palo/Tähtinen*, 2013; *Schneider/Spieth*, 2013). This is surprising given the strong emphasis on process structure in product development literature. Initially, BMI

could draw on established innovation processes (*Bucherer et al.*, 2012), like the stage-gate logic of "discovery, scoping, definition, development, testing & valuation, launch" by *Cooper/Kleinschmidt* (1990). Such a linear approach, however, may not correspond with the complexity of BMI. *Chesbrough* (2010), *McGrath* (2010), and *Sosna et al.* (2010) hence call for a process of "experimentation and effectuation", meaning a discovery-driven trial-and-error methodology that would help to generate data and experience in previously unknown fields. It would also allow for tangible results, and mistakes to be learning opportunities right from the beginning. The "design-thinking" approach, for instance, accommodates these requirements and proposes frequent iterations over the course of the entire process. Such an approach requires solid leadership with sufficient authority and risk acceptance as well as a high degree of strategic agility (*Doz/Kosonen*, 2010). It must cover decisions on the core BM elements (*Morris et al.*, 2005; *Teece*, 2010).

For this purpose, *Gibson/Jetter* (2014) derived three generic building blocks for a BMI process (search and learn, articulate and communicate, and analyze and test) from literature and suggested refining these activities in further research and complement them using dedicated tools. *Palo/Tähtinen* (2013) present a high-level, agile phase model for the special case of a networked BM development: a service-development phase, a pilot phase, and a market phase with general activities both at the company and network level. In the practitioner-oriented literature, *Osterwalder/Pigneur* (2010) suggest a BMI process template of five non-linear steps (mobilize, understand, design, implement, manage) which can serve as a first orientation, but has to be substantiated to meet an organization's individual requirements. Despite these early attempts, an established and empirically validated process structure for BMI is still missing.

An appropriate *organizational setup*, including project structure, leadership, and culture, has been identified as a critical success factor for *any* innovation project (*Chesbrough*, 2010; *Bock et al.*, 2012; *Zellner*, 2013). Culture influences the innovativeness and strategic flexibility of a company – particularly if innovative/disruptive solutions are to be identified and environmental turbulence is high (*Bock et al.*, 2012; *Fleisch et al.*, 2014). For these reasons, *Markides/Geroski* (2005) propose that established companies should set up disruptive innovation in small, independent units that have different requisite skills and attitudes. Start-up-like environments in an incubator or corporate venture fund with fast decision processes and iterations can promote BMI without interfering in the existing business (*Ries/Euchner*, 2013; *Clough*, 2014). The more recent understanding of BMI (*Osterwalder et al.*, 2014), on the other hand, regards BMI as an activity that should become part of the job of any product manager or innovation project. The idea is that today's technological and competitive dynamic often mandates that a radical product innovation project must be accompanied by a BMI project. This should at least validate whether the existing BM is still viable to support the planned product innovation. However, dedicated empirical research about the best way to anchor an organizational BMI process and its contingencies is still missing.

In addition, little has been published on dedicated *methods and tools* for BMI. One of the best known, practitioner-oriented frameworks is the "Business Model Canvas" by *Osterwalder/Pigneur* (2010) which fosters a creative workshop environment analyzing as-is and defining to-be BMs along a framework of the nine elements. This and other canvas templates are also an important element of an iterative BMI process, as they can serve as easy prototypes to illustrate BM alternatives. Another dedicated tool is collections of BM

patterns i.e., commonly used and proven configurations of specific BM components. The idea is that innovative BMs can be created by rearranging and composing existing patterns. *Gassmann et al.* (2013), for example, propose a set of 55 BM patterns. For the IoT ecosystem, *Fleisch et al.* (2014) elaborate on digital BM patterns. When building on existing competencies and requirements, patterns can be used to enrich an existing BM with new elements (*Rudtsch et al.*, 2014), as they help to become more abstract and detached from existing (biasing) structures. *Westerlund et al.* (2014), for example, suggest using BM patterns to shift the level of analysis from the company level to the ecosystem, thereby allowing a greater variety of value creation options to be taken into account.

Finally, BMI must overcome inherent *challenges and hurdles* in implementing the new BM. As is similar in other exploration activities, BMI is up against organizational inertia, dominant logic, path-dependencies, and other hurdles that restrain an established organization in its efforts to change and adapt (*Cavalcante et al.*, 2011). New and disruptive BMs naturally conflict with rigid corporate structures (*Christensen*, 1997; *Markides*, 2006; *Chesbrough*, 2010; *Demil/Lecocq*, 2010; *Doz/Kosonen*, 2010). Not only do new value propositions disrupt the traditional ones, but they often require substantial change to the value creation structure i.e., different resources, processes etc. Managers frequently tend to avoid risks and radical change despite a business opportunity – especially when risks and chances are not immediately clear (*Markides*, 1997; *Cavalcante et al.*, 2011; *Rudtsch et al.*, 2014). Moreover, the business cases and profit margins are typically less advantageous for emerging BMs in the short term when compared to the existing BM (*Christensen*, 1997; *Cavalcante et al.*, 2011). Subsequently, investments, management attention, and business direction are likely to be allocated to the on-going profitable business. But even when managers are supportive and willing to support a novel BM, their scope of control and responsibility is often limited (*Bock et al.*, 2012; *Westerlund et al.*, 2014). This mismatch is further fueled by politics and informal power distributions in established companies (*Cavalcante et al.*, 2011). While some dedicated research has addressed these issues, we believe that a systematic methodology of BMI must also focus (in particular) on these questions of implementation and change.

In summary, professionalizing the BMI process offers significant upside potential to a firm. This is particularly true in this age of I40, where first mover advantages can result from an early accumulation of data, experience, and standard-setting ability (*Porter/Heppelmann*, 2014). While the growing BM literature offers plenty of case studies and conceptual frameworks that build our understanding of the BM construct, the discussion of specific aspects of the BMI process is still in an early high-level conceptual state. It lacks in-depth empirical analysis, and does not distinguish how the product innovation process is different. Similarly, we were able to find little research on the specific aspects of BMI for I40 i.e., specific patterns or components of I40 BMs. I40 literature currently available remains relatively abstract and focuses mostly on conceptual or technical issues. By analyzing I40 BM characteristics and the approaches of pioneering companies to instigate BMI for I40 in more detail in this study, we aim to contribute with exploratory insights to close these two gaps. Our research objective is to gain insights into the process of BMI in established (and large) companies, using the paradigm shift of I40 as our contextual anchor to understand how new BMs are being designed, implemented, and supported.

3. Method and Data

Given the lack of existing research, our paper is based on an exploratory interview study. This approach seems to be best suited to increase transparency on the matter and establish the topic in the literature (*Shields/Rangarajan*, 2013). We follow a case-study approach with a multiple case design to gain insights from a number of companies and experts across different industries. Data was collected in 14 structured interviews following previously circulated interview guidelines. Divided into two parts, the interview guidelines covered the interviewees' understanding of I40, and their BMI approach. Its structure built on a model of business process components, as described by *Zellner* (2013). This framework distinguishes a trigger (initiating the process), activities and flow (a performed task (process) to achieve defined goals and their sequence), organization (department, unit, person executing the activity), and resources (methods or tools supporting the activities). Interviews lasted for between 60 and 120 minutes and were conducted face-to-face, if possible, or by telephone. Some interviewees involved another colleague with special knowledge of I40 or BMI to complement their answers. All interviews were recorded, transcribed, and organized in a structured spreadsheet. During the interviews, we also gained an insight into selected supporting documents such as process/org charts, BMI toolkits, and studies published by the interviewees (or their companies) on the matter. Moreover, one author took part as an observer in an I40 BMI workshop conducted by one of the companies interviewed. These data helped us to triangulate our findings.

In addition, two of the authors were part (as the academic coordinator) of an industry consortium of 22 companies organized by a large technical association (VDI/VDE) for the specific purpose of sharing practices and experiences for BMI in the context of I40. This consortium was initiated in September 2014, and we participated as observers and facilitators of four meetings in this industry consortium (following the approach described by *Schiele/Krummaker*, 2011).

As *Miles/Huberman* (1994) posit, sample choice influences a study's results. We used a convenience sampling approach that enabled us to conduct 14 interviews with participants from leading companies in relevant industries as well as associations from the high-tech and engineering space (Appendix 1). The sample was composed of contacts from our professional network, speakers at relevant conferences, and people identified in the trade press. All interviewees held management positions with relevant experience in and exposure to their companies' activities in I40 and BMI. In this way, we could be sure to receive valuable and informed answers on the topic. However, a limitation of this approach is that we excluded companies that do not (yet) engage in I40 or BMI. To overcome this, we included a second, more objective perspective by factoring in representatives from industry associations to our sample.

Our data analysis follows approaches common to qualitative research (*Glaser/Strauss*, 1967; *Eisenhardt*, 1989; *Miles/Huberman*, 1994). We use an inductive process, analyzing and then interpreting the data as suggested by *Spiggle* (1994). Following this approach, the analysis includes the categorization, abstraction, comparison, dimensionalization, integration, iteration, and refutation of data. We started with the categorization of data into our perspectives and problem areas (trigger, process, organization, tools/methods), followed by abstraction to a more general level and integration with theoretical aspects. If possible, issues were dimensionalized into polar aspects e.g., linear <> iterative processes, and compared for differences and similarities within the sample. Preliminary findings were

iterated with interviewees from associations and consultants, and revised if necessary. In order to interpret and meet the objectives of this paper, the data are discussed in the following on a higher level, also taking literature and practical considerations into account.

4. Results and Discussion

In this section, we present our findings using the business process components proposed by *Zellner* (2013). These also structured our data-collection process. We start by discussing opportunities that trigger the initiation of a BMI process, describe its typical activities and tasks, comment on organizational issues as well as the resources (tools) used to support these activities.

4.1 Business Model Opportunities from Industrie 4.0

Opportunities for BMI from I40 not only direct the innovation efforts of a company, but also reflect a company's entrepreneurial imagination. Subsequently, BMI management approaches shall be designed to convert these visions into practice. All participants in our study believe that I40 offers new value propositions and advancements in value-creating structures. Typical expectations include:

> *"Product benefits will be better differentiated and tailored to individual demands." (Interviewee #9)*

> *"The focus will be shifted to the end customer." (#6)*

> *"The service business offers huge potential and serves as an interface between the customer and the customer data." (#11)*

> *"We will be able to extend our customer base and address new customer segments with new value propositions in all our business areas." (#1)*

These statements indicate a disruptive shift right at the beginning, given that the majority of our case-study companies were large industrial groups in the B2B environment. New value propositions are expected to arise in all business areas and to be more customer-centric, like tailored services or holistic solutions with closer (end) customer relations on the basis of customer data. Recent managerial publications confirm this shift (*Kagermann et al.*, 2013; *Porter/Heppelmann*, 2014). Consider as a typical example the opportunity from better connected information flows that will enable former B2B businesses to reach the end customer directly, and reinvent customer relations while bypassing players that populate the intermediate stages of the value chain:

> *"Customer service has always been a necessary evil that we have happily given away – until now. Now it offers huge potential connecting us and the customer. This not only enables us to offer the right service, but also tells us how our clients use our products and which products they really need." (#6)*

> *"We don't do B2B anymore. It's B2B2C! Beyond our 400 business customers, we can reach their 500 million end customers." (#10)*

For manufacturing and delivery, new opportunities reside in the ability to access information along the entire value chain and to execute consolidated control. Production will be-

come more flexible with shorter cycle times and optimized networks, which will also offer strategic options for new value propositions (e.g., on-demand manufacturing) and data-driven operational excellence. However, this process is *broadly* seen more as something that will evolve in line with supply-chain optimization:

> *"Industrie 4.0 gives us the chance to optimize our value-creating structures in every respect e.g., regarding costs, timing, resource utilization, sustainability." (#5)*

> *"IT entered production maybe 20-30 years ago and became more and more important. We need to acknowledge some paradigm shifts through IoT, but development as regards supply-chain optimization is more something that's evolutionary." (#7)*

Some interviewees, however, had a more radical view on the interplay between value propositions and value creation. They predict more disruptive change – especially in the case of smaller companies with a capability base that is possibly more restricted:

> *"Theoretically, we are taking a step back from industrial to craft production – but the opportunity to maintain the cost structure and efficiency of a standardized industrial production at the same time is a paradigm shift." (#10)*

> *"The ability to combine machinery with the digital world i.e., specialist engineering and IT know-how, might not be available in one single place. The ability to build partnerships is becoming more important than ever." (#9)*

Classical mechanical engineering businesses, for instance, will have to extend their focus in the direction of software, networks, and system development. Similarly, digital companies like Google, Amazon, or Apple are likely to expand into the hardware business, capitalizing heavily on their core IT capabilities. Consequently, both sides have to extend their existing resources and capabilities, demanding an even greater need for BMI competencies to find distinctive value propositions and implement a corresponding system of value delivery and capture (*Geisberger/Broy*, 2012; *Iansiti/Lakhani*, 2014). Losing control to a software or data-driven company (e.g., Google) ultimately results in a loss of competitive advantage for traditional companies. Thus, the competitive focus is shifting from core engineering to digital capability. Going even further, access to and control over the information flow might change the power relationship in the supply chain:

> *"The key enabler and source of competitive advantage is access to and control of machines and products along the entire value chain." (#8)*

> *"The problem is that our thinking and management systems do not allow us [Germans] to appreciate the value of data and digital structures. It is totally different in America where companies like Facebook, for instance, still working on their actual business model, are valued at $100bn and more." (#1)*

An often mentioned "solution" is the implementation of a platform-driven business, where one focal company turns into the role of a platform operator, connecting solution providers and customers (often in a two-sided market place). Even though the significant value of a platform model has been discussed extensively in the literature (*Kagermann et al.*, 2013; *Iansiti/Lakhani*, 2014; *M. Porter/Heppelmann*, 2014), our case-study companies do not seem to adopt this potential actively and remain relatively close to their core business. Established companies seem to lack a "role model" from their domain to inspire

more radical thinking. As a consequence, the pace and progress of I40-enabled BM implementation varies among the companies as well as internally between business units. Some interviewees indicated that they were making good progress, with concepts in place or even implemented already:

> *"We have been working on it for five years and will start the rollout shortly." (#10)*

> *"Some business units are leading in Industrie 4.0, others still need to be convinced of its benefits." (#5)*

At the other extreme, some companies are still at the beginning of a BMI process:

> *"We have identified opportunities but not yet conceptualized them further since we are cautious with new things and definitely not revolutionary." (#6)*

> *"We are pretty much at the beginning, chances need to be identified thoroughly and people need to be made aware of them." (#7)*

A rather critical picture is provided by an interview with representatives of a large industrial association, who were rather critical:

> *"About a quarter of all German companies have not yet understood the opportunities to be gained from Industrie 4.0, a quarter have identified potential but have not yet been 'thrilled' by it, a quarter have identified interesting potential but no business case yet. Only the remaining 25 per cent could progress with innovation at a higher level – but are hesitant for various reasons. […] We meet the same 100 participants at Industrie 4.0 conferences every time. Overall, there are about 50,000 companies in the industrial space – where are the rest? […] Large parts of the German 'Mittelstand' (SMEs) seem not to be interested yet." (#11)*

In summary, the perception of the influence of I40 on a firm's current BM varies among the interviewees – ranging from seeing it as tool for data-driven efficiency improvements *("this has been and will be more of a continuous development")* to entirely new roles and product/service combinations *("new roles in the ecosystem like platform operators will deal with important parts of the value chain, others will become obsolete")*. The latter perspective would imply strong market structure effects. Still, German companies overall seem to be hesitant to proactively capture opportunities from I40 for BMI, especially if it is more distant from their core business.

4.2 Triggers

In our sample, BMI processes are mostly triggered by imminent new technology opportunities, changing customer requirements, or a need for operational improvement – a "Steve-Jobs-like" entrepreneur driving BMI is much rarer:

> *"Surely, there are some of these Steve-Jobs-guys, but technology pushes or concrete customer requests are a lot more common." (#3)*

> *"There are two ways that BMIs can be triggered in our company: either by a technology push through the product innovation process or through a second process that accounts for new market demands and independent ideas. Both have a flow, but are very agile as well." (#4)*

> *"In 60% of cases, BMI is triggered by the development needs of a particular product, in 30% it is because managers need additional boost to meet their targets, but in 10% there is an entrepreneurial vision for a new business model." (#1)*

However, beginning to realize the need for new ideas, companies are increasingly promoting a spirit of corporate entrepreneurship e.g., through internal ideation activities, creativity workshops, trend analyses, and the implementation of think-tanks involving experts and employees alike:

> *"Everybody is asked to submit business model ideas [through an internal intranet-based ideation portal]." (#4)*

> *"We require substantial creativity and a strong business-mind from our employees at all levels. Ideas enter a competition, the best salesmen receive support." (#10)*

External observers (from industry associations) recognize these developments in the earlier process stages, but also complain that the handling and transition of BM ideas is often not as visionary as it should be. This lack of internally initiated triggers thus remains a clear weakness:

> *"Awareness and impulse for trends and developments were usually triggered by [external] associations, consultants, or policy makers. However, there was nowhere near enough internal impetus – especially in smaller companies." (#12)*

> *"Developments from other industries are rarely accepted. Industry-industry transfer, or let's call it 'respect', can surely be worked on." (#8)*

Making use of the right triggers has been named a key success factor for the BMI process – it is its starting point (*Demil/Lecocq*, 2010; *Saritas/Smith*, 2011; *Höflinger*, 2014). This seems to be particularly relevant in the course of I40, where the technology already exists, but use cases and BMs to capitalize on are often still rather ambiguous. Interestingly, this is an area with unrealized potential not just for companies, but also for further research. Opportunity identification and initiation are well-documented activities at the front end of new product development processes. The BMI front end, however, seems to be an under-utilized and under-researched area.

4.3 Process

BMI processes vary significantly among the companies interviewed regarding stages, the system, sequence and flexibility, and their relation to existing product innovation processes. Interviewees frequently described the BMI processes in terms of moving from an aggregated perspective into idea generation and analysis, elaboration, evaluation, decision, and implementation. Interestingly, BMI is often seen as an extension of technology-portfolio planning. As a consequence, most companies today have a close link between BMI, their product-innovation process, and their technology portfolio management:

> *"We have a consistent portfolio process that offers a lot of flexibility for innovation. It builds on an advanced and managed idea management process. Innovative business model ideas are just becoming part of it." (#5)*

"Technology packs are being evaluated quarterly and analyzed for portfolio fit. Business models will be built around promising ideas." (#7)

"So far, we have developed the product first and then the related business model. In the future we want to run this more in parallel." (#4)

A few companies have established a second process dedicated to market or trend-related BMI, running independently from product development:

"At our company, there are three ways: classic product innovation, an incubator, and a dedicated BMI process within specialized teams." (#9)

"[For BMI], we run a modified and rather flexible stage-gate process with fall-back loops that is operated by a special team." (#10)

"There are two processes: the classic product innovation process (push) and a technology/market scouting process (pull)." (#4)

This latter, separated approach seems to be more advantageous. It provides higher degrees of freedom, as suggested by *Chesbrough* (2010) and *McGrath* (2010). Seeing BMI as having a "different object(ive) at its core", *Markides* (2006) emphasizes the broader-scale, different themes and different objectives typical for BMI. Those, in turn, demand dedicated organization of the BMI process. We believe that companies regarding BMI as just as an extension of their product development process are more likely to miss important opportunities in I40, which offers the potential to significantly enhance value propositions, extend the customer base, and optimize value-creating structures. But at the same time, it requires substantial changes to the business logic, resources and capabilities base and often a redefinition of the firm boundaries. For these challenges, the established product development process is not well-suited.

Our interviews also provide insight into dedicated activities within the different phases of the BMI process: for *idea generation and analysis,* internal and external inputs are used by all case companies, but the set-up can be very different. About half the companies in our sample rely on a more "reactive" idea-generation approach, which is fed by a concrete technology push, customer/market requirements, and employee suggestions:

"We have a sophisticated tool which helps with discussing, evaluating and managing innovation ideas before the best are selected and pursued further." (#5)

However, the BMI process follows the interpretation of these ideas and their achievement only starts when valuable ideas are collected and prioritized in the idea-generation process. The remaining companies follow a more "proactive" idea-generation process and deliberately engage in trend analysis, organize customer workshops, and host expert panels on a regular basis:

"We regularly run expert panels and workshops within our teams to discuss trends and business model ideas." (#6)

Inputs of these activities are then screened for ideas and demands for new BMs. In both approaches, however, we got the impression that companies had not adopted the full open innovation perspective from product and technology development for BMI. All activities reported to us for this stage seem to follow the direct search approach i.e., companies in-

crease their search depth and width by interacting with external partners (illustrative for I40 is that the industrial companies in our sample frequently reported following the trends of the consumer IoT movement closely to generate ideas and inspiration). However, we have seen no instances of using crowdsourcing or other open innovation mechanisms for I40 in our sample. Investigating these novel search strategies for BMI seems to be an interesting opportunity for both BMI practice and future research. Especially in the I40 environment, where engineering and IT skills need to be combined in novel ways, such an open innovation approach could yield interesting opportunities for the I40 BMI process.

Later in the *analysis phase*, companies discuss the opportunity and its market environment i.e., customers and segments, channels, relations, and the requirements to pare down value propositions to the customer and the company. A few companies have adopted a broader systematic ecosystem approach to analyzing the (I40) environment more holistically and detect trends and opportunities in the market. On the other hand, we found rather few instances in our case companies where the value proposition was clearly defined. The value proposition is often called the core of any BM (*Johnson et al.*, 2008; *Osterwalder et al.*, 2014). The development of methods that help companies to transfer trends, ideas, and market insights into testable alternatives for the value proposition seems to be another area that needs further management attention – and supporting academic research.

In the following stages of the BMI process, BM (alternatives) are *defined, evaluated and approved*. While companies used different approaches with regard to single activities at any particular stage, it became obvious that most of them were mimicking the established stage-gate logic with a defined sequence and decision points after each step (*Cooper/Kleinschmidt*, 1990). Thereby, most companies increase flexibility through large degrees of freedom in a high-level process model as opposed to strictly defined granular processes steps:

> *"We use the classic stage-gate logic, since something like SCRUM would not fit our DNA. But we have fall-back and cut-off options in place that offer the appropriate flexibility." (#10)*

> *"Our innovation process has solid foundations, but is relatively flexible inside, which makes it possible to adapt to individual project needs." (#5)*

In contrast, just one third of the companies in our sample adopted a fully agile process that allows for multiple iterations, rapid prototyping with quick results, and early feedback loops:

> *"The process is very agile and delivers results extremely quickly. Validation, including with customers, takes place very early on. We have thus been able to reduce uncertainty significantly and time-to-market from 3 years to 1." (#9)*

In such an agile process, early iterations with customers play a key role to probe and push ideas:

> *"There is no project without close customer interaction – even to the extent of co-innovation. This increases the quality and the customers get what they need." (#9)*

This seems to be advantageous for I40 where opportunities are still ambiguous, the amount of experience is low and business ideas need to be established first along with

more differentiated and customized products as well as possibilities to revolutionize customer relations.

A critical part of the BMI process is the *evaluation* i.e., validating and prioritizing different BM alternatives. For this activity, all interviewees suggest a combination of quantitative indicators and more strategic qualitative criteria. Still, the logic of business cases such as revenue growth, cash-flows, profitability, pay-back etc. often plays a dominant role in nearly all decision processes. In contrast, a few interviewees stressed that *"their organizations learned from the past"* and appreciated the strategic value of ground-breaking projects over financial data. This facilitates entrepreneurial decision-making and bolder innovation:

> *"Projects like Industry 4.0 will never fit with strict business case requirements. We have to be flexible and use different measures." (#9)*

Given that a core idea of BMI is to build and test various alternatives to BM prototypes at a very early stage, and to improve on these prototypes iteratively and collaboratively, we suggest that observed dominance of "stage-gate thinking" may become a core obstacle in implementing an efficient BMI process. In addition, companies in our sample who were advanced in their BMI process all stressed the need of strong top management commitment and vision – rather than pandering to the influence of accountants:

> *"Calculating business cases for disruptive projects like I40 is nothing better than making a guess. Data is mostly unreliable anyway. […] Applying strict financial criteria like 2 year break-even points will nip any disruptive innovation project in the bud." (#9)*

As selection criteria, strategic fit, strengths of the value proposition, imitability/quality of barriers, brand and portfolio fit, as well as the perceived overall risks were named most frequently. How these criteria are used depends on the process design. Companies following stage-gate logic have clearly defined decision points as well as a major milestone decision typically after concept finalization and before implementation. Agile processes, on the other hand, reportedly have closer decision circles with broader and more fundamental decisions being taken early in the process e.g. in the course of investment approval for prototyping, and thus become increasingly stable towards the end.

In the BM *implementation* phase, the new BM will be set up and eventually go live on the market. Several interviewees indicated that evolutionary BMs will usually be combined within the current business, whereas a tendency to hive disruptive BMs off in a start-up environment does exist, too. Following *Markides/Geroski* (2005), companies may achieve better growth prospects in the more flexible structures typical of spin-offs. Some companies preferred this approach due to easier set up and reduced conflict potential. Other interviewees therefore criticized the start-up approach as being highly risky due to a loss of control and "integratability" – suggesting instead that existing management structures shall be adapted for different BM needs and market developments, so that all (new) businesses would be *"under one roof"* where they could benefit from each other. This is definitely one area where more research is still required, as without a proper implementation structure, all the previous efforts and decisions would become obsolete.

In summary, flexibility, openness, and market-relatedness seem to be important characteristics of BMI processes. This correlates with calls from *Chesbrough* (2010) and *McGrath* (2010) for a discovery-driven BMI approach. Hence, proactive management of cre-

ativity, exploration, and "top-down" analysis of new fields e.g. from an ecosystem perspective, helps to gain transparency for the business opportunities and to set clear directions. Openness, fast knowledge-building and checks with the market are key when information and experience in new business areas is scarce. Those companies that already have a systematic BMI process in place indicated that their development times reduced significantly and outcomes yielded a better fit-to-market. Interestingly, these companies were also characterized by high optimism and strong progress in their I40 efforts.

4.4 Organization and Governance

We found large differences in the organizational anchoring of BMI processes. BMI usually has a top management sponsor (C-level or C-level -1). In most companies, the BMI project lead is either a manager from the technology side with a background in research/innovation, or one from the business side, including members of the business unit management, product management, or business development departments. Interviewees claim that governance is a success factor – and is usually perceived as too weak:

> *"BMI is a task for the top management first of all. It needs to be sensitive to trends and opportunities and must give directions and incentives." (#11)*

> *"Governance is a central topic and needs to be allocated to an appropriate level with sufficient power and scope of control – ideally to higher or the highest management levels. Top management sponsorship is not enough." (#8)*

> *"A BMI project requires defined responsibilities and capacity to secure the entrepreneurial passion and drive behind it." (#1)*

A conflict of goals arises between the practicality of delegating BMI management to lower levels and the required power/scope of control from higher levels. To overcome this conflict, a few companies have designated BMI teams that assist managers from across the group with the BMI process by providing tools, know-how and a network:

> *"We have a dedicated BMI team that helps our various businesses to push BMI from early analysis to implementation." (#1)*

Similarly, another few companies have established dedicated I40 units that are directly responsible for developing this field and driving BMI:

> *"There is a dedicated Industrie 4.0 team that exploits the opportunities from both the technical as well as the business model side." (#10)*

These approaches are a way of ensuring that BMI projects are supported with appropriate leadership, relevant skills and entrepreneurial mind-sets. Not all companies, though, have *dedicated* resources or organizational structures for BMI management (support) in place, which is usually the case when BMI and product innovation processes have not been differentiated.

Companies with a dedicated BMI project team staff them from different departments to create an interdisciplinary unit (e.g., Sales, Marketing, R&D, IT, Operations, Legal, HR, etc.) and, in some cases, even cross-business units and cross-legal entities. However, the majority of interviewees criticized weaknesses of internal interfaces, politics and silo mentality as a barriers to effective internal collaboration:

"Internal interfaces are frequently disturbed by silo mentality which is promoted through conflicting P&L targets from different departments and units." (#1)

This is a significant problem as I40 requires closer collaboration and integration between different departments, especially IT and Operations, but also with client-facing functions:

"An important aspect is the close alignment of IT and operations/production – functions that usually don't work well together due to different mind sets, cultures and paces." (#12)

Only in a few cases was internal collaboration praised as "open – including between organizational layers", "enthusiastic", and "intrinsically motivated".

"We even collaborate with intrinsic motivation beyond legal entities because employees are interested in the topics and feel they can contribute to change." (#10)

This ethic applies to the more entrepreneurial and younger organizations who have striven to join efforts to achieve common goals.

External partnerships became equally essential to complement skills, gain access to technology or markets, and benefit from the partners' structures and management:

"Partnerships are important especially for Industrie 4.0, as good hard- and software skills must be combined." (#8)

There are different approaches to partnerships, ranging from loose development partnerships to joint businesses with differing levels of success. Some companies rely on ad-hoc partnership management, while others introduce dedicated functions for partnering and offer guidelines and support for easier initiation, collaboration, and control. We believe that professional partnering and openness of BMs is one of the core success factors in the course of I40, given its requirement to combine and link interdisciplinary skills, data relationships, and value creation processes.

Corporate culture is another important contingency for BMI. Interviewees repeatedly pointed out that bureaucratic structures and a conservative "company DNA" impede and delay BMI efforts. In order to become more flexible, many companies report establishing a more entrepreneurial mind-set with higher degrees of freedom and responsibility for employees as well as more advanced failure management:

"We need our group structures to manage this large company. But if we have an important strategic or disruptive topic that collides with existing structures, we will break them up – if necessary – with the help of a board member." (#9)

"Our overarching goal is innovation leadership. We are very business-minded, which is also promoted and led by example from the management. We cannot afford structures that are too rigid or silos in our organization." (#4)

On a different note, observers criticize German industry as being too conservative:

"Many companies still run a 'Swabian engineering culture' on the q.t. while getting overtaken by those who foster openness, partnering, and focus-setting which is more fruitful in times of accelerating innovation cycles and the need for skill extension." (#8)

One interviewee from a large industry group spoke out by way of example:

> *"Disruption simply is not part of our DNA. We have never been risk-taking and we will never be so." (#6)*

In line with the literature, an entrepreneurial mind-set is a key foundation for driving BMI. In the I40 environment in particular, where entirely new value propositions and value-generating structures will arise, a more entrepreneurial culture fostering openness, pragmatism, and strategic thinking with appropriate risk acceptance is required to overcome conflicts within rigid structures. This becomes even more relevant if existing business structures are disrupted directly. Accordingly, internal targets need to be aligned to incentivize joint BMI efforts. The bandwidth in our sample indicates that some companies have been working on promoting more entrepreneurial cultures over the past years. Others still have large development potential that needs to be addressed to provide a better foundation for BMI.

4.5 Resources and Tools

Finally, BMI requires dedicated resources and tools. Their development and deployment seems today to be scattered between companies. The bandwidth ranges from not having a dedicated BMI toolkit at all to having a sophisticated and IT-supported solution in place. Frequently used tools are *Osterwalder's* BM Canvas (*Osterwalder/Pigneur*, 2010) as a tool for structuring BM ideas and *Gassmann's* BM Patterns (*Gassmann et al.*, 2013) for creativity support. Interviewees appreciate the simplicity and practicability of these tools in a workshop setting. Most companies, however, criticize these tools as being too high-level, too restrictive within the parameters they define, and lacking consistency over the entire process:

> *"Osterwalder is helpful but requires additional analysis as to preparation, and more tools after filling the canvas, until the business is ready for implementation." (#3)*

As an example, support for preceding analysis, like modelling the ecosystem, or for subsequent steps e.g., detailing, evaluation and implementation guidance, is not yet properly supported by the standard tools and templates available today. BMI for I40 requires such tools to systematically analyze and understand relationships within the ecosystem and to define compelling value propositions. Thus, some of the companies interviewed modified and supplemented the tools with their own ideas.

> *"We [proudly] developed a toolbox even before Osterwalder that covers all steps and includes an analysis method for business ecosystems, a modelling tool for business models, a business model testing tool, as well as a framework for business planning which can be customized depending on project requirements. Our team provides consultants with BMI know-how to the business units and assists with the management of the process." (#1)*

A few companies have also adopted existing tools for product lifecycle and portfolio management for BMI. But overall, we conclude that the heterogeneity of tools observed indicates that there is a need for more and better tools. Here, we see great opportunities for future research. Similar to the large catalog of innovation management tools for the prod-

uct development process, research and practice need to engage in building a larger library of validated BMI tools.

4.6 Promising Practices of BMI for Industrie 4.0

To conclude the discussion of our findings and observations, *Table 1* contrasts the characteristics of BMs for I40 (rows) with the observed practices (columns) in our case companies. By highlighting significantly supportive and promising practices for developing I40 BMs (marked as "X" at the intersections in the table), we identify key BMI competencies with relevance along most dimensions. Thereby, organizational aspects such as a dedicated BMI/I40 team, inter-departmental collaboration, defined responsibilities, openness, an entrepreneurial culture have significant relevance for all BM dimensions and thus might be the starting point and foundation for any BMI initiative. In addition, setting up an agile (iterative) BMI process with an open and proactive front end to frame the activities is of similar importance.

5. Implications and Conclusions

The objective of our research was to contribute with exploratory insights to a better understanding of how new BMs are being designed, implemented, and supported, using the paradigm shift of I40 as our contextual anchor. First, we identified a number of changes expected in a firm's BM as a result of I40. Second, we analyzed current approaches to BMI and derived best practices regarding process, organizational structure, and tools, suggesting a contingent relationship between the design of a BMI process and the inherent characteristics of the BM it aims to innovate. This observation supports our initial proposition that using *appropriate BMI structures* facilitates the exploitation of opportunities offered by I40 *in time* and will decide on future market position and profitability of companies in the long run. Thus, BMI represents a critical contingency for company performance, especially in times of I40. This research has a number of implications for theory and practice, which will now be discussed.

5.1 Implications for Research

The peculiarities of I40 BMs bear interesting theoretical implications and a multi-faceted disruptive shift. While the focus of our study was on the process of BMI, we will first comment on a few implications on the resulting outcome of this process: the BM in times of I40. Enabling, for example, customization and efficiency optimization at the same time, I40 helps minimize the commonly dichotomous trade-off between product differentiation and cost leadership (Porter, 1980) or BM design choices (e.g., Zott and Amit's (2007) novelty-centricity and efficiency-centricity). Thus, the technological infrastructure behind I40 could enable the design of entirely new BMs that break with established paradigms in the strategy literature. Researching these relationships between BM alternatives, competitive strategy, and the resulting performance outcomes against the background of I40 will become a fruitful domain for further research.

I40 is expected to change existing distribution channels and customer relations through digital communication links and integration. Enabling former B2B businesses to broaden their footprint and directly reach the end-customer ("B2B2C") who owns/uses their products will disrupt existing industry structures and likely strengthen the position of domi-

Table 1: I40 Business Model Characteristics and Business Model Innovation Best Practices

I40 BM Characteristics			Business Model Innovation: Observed Best Practices																	
			Process (incl. trigger)						Organization						Resources and Tools					
			• Agile and iterative BMI process	• Proactive + open BMI process front-end	• Systematic VP (alternatives) design based on customer/market requirements	• Rapid prototyping/realization of minimal viable solutions	• Feedback loops with customers	• Early evaluation and decision gates	• Top-management sponsorship, management and directions	• Defined responsibilities and capacity for BMI lead/support	• Dedicated BMI or I40 team with interdisciplinary staffing (incl. IT + Ops)	• Inter-departmental and cross-entity collaboration	• Open organization with dedicated partnership mgmt.	• Entrepreneurial culture with freedom and responsibility	• Dedicated BMI toolkit incl. BM structuring + VP modelling framework	• Ecosystem analysis methodology tools and networking skills	• BM evaluation method with qualitative + quantitative criteria	• IT support for BMI (front end, collaboration tool, monitoring etc.)	• Intra-industry knowledge transfer	• Aligned performance mgmt. system to account for BMI + long-term performance
VP	• High product/service differentiation/customization	→ I40 Business Model Patterns	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
	• End-customer focus, B2B2C		X	X	X	X	X		X		X	X	X	X	X	X		X	X	X
	• Comprehensive Service business		X	X	X		X		X		X	X	X	X	X	X			X	X
	• Synchronized product/service combinations/VAS		X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X
VCr	• Value chain integration, consolidated control		X	X				X	X	X	X	X	X	X	X	X		X	X	X
	• Flexible and dynamic VCr networks		X						X	X	X	X	X	X	X	X		X	X	X
	• Connected information flows		X	X			X			X	X	X	X		X	X		X	X	X
	• Close (End-)customer relations, B2B2C		X	X	X		X			X	X	X	X	X	X	X		X	X	X
	• Short time-to-market		X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X
	• High efficiency							X	X	X	X	X	X				X			
	• High scalability										X	X	X			X				
	• High availability, preventive maintenance	→								X	X	X							X	
VCa	• Value appropriation from data/digital structures		X	X	X		X		X		X	X	X	X	X	X	X	X	X	X
	• Variabilization of prices and costs		X									X	X	X			X			
		Goal	↓ • Increase flexibility of the process and overcome experience-gap • Reduce development time • Market relatedness						↓ • Extension of roles and skills • Openness • Pragmatism • Entrepreneurial thinking						↓ • Optimal process support • Structuring guide • Decision support					

VP = Value Proposition, VCr = Value Creation Layer, VCa = Value Capture Layer
X = Identified practices that are significantly supportive or even critical for this issue

nant players such as OEMs and key technology leaders (*Porter/Heppelmann*, 2014), who then become platform owners. In turn, the resulting ability to control digital structures, information availability, and information access may have an impact on firm boundaries or even constitute new forms of firm boundaries (*Leih et al.*, 2015). Assets (information) and span of control (through digital structures) may not lie within the classical boundaries of the firm any longer and "integration" will thus differ from the conventional notion of vertical integration in organization studies. As a result, new concepts of firm boundaries may be required, such as the "open business model" (*Chesbrough*, 2006; *Frankenberger et al.*, 2014). Moreover, adjacent concepts such as networks and platforms will command increasing importance (*Zott et al.*, 2011; *Palo/Tähtinen*, 2013), especially in industries that have not been affected by these drivers previously.

These new BM opportunities are the outcome of the underlying process practices of BMI, constituted by a flow of activities and methodological approaches applied for each process stage. Our exploratory insights about this BMI process yield a number of further theoretical implications. Earlier literature discussed whether BMI should be regarded as an extension of product development or technology portfolio planning, or as a distinct process with dedicated structures and processes. We saw these opposing views represented in our sample. Our data indicates that the peculiarities of the BMI processes differ substantially from conventional product development and provide strong arguments for a separation of product development and BMI. Thus, we support *Markides* (2006) and call for a more prevalent differentiation between product innovation and BMI (processes) for I40 as well as in general. To organize the BMI process, respondents stressed the need for an agile, highly iterative process as opposed to the conventional sequential stage-gate processes frequently used in development and engineering. Agile processes provide higher flexibility and market-relatedness. Moreover, they allow a firm to generate and test several BM alternatives quickly. Key aspects here are the rapid prototyping of BM alternatives, organizational learning, early and frequent iterations with customers, and early decision-making for major issues. BMI literature has covered these aspects at a high level so far (*McGrath*, 2010; *Sosna et al.*, 2010; *Fleisch et al.*, 2014; *Gibson/Jetter*, 2014). Future research might analyze BMI processes at a more granular level, and deliver quantitative evidence for the performance relationship of BMI process design choices.

The front end of BMI consists of opportunity recognition and ideation. We found that companies often apply a "direct process" rooted in the product or technology space. This, however, bears a significant risk of being biased by existing knowledge and missing out opportunities that originate from the market side (*Chesbrough/Rosenbloom*, 2002). Applying open innovation principles at the BMI front end could offer significant potential by increasing the width and breadth of search. Involving actors from outside the firm with complementary skills (engineering, IT), who may later become partners as well, could be extremely helpful for the development of I40 BMs. With the divergent and cross-industry potential of I40, this is an area where we see many opportunities. Interestingly, "openness" in the context of BMI has only been discussed with regard to the resulting BMs (*Chesbrough*, 2006; *Frankenberger et al.*, 2014; *Saebi/Foss*, 2014; *Weiblen*, 2014), but not for the process of BMI. Highlighting the relevance of open innovation for BMI, I40 may provide the ground to connect these two research areas better in the future.

Governance and leadership for BMI has been identified as a key success factor by our respondents. This includes the definition of sufficient power and span of control as well as

sufficient cognitive capacity among the managers responsible and promoters of the BMI task. It further addresses the need for an entrepreneurial culture and corresponding organizational structures (e.g., a dedicated BMI team and defined responsibilities). The academic discussion of these organizational requirements has only very recently become a subject of debate in academic literature (e.g., *Hao-Chen et al.*, 2013; *Foss/Saebi*, 2015). Thereby, ties with entrepreneurship literature are starting to emerge, and help to explain the phenomenon better (*George/Bock*, 2011). The experiments of General Electric in adopting the "lean start-up mentality" (*Clough*, 2014) to enable better reaction to the changes implied by I40 have been named as a promising example in this regard. Conflicts arising from BMI within or between assets have been discussed in literature before (*Christensen/Bower*, 1996; *Markides/Geroski*, 2005; *Chesbrough*, 2010), but we found that existing recipes for anchoring a BMI optimally (e.g., integrated or separated) are rather abstract. They need to involve more complex and not necessarily straightforward strategic and organizational considerations. This is one of the largest and most important domains for further research: how to anchor both the BMI process as well as the implementation of its outcomes in an organization.

As regards methods, BMI activities often rely on existing tools and established frameworks. While the *BM canvas* by *Osterwalder & Pigneur* (2010) has become the "gold standard" to represent a BM, existing toolkits for innovation management that could help to come to such a description are lacking and do not cover all the steps required for BMI. Hence, some pioneering companies have developed their own tools. The high customer-centricity of I40 value propositions mandates a focus for identifying and evaluating customer value drivers. Better methods for customer-centric value proposition design (*Kagermann et al.*, 2013; *Westerlund et al.*, 2014) could provide greater benefits. In correspondence with *Chesbrough* (2010), we also propose that the focus on customers and networks will change their roles in the BMI process – possibly by giving them an even stronger role than in product innovation. In our sample, we found surprisingly little attention paid to these aspects and call for further research that could help companies to define a value proposition (and corresponding offerings) that incorporate this new approach to customers and data.

Finally, our interviews indicate that one of the core ideas of systematic BMI – efficiently generating and testing *many* BM alternatives (*Osterwalder*, 2004; *Osterwalder/Pigneur*, 2010) is not part of the dominant thinking in companies yet. Often, getting (only) *one* BM canvas across is seen as sufficient, as following the conventional understanding of calculating one business case. However, more experienced companies frequently saw standard business case templates as an obstacle to BMI projects. In these companies, qualitative information and amended financial requirements for strategic projects like I40 have replaced purely quantitative calculation sheets. They also define and evaluate BM alternatives to account for different scenarios, data uncertainty, and possible changes in the market. Future research should engage in developing a set of more reliable qualitative evaluation criteria to better analyze and capture the value of strategic BMI projects with ambiguous financial cases. It should further contribute to better understanding the practice of experimentation and rapid evaluation.

5.2 Implications for Management

In order to exploit I40 business opportunities, we suggest managers take the initiative and systematically build an understanding of I40 technology and the resulting BM opportunities originating from within and outside their principal industry. The analysis of these opportunities should have a strong focus on the customer or user perspective – not just on technological capabilities or standards. A good way to do this is to participate in relevant conferences or working groups and connect both within and outside the industry to broaden the view. Also, connecting (with) experts inside the company from various functions e.g., from R&D, Operations, and IT, but also customer-facing functions like Sales or Service, will unlock valuable expertise. This can be started in informal meetings, expert panels with "impulse speeches" from external speakers, or exploratory workshops providing the impetus for a later BMI process. In some of the larger organizations in our sample, we also saw patterns of practitioner communities that evolved informally at the beginning of an I40 initiative, connecting people intrinsically interested in the topic. Facilitating and nurturing these bottom-up initiatives could also provide much benefit.

The first more formal step to establishing dedicated I40 BMI activities would be to separate BMI from product planning and foster an entrepreneurial spirit in close collaboration with top management and functional leaders. Our analysis showed that appropriate organizational anchoring is the key to any BMI activity. Thus, we recommend the formation of a dedicated BMI team with specialized BMI skills and responsibilities, equipped with dedicated resources and supported by a strong executive promoter. For I40, we further recommend forming an additional expert group with functional know-how of both engineering and IT. The combined project team of BMI and I40 specialists will set the BMI process up and, in parallel, foster organization learning and skill development. Furthermore, internal interfaces and collaboration need to be strengthened to prevent silo thinking and self-optimization. This can be done by aligning common targets and performance management systems, allowing larger degrees of freedom in assigning responsibilities, but also by means of an entrepreneurial role model. Our respondents frequently mentioned that managers needed to lead by example, give directions, and incentivize BMI through group-wide targets.

Our research also identified a number of promising practices for the set-up of a BMI process, starting with a flexible/agile process design with a proactive and open ideation processes. The value proposition and BM design may follow available tools and involve interdisciplinary resources, including outside partners. The goal is to develop "minimal viable prototypes" that then will be iterated with potential customers quickly and frequently. For their evaluation, we suggest amending business case templates with qualitative/strategic aspects and increasing the tolerance for financial cases since strategic (BMI) projects have different payback periods, but also longer lasting effects. When anticipating the results of further (empirical) research, we propose that the systematic and agile BMI process suggested with high-level organizational anchoring, supported by a special BMI team and an entrepreneurial culture as well as an extensive toolkit, serves as a key foundation for successful BMI in the course of I40. The companies in our sample whose BMI approaches corresponded to these characteristics showed remarkable higher confidence and progress in their BMI activities for I40 as well as an indication of a higher innovation performance. Offering a holistic BMI toolkit with new approaches around existing frameworks is highly necessary. Given the highly dynamic and competitive urgency observed among the leaders

of our case companies, we believe that the current I40 "hype" is fostering exactly this development in many companies today. I40 is becoming a main driver for the implementation of dedicated BMI activities in industry.

5.3 Limitations and Future Research

Our research is not without limitations. Its design is of an explorative nature and thus provides a quite high-level analysis across our case companies. It derives conclusions from qualitative information and relies on the interviewees' insights and experience from their own companies. We used a convenience sampling approach, building on interviews with large European companies and associations. To achieve validity, we aimed at ensuring a high quality of inputs by selecting interviewees with a high level of seniority, I40 experience, and existing BMI activity while mirroring the corporate perspective with interviewees from industry associations. After 14 interviews, we observed saturation regarding the underlying phenomena. Thus, we expect that the general findings of the management approaches and success factors discussed will apply to other established companies outside our study. On more granular levels, differences will exist due to individual companies' conduct. Our methodological approach could not capture the effect of these differences in full detail. This is a subject for further empirical research.

We expect that a success-factor-based approach to investigating BMI activities and processes in a large sample of companies could yield fundamental results similar to those from classic studies in innovation management. Benchmarking BMI performance (and activities regarding I40) over a broader sample e.g., including American and Chinese companies, as well, would be extremely interesting. Such research would not only help companies to better position themselves in the race for I40 leadership, but would also provide a better understanding of which characteristics, cultural differences, and methodological approaches can lead to successful BMI.

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References

Ansoff, H. I. (1975): Managing Strategic Surprise by Response to Weak Signals, in: California Management Review, Vol. 18, No. 2, p. 21-33.

Aziz, S. A./Fitzsimmons, J./Douglas, E. (2008): Clarifying the Business Model Construct, Paper presented at the AGSE International Entrepreneurship Research Exchange.

Baden-Fuller, C./Haefliger, S. (2013): Business Models and Technological Innovation, in: Long Range Planning, Vol. 46, No. 6, p. 419-426.

BITKOM/Fraunhofer IAO (Ed.). (2014): Industrie 4.0 – Volkswirtschaftliches Potenzial für Deutschland, Berlin: BITKOM.

BMBF. (2013): Hightech-Strategie: Zukunftsbild Industrie 4.0, Bonn.

Bock, A. J./Opsahl, T./George, G., et al. (2012): The Effects of Culture and Structure on Strategic Flexibility during Business Model Innovation, in: Journal of Management Studies, Vol. 49, No. 2, p. 279-305.

Bucherer, E./Eisert, U./Gassmann, O. (2012): Towards Systematic Business Model Innovation: Lessons from Product Innovation Management, in: Creativity and Innovation Management, Vol. 21, No. 2, p. 183-198.

Casadesus-Masanell, R./Ricart, J. E. (2010): From Strategy to Business Models and onto Tactics, in: Long Range Planning, Vol. 43, No. 2-3, p. 195-215.

Casadesus-Masanell, R./Zhu, F. (2013): Business model innovation and competitive imitation: The case of sponsor-based business models, in: Strategic Management Journal, Vol. 34, No. 4, p. 464-482.

Cavalcante, S./Kesting, P./Ulhøi, J. (2011): Business model dynamics and innovation: (re)establishing missing linkages, in: Management Decision, Vol. 49, No. 8, p. 1327-1342.

Chesbrough, H. (2006): Open business models how to thrive in the new innovation landscape, Boston: Harvard Business School Press.

Chesbrough, H. (2010): Business Model Innovation: Opportunities and Barriers, in: Long Range Planning, Vol. 43, No. 2-3, p. 354-363.

Chesbrough, H./Rosenbloom, R. S. (2002): The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies, in: Industrial and Corporate Change, Vol. 11, No. 3, p. 529-555.

Christensen, C. M. (1997): The Innovator's Dilemma, Cambridge, MA: Harvard Business School Press.

Christensen, C. M./Bower, J. L. (1996): Customer Power, Strategic Investment, and the Failure of Leading Firms, in: Strategic Management Journal, Vol. 17, No. 3, p. 197-218.

Clough, R. (2014): General Electric Wants to Act Like a Startup, Bloomberg Businessweek, Retrieved from http://www.businessweek.com/articles/2014-08-07/ge-taps-lean-startup-ideas-for-faster-cheaper-product-rollout on 10.1.2015.

Cooper, R. G./Kleinschmidt, E. J. (1990): The Key Factors in Success, Chicago: American Marketing Association.

Demil, B./Lecocq, X. (2010): Business Model Evolution: In Search of Dynamic Consistency, in: Long Range Planning, Vol. 43, No. 2–3, p. 227-246.

Doz, Y. L./Kosonen, M. (2010): Embedding Strategic Agility, in: Long Range Planning, Vol. 43, No. 2-3, p. 370-382.

Eisenhardt, K. M. (1989): Building Theories from Case Study Research, in: The Academy of Management Review, Vol. 14, No. 4, p. 532-550.

Evans, P./Annuziata, M. (2012): Industrial Internet – Pushing the Boundaries of Minds and Machines: GE.

Fleisch, E./Weinberger, M./Wortmann, F. (2014): Business Models and the Internet of Things, St. Gallen: Bosch Internet of Things & Services Lab Universität St. Gallen.

Foss, N. J./Saebi, T. (2015): Business Model Innovation – The Organizational Dimension, Oxford: Oxford University Press.

Frankenberger, K./Weiblen, T./Gassmann, O. (2014): The antecedents of open business models: an exploratory study of incumbent firms, in: R&D Management, Vol. 44, No. 2, p. 173-188.

Gassmann, O./Frankenberger, K./Csik, M. (2013): Geschätsmodelle entwickeln – 55 innovative Konzepte mit dem St. Galler Business Model Navigator, München: Hanser.

Geisberger, E./Broy, M. (2012): agendaCPS – Integrierte Forschungsagenda Cyber-Physical Systems, München: acatech.

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

Gibson, E./Jetter, A. (2014). Towards a Dynamic Process for Business Model Innovation: A Review of the State-of-the-Art. Paper presented at the PICMET, Kanazawa.

Glaser, B. G./Strauss, A. L. (1967): The discovery of grounded theory strategies for qualitative research, Chicago: Aldine.

Hao-Chen, H./Mei-Chi, L./Lee-Hsuan, L., et al. (2013): Overcoming organizational inertia to strengthen business model innovation, in: Journal of Organizational Change Management, Vol. 26, No. 6, p. 977-1002.

Höflinger, N. (2014): The business model concept and its antecedents and consequences – towards a common understanding, Paper presented at the Academy of Management Annual Meeting.

Iansiti, M./Lakhani, K. (2014): Digital Ubiquity: How Connections, Sensors, and Data Are Revolutionizing Business, in: Harvard Business Review, Vol. 11/2014.

Johnson, M. W./Christensen, C. M./Kagermann, H. (2008): Reinventing your business model, in: Harvard Business Review, Vol. 12/2008, p. 50-59.

Kagermann, H./Wahlster, W./Helbig, J. (2013): Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0. Abschlussbericht des Arbeitskreises Industrie 4.0., Frankfurt/Main: Forschungsunion Wirtschaft-Wissenschaft/acatech.

Leih, S./Linden, G./Teece, D. J. (2015). Business Model Innovation and Organizational Design: A Dynamic Capabilities Perspective. In N. J. Foss & T. Saebi (Eds.), Business Model Innovation: The Organizational Dimension. Oxford: Oxford University Press.

Markides, C. (1997): Strategic Innovation, in: Sloan Management Review, Vol. 38, No. 3, p. 9-23.

Markides, C. (2006): Disruptive Innovation, In Need of Better Theory, in: Journal of Product Innovation Management, Vol. 23, p. 19-25.

Markides, C./Geroski, P. (2005): Fast second: How smart companies bypass radical innovation to enter and dominate new market, San Francisco: Jossey-Bass.

Massa, L./Tucci, C. (2013). Business Model Innovation. In M. Dodgson, D. Gann & N. Phillips (Eds.), The Oxford Handbook of Innovation Management. Oxford: Oxford University Press.

McGrath, R. G. (2010): Business Models: A Discovery Driven Approach, in: Long Range Planning, Vol. 43, No. 2-3, p. 247-261.

MFW BW/Fraunhofer IPA (Ed.). (2014): Strukturstudie "Industrie 4.0 für Baden-Württemberg", Stuttgart: MFW BW/Fraunhofer IPA.

Miles, M. B./Huberman, A. M. (1994): Qualitative data analysis: an expanded sourcebook: Sage Publications.

Morris, M./Schindehutte, M./Allen, J. (2005): The entrepreneur's business model: toward a unified perspective, in: Journal of Business Research, Vol. 58, No. 6, p. 726-735.

Olschewski, F./Weber, M. (2014): Geschäftsmodelle der Industrie 4.0, in: inspect, Vol. 05/2014.

Osterwalder, A. (2004): The Business Model Ontology – A Proposition in a design science approach (Dissertation). University of Lausanne, Lausanne.

Osterwalder, A./Pigneur, Y. (2010): Business Model Generation, Hoboken: John Wiley & Sons.

Osterwalder, A./Pigneur, Y./Bernarda, G., et al. (2014): Value Proposition Design: How to Create Products and Services Customers Want, Hoboken: John Wiley & Sons.

Osterwalder, A./Pigneur, Y./Tucci, C. (2005): Clarifying Business Models: Origins, Present, and Future of the Concept, in: Communications of the Association for Information Systems, Vol. 16, p. 1-25.

Palo, T./Tähtinen, J. (2013): Networked business model development for emerging technology-based services, in: Industrial Marketing Management, Vol. 42, No. 5, p. 773-782.

Porter, M./Heppelmann, J. E. (2014): How Smart, Connected Products are Transforming Competition, in: Harvard Business Review, Vol. 11/2014.

Porter, M. E. (1980): Competitive Strategy: Techniques for Analyzing Industries and Competitors, New York: Free Press.

Ries, E./Euchner, J. (2013): Conversations: What Large Companies Can Learn from Start-ups: An Interview with Eric Ries, in: Research-Technology Management, Vol. 56, No. 4, p. 12-16.

Rudtsch, V./Gausemeier, J./Gesing, J., et al. (2014): Pattern-based Business Model Development for Cyber-Physical Production Systems, in: Procedia CIRP, Vol. 25, p. 313-319.

Saebi, T./Foss, N. J. (2014). Business Models for Open Innovation: Matching Heterogenous Open Innovation Strategies with Business Model Dimensions. Norwegian School of Economics (NHH).

Saritas, O./Smith, J. E. (2011): The Big Picture – trends, drivers, wild cards, discontinuities and weak signals, in: Futures, Vol. 43, No. 3, p. 292-312.

Schiele, H./Krummaker, S. (2011): Consortium benchmarking: Collaborative academic–practitioner case study research, in: Journal of Business Research, Vol. 64, No. 10, p. 1137-1145.

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

Schröder, H.-H. (2008): Technologie- und Innovationsplanung (4 ed. Vol. 2), München: Schäffer-Poeschel

Schumpeter, J. A. (1934): The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle, London: Oxford University Press.

Shafer, S. M./Smith, H. J./Linder, J. C. (2005): The power of business models, in: Business Horizons, Vol. 48, No. 3, p. 199-207.

Shields, P. M./Rangarajan, N. (2013): Playbook for Research Methods: Integrating Conceptual Frameworks and Project Management, Stillwater: New Forums Press.

Simonite, T. (2014): The Internet of Things, in: MIT Technology Review, Vol. 117, No. 4, p. 68-78.

Sosna, M./Trevinyo-Rodríguez, R. N./Velamuri, S. R. (2010): Business Model Innovation through Trial-and-Error Learning, in: Long Range Planning, Vol. 43, No. 2-3, p. 383-407.

Spieth, P./Schneckenberg, D./Ricart, J. E. (2014): Business model innovation – state of the art and future challenges for the field, in: R&D Management, Vol. 44, No. 3, p. 237-247.

Spiggle, S. (1994): Analysis and Interpretation of Qualitative Data in Consumer Research, in: Journal of Consumer Research, Vol. 21, No. 12, p. 491- 503.

Teece, D. J. (2010): Business Models, Business Strategy and Innovation, in: Long Range Planning, Vol. 43, No. 2-3, p. 172-194.

Webster, J./Watson, R. T. (2002): Analyzing the Past to Prepare for the Future: Writing a Literature Review, in: MIS Quarterly, Vol. 26, No. 2, p. xiii-xxiii.

Weiblen, T. (2014): The Open Business Model: Understanding an Emerging Concept, in: Journal of Multi Business Model Innovation and Technology, Vol. 1, No. 1, p. 35-66.

Westerlund, M./Leminen, S./Rajahonka, M. (2014): Designing Business Models for the Internet of Things, in: Technology and Innovation Management Review, Vol. 4, No. 7, p. 5-14.

Zellner, G. (2013): Towards a framework for identifying business process redesign patterns, in: Business Process Management Journal, Vol. 19, No. 4, p. 600-623.

Zott, C. (2003): Dynamic capabilities and the emergence of intraindustry differential firm performance: insights from a simulation study, in: Strategic Management Journal, Vol. 24, No. 2, p. 97-125.

Zott, C./Amit, R. (2007): Business Model Design and the Performance of Entrepreneurial Firms, in: Organization Science, Vol. 18, No. 2, p. 181-199.

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

Zott, C./Amit, R./Massa, L. (2011): The Business Model: Recent Developments and Future Research, in: Journal of Management, Vol. 37, No. 4, p. 1019-1042.

Zühlke, K. (2015): Plattform Industrie 4.0 steht vor dem Aus – Deutschland hat die erste Halbzeit verloren, Retrieved from http://www.funkschau.de/telekommunikation/artikel/116899/ on 11.2.2015.

Appendix 1: Interview Partners

The following tables provide an overview of the interviews conducted. The name of the company and interviewees remain anonymous for reasons of confidentiality.

Interviewees from Industry

#	Industry	Revenue (group)	Employees	I40 Expertise	BMI Expertise	Education	Rank	Duration (min)
1	Engineering	>€50bn	>250.000	Project work	Main task	Economist	Senior Manager	120
2	Engineering	>€50bn	>250.000	Main task	Main task	Engineer Dr.	Senior Manager	60
3	Engineering	>€10bn	>100.000	Project work	Project work	Engineer Dr.	Manager	60
4	Engineering	>€1bn	>10.000	Project work	Project work	Engineer	Manager	60
5	Steel	>€10bn	>100.000	Main task	Project work	Engineer Dr.	Senior Manager	60
6	Consumer products	>€10bn	>10.000	Project work	Project work	Economist	Manager	60
7	Pharma	>€10bn	>100.000	Interested	Main task	Physicist Dr.	Senior Manager	90
8	Consulting	>€10bn	>250.000	Project work	Project work	Economist	Senior Manager	90
9	Software	>€10bn	>50.000	Project work	Main task	Economist	Manager	75
10	ICT Services	>€1bn	>50.000	Project work	Main task	Economist Dr.	Senior Manager	60

Interviewees from Industry Associations

#	Membership base	Members	I40 Expertise	BMI Expertise	Education	Rank	Duration (min)
11	Engineering	>100.000	Main task	Main task	Engineer Dr.	Director	120
12	ICT	>2.000 corporations	Main task	Interested	Engineer	Senior Manager	60
13	Engineering	>3.000 corporations	Interested	Interested	Engineer Dr.	Senior Manager	45
14	High-Tech	>1.000 corporations	Main task	Interested	Engineer	Senior Manager	45

Christian Burmeister is a Doctoral Researcher at the Technology and Innovation Management Group (TIM) at RWTH Aachen University and a Strategy Consultant focusing on corporate strategy, business models, and IT. burmeister@time.rwth-aachen.de

Dirk Lüttgens is an Assistant Professor at the RWTH Technology and Innovation Management Group (TIM) at RWTH Aachen University and a lecturer at the University of Applied Sciences, Luzern. luettgens@time.rwth-aachen.de

Frank T. Piller holds the Chair in Technology and Innovation Management at RWTH Aachen University and is the co-director of the Smart Customization Group at the Massachusetts Institute of Technology (MIT). piller@time.rwth-aachen.de

Address: RWTH Aachen University, Technology and Innovation Management (TIM), Kackertstraße 7, 52072 Aachen, Germany.