Towards a Conceptualization of Capabilities for Innovating Business Models in the Industrial Internet of Things

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Abstract. The emergence of Internet of Things (IoT) technologies offers promising value potentials for industrial manufacturers based on the combination of smart products and data-driven services. At the same time, many incumbent firms experience a threat to their traditional value proposition and are challenged to innovate and reconfigure their existing business models. However, many of these traditional manufacturers lack or are unaware of the required capabilities for successfully reinventing their business model using IoT technologies. We therefore adopt the lens of dynamic and operational capabilities and conduct an empirical analysis of organizational capabilities required for successful IoT-enabled business model innovation (BMI). Through an exploratory, qualitative study based on interviews with decision makers in industrial manufacturing companies and experts in practice-oriented research institutions, we identify eleven distinct dynamic and operational capabilities. Our findings provide useful insights for research and practice and advance the understanding of enablers in IoT-enabled BMI.

Keywords: Digital Transformation, Industrial Internet of Things, Dynamic Capabilities, Operational Capabilities, Business Model Innovation

1 Introduction

In recent years, the Internet of Things (IoT) received enormous attention in academic literature as well as industry practice and still remains a promising research area [1]. The emergence of IoT technologies and their application in the industrial context, also known as the Industrial Internet of Things (IIoT), changes competitive dynamics by erupting traditional market boundaries between industrial manufacturers, software providers, and technology start-ups [2, 3]. Traditional manufacturers are challenged to generate new value propositions through data-based services and predictive solutions [4] which often requires adaptation of existing business models [5]. The German automotive supplier Bosch, for example, uses IoT technologies to enable customers of its fleet management system to identify potential problems in advance and to analyze the driving behavior of individuals [4]. However, such change brings along numerous challenges and has major implications for incumbent firms [3, 6]. While traditional

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manufacturers possess critical industry knowledge, they most likely face substantial skill gaps when it comes to IoT and related business model innovation (BMI) [2, 6]. Besides a lack of technological expertise in areas such as IoT infrastructure, data analytics, and software engineering, industrial manufacturers are required to rethink existing business model components and to implement new approaches towards customer relationship management, sales, and collaboration with technology providers [3]. All in all, the IoT constitutes an exogenous technological change to which industrial manufacturers need to react by adapting their business model in order to capture the value potential and to secure future competitiveness [7].

Existing academic work on IoT-enabled BMI is still young and little is known about how the change in business models actually occurs. Most notably, there is a missing perspective on how to overcome the identified challenges and barriers of IoT-enabled BMI. In fact, based on our assessment, current literature fails to analyze enablers of IoT-enabled BMI and to conceptualize relevant organizational capabilities. There is thus a strong need to better understand the complex underlying processes and drivers of successful IoT-enabled BMI. Overall, existing research does not clarify the nature of required organizational capabilities for IoT-enabled BMI. In this paper, we present a conceptualization of eleven organizational capabilities that are required for IoT-enabled BMI. We identified these capabilities through an exploratory approach involving semi-structured interviews with decision makers in the German manufacturing industry and experts in practice-oriented research institutions. In the following, we introduce our understanding of IoT-enabled BMI and organizational capabilities that we applied in our exploratory research.

2 Theoretical Background

2.1 IoT-enabled Business Model Innovation

Despite a large body of research, existing theory still misses a common understanding about both business model (BM) and BMI [6, 8]. Therefore, it is essential to define both concepts in the context of our study. Business models are described as "mental models" [9] that represent the underlying architecture of a firm's overall business [10]. The concept focuses on the underlying organizational structures, processes, and resources that enable value creation [9] and defines "[…] the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit" [11]. According to Foss and Saebi [8] BMI encompasses "[…] designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements". Following Tesch, Brillinger and Bilgeri [2], in the context of our study this includes both "the 'modification, reconfiguration and extension […] of existing business models' (business model development) as well as the design of 'fundamentally new and sometimes disruptive' business models (business model design)". Furthermore, we refer to BMI using IoT technologies as IoT-enabled BMI.

Literature on IoT-enabled BMI can be grouped into three major research streams. The first stream focuses on the analysis of business model patterns and frameworks for the IoT and identifies new patterns such as remote usage or condition monitoring [1, 4, 12-14]. While many studies analyze the influence of IoT on specific business model components and describe underlying changes [12, 13], other studies do not focus on single organizations but take a broader view on the overall IoT ecosystem by analyzing the interaction and collaboration of different players [14]. Second, a group of studies analyzes the process of IoT-enabled BMI itself [2, 6]. For instance, Tesch, Brillinger and Bilgeri [2] apply a stage-gate model to IoT-enabled BMI and identify a semi-structured, iterative process. Moreover, current literature builds on processes identified in product development research, such as innovation stages in the process of IoT-enabled BMI [6]. Third, an emerging stream of literature analyzes challenges and barriers in IoT-enabled BMI [4, 6, 15]. Thereby, challenges are analyzed from both a technical and business perspective [6]. Manufacturers require new capabilities to incorporate software, data analytics, and data-based service offerings [2, 15]. All in all, companies need to develop capabilities to master both technology and business-related challenges in order to successfully implement IoT-enabled BMI [4]. However, current research is missing a close analysis of such organizational capabilities.

2.2 Organizational Capabilities

In this paper, we conceptualize organizational capabilities as dynamic and operational capabilities. The concept of dynamic capabilities was first introduced to better address the characteristics of today's volatile business environments and markets [16, 17]. They are described as "higher-order organizational capabilities" [18] that enable incumbent firms to modify existing capabilities, organizational structures, and even company culture [7, 18, 19]. The framework refined by Teece [20] distinguishes three basic dimensions of dynamic capabilities and differentiates the underlying organizational processes into the classes of sensing, seizing, and reconfiguration. Sensing capabilities encompass the organizational ability to discover opportunities related to technological developments as well as changes in customer requirements and the overall market [20, 21]. Seizing capabilities mainly encompass processes related to organizational value generation as well as new product development or service innovation [20]. Reconfiguration capabilities are based on processes for the alignment and realignment of organizational assets in order to meet new requirements [20]. These capabilities can address organizational topics such as decentralization or co-specialization and encompass critical processes of organizational knowledge management [20, 21].

Existing literature argues for the need to differentiate between different levels of hierarchy of organizational capabilities in order to reduce confusion about the concept and to eliminate its "tautological feel" [22]. Therefore, we distinguish two main classes of organizational capabilities: Dynamic capabilities and operational capabilities [23, 24]. Operational capabilities, also described as ordinary [16] or zero-level capabilities [17], encompass the operational function of a firm and enable the value proposition of a business model [22]. They are responsible for the execution of daily business operations and can be described as "how you earn your living" capabilities [17, 22]. In contrast, dynamic capabilities represent “how you change your operational routines” capabilities [22].

2.3 Dynamic Capabilities as Antecedents of Business Model Innovation

Several scholars regard dynamic capabilities as internal antecedents and drivers of BMI processes [8, 25]. Dynamic capabilities are integral to BMI as they enable firms to design and implement effective new business models [20, 25]. In addition, BMI requires strong dynamic capabilities as it involves a complex process of organizational and strategic renewal [19]. Besides strong sensing capabilities to realize the need for change, seizing capabilities are required for the modification and redesign of existing business models [19]. However, Leih, Linden and Teece [19] argue that capabilities for organizational reconfiguration and actual implementation of the business model are most critical, as BMI processes affect organizational boundaries, internal structures, and even company culture. Several authors build on the dynamic capabilities framework to advance theory on enabling capabilities. Mezger [18] conceptualizes BMI itself as a “distinct dynamic capability” and identifies corresponding organizational routines and processes. He uses the original framework by Teece [20] to disaggregate BMI dynamic capability into the dimensions of sensing, seizing, and reconfiguring capabilities. Thereby, “business model sensing” capabilities enable opportunity recognition by monitoring competition, market developments, and changes in industry-wide business models [18]. “Technology sensing” capabilities allow for a systematic assessment of technological possibilities and the exploration of new ideas. Seizing capabilities comprise innovation activities for the design and configuration of business models. Actual business model implementation is realized by reconfiguring capabilities that facilitate the realignment of operational capabilities and resources [18].

3 Methodology

We apply an exploratory, qualitative research design based on interviews with knowledgeable experts from the field to explore and describe the phenomenon of IoT-enabled BMI. We argue that the complex and highly context-specific nature of organizational capabilities is well-suited for the use of qualitative research methods. This approach allows us to generate rich theoretical insights from complex organizational decisions and processes. Further, the present study draws on evidence from multiple organizations to include several perspectives on the researched phenomenon. In the following, we describe our approaches for data collection and analysis in more detail.

3.1 Empirical setting

Regarding our industry interviews, we apply an industry focus on German small and middle sized enterprises (SMEs) in machinery and plant engineering to control for industry, regional, and strategic context [18]. The German industry is characterized by many highly specialized SMEs that contribute large economic value. Although many of the firms are global market leaders in specific segments, their positions are threatened by ongoing commoditization of machinery and by new competition arising from outside of the traditional manufacturing industry [26]. Thereby, most SMEs in machinery and plant engineering represent typical product-oriented manufacturers that are now challenged to innovate their business models [13, 26]. In addition, SMEs are likely to possess fewer resources as compared to industrial giants such as GE. Thus, they might lack sufficient capacities to react to technological change appropriately. The European Commission defines SMEs based on staff headcount and either turnover, or balance sheet total [27]. Thereby, a company qualifies as SME if it does not have more than 249 employees and its annual turnover does not exceed 50 Million €. However, many firms of the so-called "Mittelstand" in German machinery and plant engineering do not meet these requirements. Therefore, we apply the broader definition of SMEs provided by the Institute for SME research in Bonn to our company sample. Consequently, we also consider companies where the majority of company shares is hold by up to two natural person or their family members, given that these shareholders are active in the executive board [28].

We use theoretical sampling [29] to identify appropriate organizations for the empirical analysis. The objective of the selection process was to identify SMEs in the industry that already engage in IoT-enabled BMI and that experience the related transformation towards product-service combinations. We conducted an online search, using information from industry association websites and trade journals, to identify promising manufacturers for our research approach. We then gathered more specific information on single companies based on their corporate websites, product and service portfolios, and related press articles. In total, we contacted 50 individuals of 37 different companies, from which 17 executives replied. Some of them declined participation due to reasons of confidentiality, time pressure, or lack of experience. Eventually, we were able to schedule interviews with representatives from seven different SMEs. Our sample comprises six machine manufacturers and one electrical component supplier. All SMEs are headquartered in Germany but are present on international markets and often conduct global operations.

3.2 Data collection and analysis

In total, we conducted eight qualitative interviews with industry experts on IoT-enabled BMI. Seven interviews represent conversations with representatives of manufacturing firms. Thereby, we performed one interview per organization with each one executive. Moreover, we conducted one additional interview with an industry expert from a renowned research institution at the beginning of the data collection process. The interview was not firm-specific and rather explorative. We used the insights to generate a first understanding of IoT-enabled BMI in machinery and plant engineering and to further refine our interview guideline. **Table 1** represents an overview of all conducted interviews and the respective interview partners. Thereby, all interviewees were required to have at least three years of industry or research experience and, in the case of manufacturing organizations, to hold a managing position, preferably senior management, in research and development, business development, or product and innovation management.

Table 1. Overview of interviewed experts (M = manufacturing organization; R = research institution)

ID	*Expert role*	*Business sector*	*Founding year*	*Number of employees*	*Sales turnover*
M1	Head of Business Development	Packaging machinery and solutions	1869	2.500	€ 835 Million (2017)
M2	Senior Business Development Manager	Packaging machinery and solutions	1922	2.250	€ 350 Million (2017)
M3	Head of Product Engineering	Raw material processing and recycling machinery	1969	400	€ 100 Million (2017)
M4	Chief Information Officer	Environmental simulation and welding machinery	1913	8.200	€ 1,2 Billion (2017)
M5	Head of Digitalization	Packaging machinery and solutions	1961	5.065	€ 1 Billion (2017)
M6	Head of Machinery Solutions	Electrical component supplier	1850	4.700	€ 740 Million (2017)
M7	Head of Process Engineering	Water processing and machinery	1989	220	€ 19 Million (2016)
R1	Research Expert on Digital BMI	Research institution	1995	25.000	n/a

The interviews were recorded and transcribed afterwards. We used Qualitative Content Analysis as introduced by Mayring [30] to evaluate the transcribed expert interviews. While the initial categories were derived directly from the text basis using an open coding approach, we developed the main categories in close relation with existing theory on organizational BMI capabilities [18]. Challenges encountered by the organization on their way to IoT-enabled BMI constitute the basis of our category system. Thereby, a challenge comprises a situation that is described as being problematic and relatively new to the firm. Moreover, it cannot be solved with existing organizational processes, but requires management attention and dedicated investments. In addition, the challenge must not be firm-specific but can be transferred to the context of other organizations. The coding itself was conducted separately for each case study in order to allow for within-case analysis before aggregating the results. We then used existing literature on organizational capabilities to develop main categories for the identified challenges. The main categories group similar findings and allow us to identify critical capabilities for IoT-enabled BMI.

4 Organizational Capabilities for IoT-enabled BMI

We propose a conceptualization of IoT-enabled BMI organizational capabilities to link our findings to extant literature. We apply the lens of dynamic and operational

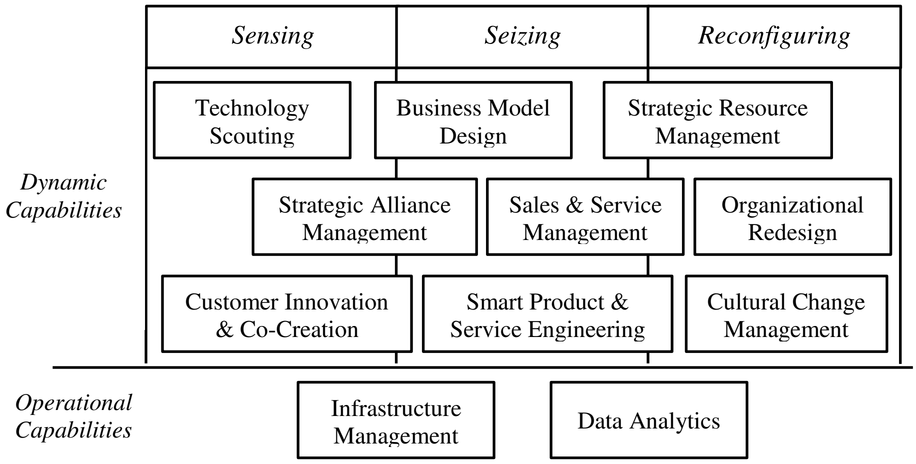

Figure 1. Conceptualized organizational capabilities for IoT-enabled BMI

capabilities to interpret our findings and group them according to the three dimensions of sensing, seizing, and reconfiguring dynamic capabilities [20]. Moreover, we use the concepts of dynamic and operational capabilities to distinguish between different types of organizational capabilities and the level of hierarchy on which they operate. Figure 1 presents our theoretical model that integrates the empirical findings into existing theory on BMI capabilities. We do not interpret the identified dynamic capabilities as purely sensing, seizing, or reconfiguring since they are often based on intertwined processes that relate to more than one capability dimension. Therefore, we interpret the three dimensions rather as a continuum and allocate identified dynamic capabilities in accordance to their main function and purpose. Furthermore, the model does not imply a strict chronological order. Although sensing capabilities are clearly needed at the beginning of the innovation process, the process of BMI is of iterative nature [2].

(1) Technology Scouting: A key challenge described by interviewees from all organizations in our sample is the understanding of IoT as a technology itself. Moreover, companies need to track the trends in technology development and assess the potentials of current IoT technologies. They first need to identify and then test appropriate solutions for the implementation within the own business environment:

> *"To a certain degree we are confronted with a real flood of suppliers. […] Consequently, there are incredibly many service providers and suppliers of IoT technologies that are entering the market. And […] it is a big challenge to […] identify the right technologies that are appropriate for the own use case."* (M5)

This underlines that without a critical assessment at the beginning of the BMI process, companies will not be able to fully leverage the potential of IoT technologies and establish them at the foundation of their new business models. The capability "technology scouting" guides the evaluation process and increase the overall understanding of the technology itself.
(2) Infrastructure Management: Another challenge is the establishment of infrastructure that enables interconnection. Manufacturers need to install the required sensor technology on the machinery and establish network connections. Thereby, data and network security are highly important and need to be assured at all time:

"*Usually, our clients have their internal networks which are secured and protected. This is a major topic nowadays. Network security. But you have to access these networks. You have to access the client's network from the outside to do your job and this a major technical challenge"* (M7)

This also includes important decisions with regards to infrastructure for data storage, data processing, and data utilization. Many SMEs in machinery and plant engineering have no or little experience when it comes to sensor technology and IT security. Therefore, Infrastructure Management represents a critical IoT-enabled BMI capability. It encompasses the ability to establish and manage the required IoT-infrastructure for data generation and data-based value creation.
(3) Data Analytics is another organizational capability that is required to address the challenge of IoT technology as an enabler of BMI. It constitutes the capability to generate customer value from machine and process data, and to develop related software applications for data-based services. Therefore, organizations need to expand their existing skills in software engineering and build up critical expertise in areas such as big data or data science:

"I believe that one challenge that many companies face is to extensively collect data, to retrieve this data, to analyze it, and to draw the right conclusions in order to generate value for customers and for themselves." (M3)

(4) Business Model Design: Besides technology-related capabilities to implement IoT technologies as the necessary foundation, actual business model design is a key challenge. Organizations need to map business opportunities and define the corresponding use cases. This includes the design of new value propositions to meet emerging customer demands and to clearly segment existing and potentially new customer groups. Altogether, business model design depends on entrepreneurial processes which enable the exploration of new value propositions. Key decision makers need to promote the idea of recurring revenues and design appropriate revenue models. We therefore propose the organizational capability of Business Model Design that enables the organization to identify IoT-enabled value propositions and to design the corresponding BM. The capability is based on a systematic process for the exploration of new value opportunities and use cases. It is required to challenge the existing

business models and to implement a systematic and strategic approach towards business model design:

"*Well, everyone has already heard at one point about leasing or predictive maintenance. But to systematically list 80 different business models and to analyze what fits to our company, that has not happened in the beginning. It was all very casual and rather informal"* (M1)

(5) Strategic Resource Management: The implementation of IoT-enabled BMI and the development of related organizational capabilities depends largely on the right resource endowments. Companies that engage in IoT-enabled BMI need to identify critical know-how and develop it within the organization:

"*I also think that we should develop a lot of these competencies internally and not source them from the outside. Because at the moment it is quite difficult to foresee which competencies will be most critical for our future business."* (M6)

This also emphasizes the need for qualified employees. Many organizations are highly dependent on specialists that bring required know-how into the organization. Several companies in our sample have mentioned challenges with regards to the location of their headquarters that are often situated in rural areas. Besides the lack of know-how, the allocation of resources to innovation-related activities in addition to the current operations represents a key challenge, especially because most of the companies from our sample face exceptional good order positions and are working at full capacity. Our proposed capability allows companies to manage internal competition for resources and to pursue BMI activities without affecting ongoing operations negatively. Moreover, it encompasses the ability to identify areas of expertise that are best developed internally in order to gain competitive advantage in the long run.

(6) Customer Innovation & Co-Creation: Customer relations represent another main challenge faced by our sample organizations. On the one hand, industrial manufacturers require a certain level of openness to collaborate with customers and consider their input for product and service innovation. They need to understand the value of such co-innovation and establish the processes for collaborative innovation. However, this often contradicts the traditional mindset of SMEs in machinery and plant engineering. Many organizations have been very critical towards open innovation in the past and now face difficulties to open themselves and promote a new understanding of their clients as valuable business partners:

"We agree that it is important to understand customers more as partners. In my opinion that is inevitable for the survival in global competition." (M3)

(7) Sales & Service Management: Our interviewees have pointed out the necessity to adapt existing marketing and sales processes. They need to create new ways on how to approach the client in order to demonstrate the value of data-based IoT services. The responsible sales teams need to understand the business value arising from software

applications as well as smart services and integrate the idea of recurring revenues in contrast to onetime sales. They also have to convince clients of the new value proposition and overcome customer concerns with regards to data privacy:

"Consequently, we have to change the way we approach our clients and how we are selling our solutions. So far, our machinery has never been online. We sold pure offline machinery that is usually located at […] storages at client site […]. This has never been an issue for them. Actually, they are very sensitive when it comes to external data and network connections, especially data sharing." (M5)

Moreover, the sales system needs to internalize a new understanding of services and digital products. In accordance with new revenue models, a shift from a product-centric towards a service-centric sales system might be required. We propose IoT Sales & Service Management as another capability to address the challenges at the front end of the IoT business model. This capability allows to market IoT-enabled products and services appropriately by reconfiguring established sales processes and by designing appropriate IoT sales and service strategies.

(8) Strategic Alliance Management: Many traditional manufacturers in machinery and plant engineering have only recently started to engage in open discussions on market and technological developments. In fact, some of them have never built on external solutions before to realize their product offerings. That is why they need to promote an integral organizational openness towards external collaboration:

"I am convinced that only those companies will succeed in IoT-enabled BMI that engage in strategic alliances. This means to cooperate with others along the value chain, with regards to data usage and data processing, if necessary with competitors […]. Only if these networks are created, which by the way is totally untypical for German machinery and plant engineering, […] success […] will be possible." (M1)

We propose that organizations need to develop Strategic Alliance Management capabilities to collaborate with external partners and networks in order to complement their existing capabilities. Moreover, they need to establish organizational processes that help to identify potential partners and to build up strategic alliances.

(9) Smart Product & Service Engineering: The value creation itself represents another major challenge. IoT-enabled BMI affects existing product innovation processes that so far are mainly oriented towards the development of physical products and add-on services such as repair and maintenance. Established product engineering processes are often not appropriate for the development of smart, digital products. Moreover, companies need to develop and implement a new understanding of a value creation that is based on machine and process data:

"Many organizations have no experience when it comes to data-based services. […] For example, if you do not sell machinery anymore but provide operator models you have to abandon the idea of onetime sales and implement processes for lifecycle-

services and recurring revenues. But this requires a huge shift in mindset with regards to value creation." (R1)

Therefore, we propose Smart Product & Service Engineering as an essential organizational capability for IoT-enabled BMI. It enables the organization to redesign existing product and service engineering processes and to develop smart products and smart services for data-based value creation.

(10) Organizational Redesign: Both scope and complexity of the organizational implementation of IoT-enabled BMI represent major challenges for our sample companies. Besides the necessity to redesign many critical organizational processes, nearly all organizational departments are affected by business model change. This emphasizes the need for a comprehensive transformation process that incorporates all organizational departments. Such complexity of implementation likely overwhelms traditional industrial manufactures:

"Another point is that we realized that the whole topic around digitalization, transformation, changing market requirements, and organizational culture involves such high complexity that we feel overwhelmed and that very likely we are not able to cope with this transformation on our own, organically." (M2)

Although all of the identified organizational capabilities enable organizations to reconfigure organizational processes, we propose a distinct capability of Organizational Redesign that allows to reconfigure organizational structures and support processes as well as to reallocate responsibilities to organizational units.

(11) Cultural Change Management: Many of the above-mentioned challenges and capabilities already point out the importance of a change in organizational mindset. Thereby, organizations not only need to challenge their existing business models, but also need to realize the importance of change in the first place. Despite current favorable market conditions, they need to take notice of the developments in the industry and raise overall awareness and openness towards change:

"It is also a very comfortable position to just say and acknowledge something could happen. I mean our order books are so full and the situation at the moment is just heavenly." (M4)

Organizations need to develop a certain organizational mindset that allows them to observe changes in market and technology and to initiate first actions. We therefore propose Cultural Change Management as an organizational capability that enables manufacturers to induce and manage cultural change throughout the organization. Thereby, it promotes a culture that values exploration and raises the openness towards IoT-enabled BMI.

5 Discussion, Contributions, and Limitations

The findings from our qualitative study support our understanding of dynamic capabilities derived from existing literature. They encompass a collective activity that enables organizations to systematically modify its operating routines [31]. We also find evidence for the key role of top management in the reconfiguration process [32]. Moreover, the empirical findings show the importance of sensing, seizing, and reconfiguring dynamic capabilities for IoT-enabled BMI [20]. In order to cope with technological change such as the emergence of IoT technologies, organizations need to reconfigure their existing resources as well as operational capabilities and establish new organizational processes [7]. Several of our identified capabilities could also be applied to general BMI (e.g., Business Model Design or Technology Scouting) or to data-driven BMI (e.g. Data Analytics), i.e., BMI based purely on the use of data analytics. However, capabilities such as Smart Product & Service Engineering go beyond the mere collection and analysis of data. While data-driven business models focus on "acquisition of data, its subsequent aggregation, the analysis of data […], and actions that are triggered" [33], we argue that IoT-enabled business models can be interpreted as an instance of data-driven business models that focus on more specific aspects such as enriching physical products with digital services [1]. However, future research could further explore how IoT-enabled BMI differs from more general data-driven BMI.

Our study contributes to literature on dynamic capabilities to advance theory on enabling factors in BMI [8]. Thereby, our set of organizational capabilities confirms the relevance of previously identified dimensions of dynamic capabilities in BMI research. Furthermore, we reduce the abstractness of the dynamic capabilities framework [5] by analyzing the underlying processes and providing a conceptualization of concrete capabilities.

The proposed findings have several important implications for industry practice and managerial decisions. In essence, SMEs are required to undertake a systematic assessment of their existing organizational capabilities and to define a set of capabilities required for their individual BMI aspirations. Key decision makers in the organization need to realize the need for change and interpret the value opportunities of IoT technology accordingly. IoT-enabled BMI very likely affects the entire organization and requires organizational redesign and restructuring. One key insight for managers is the necessity of cultural change. Leadership needs to promote an overall organizational openness towards external exploration and to overcome traditional thinking. Overall, we believe that our conceptualization of capabilities assists practicing managers in making informed decisions about the required investments in capability development and in reflecting on IoT-enabled BMI in general. Thereby, the practical implications are not limited to SMEs in machinery and plant engineering.

Our findings are not free from limitations. First, our model does not represent a complete set of capabilities and several capabilities might overlap to some degree or depend on each other (for example Organizational Redesign and Cultural Change Management). Organizational capabilities are highly context-dependent, and every incumbent firm faces different capability endowments [16]. Therefore, there is no definite set of key capabilities and our findings need to be interpreted within the given organizational context of a firm. Although we propose that our proposed capabilities lead to successful IoT-enabled BMI, we do not measure the interrelation with firm performance nor do we provide any evidence of a positive effect of the realization of our capabilities on actual BMI implementation. In fact, we argue that a capability-based conceptualization of IoT-enabled BMI alone cannot explain successful IoT-enabled BMI and superior performance since many factors need to be taken into account for an analysis of firm performance [16]. Furthermore, while exploratory, qualitative research approaches offer great potential to add new perspectives and extend existing theory, our relatively small expert sample limits the generalizability of the findings [29].

As mentioned in section 3.1, our empirical settings is focused on German SMEs in machinery and plant engineering in order to control for industry, regional, and strategic context. Furthermore, we believe that these SMEs are, due to their limited resources, under high pressure to build up relevant capabilities and thus represent an interesting context for our study. On the other hand, our identified capabilities could also be specific to SMEs in our chosen context while capabilities for large corporations or companies in other regions could be different. Strategic Alliance Management, for example, could be less critical for large corporations due to their extensive sets of existing resources. We regard our results as a first step towards an exhaustive conceptualization of capabilities for IoT-enabled BMI and invite other researchers to verify, extend, or adjust our set of capabilities by replicating our study in different contexts.

6 Conclusion and Opportunities for Future Research

The emergence of IoT technologies brings along new business opportunities in industrial manufacturing. However, IoT-enabled BMI constitutes a highly complex transformation process and implicates severe challenges [6]. Thus, the main purpose of this paper is to advance research on organizational capabilities that are required to master the challenges of IoT-enabled BMI. We identify several dynamic and operational capabilities that represent enablers of IoT-enabled BMI. Overall, organizations are required to assess their existing capability endowment and strategically invest in IoT-enabled BMI capabilities to seize the value opportunities of the Internet of Things in industrial manufacturing. Thereby, our empirical findings contribute to understanding key enablers and antecedents in BMI [25]. Finally, they outline a promising field for future research on IoT-enabled BMI.

IoT-enabled BMI in industrial manufacturing offers a promising area for future research in both information systems and strategic management literature. Especially the concepts of BMI and dynamic capabilities require additional empirical studies to advance existing conceptualization and overall understanding. While we present a rather aggregated view on different capabilities, future studies could focus on distinct capabilities and analyze underlying processes and resources in detail.

Furthermore, future research could include large-scale, empirical studies with longitudinal design. Such studies would allow observing the entire process of IoT-enabled BMI and could provide important insights on performance outcomes and the interrelation of different organizational capabilities. In addition, studies applying a retrospective analysis on success cases could provide interesting benchmarks and contribute to a comprehensive understanding of IoT-enabled BMI.

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