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# APPROACHING DIGITAL TRANSFORMATION – DEVELOPMENT OF A MULTI-DIMENSIONAL MATURITY MODEL

*Research paper*

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## Abstract

*Driven by the ever-faster emergence and adoption of digital technologies, digitalization affects almost every organization. Especially for organizations in the manufacturing industry, the development from traditional manufacturers of physical products to providers of individual digital service solutions entails massive changes on all organizational levels, e.g., infrastructure and business model. Despite growing awareness about the importance of digital transformation, scientific and professional literature mostly focuses on select aspects. Yet, an approach for structuring DT in the manufacturing industry that provides an integrated view on various organizational levels is missing. Hence, managers still struggle to transform their organizations in a structured way. Against this backdrop, we develop a maturity model to support organizational stakeholders in addressing digital transformation along various organizational levels. Based on design science research principles, we deductively and inductively derive six focus areas, 26 dimensions, and associated capabilities. To revise and evaluate our model, we conduct evaluation rounds with researchers and industry experts. Our contribution is twofold: From an academic perspective, we add to the descriptive knowledge of digital transformation. For practitioners, we provide a profound basis for the development of a digital transformation strategy by enabling the determination of an organization's current situation and desired target state.*

*Keywords: Digital Transformation, Digital Transformation Strategy, Manufacturing, Organizational Transformation, Maturity Model.*

## 1 Introduction

Digital Transformation (DT) is primarily driven by the fast emergence and adoption of digital technologies such as the Internet of Things, artificial intelligence, or cloud computing (Gimpel et al., 2018). These technologies enable organizations to create novel business models and to achieve competitive advantage (Iansiti and Lakhani, 2017; Ross et al., 2017). Due to ever-shorter innovation cycles and growing competitive pressure, organizations are increasingly forced to exploit the full potential of these digital technologies (Ismail et al., 2018). As a result, organizations must transform themselves as a whole, i.e., their organizational structures, processes, work approaches, and culture (Gimpel et al., 2018). This multi-dimensional transformation is referred to as DT (Hinings et al., 2018).

The pressure to change is recognized by organizations across all industries. In fact, organizations invested $1.2 trillion in DT activities in 2019 (IDC, 2019). In particular, organizations from the manufacturing industry recognize this need as they are ranked first among all industries, accounting for $222 billion of these expenses (IDC, 2019). However, DT proves to be a complex endeavour for organizations from the manufacturing industry (Govindarajan and Immelt, 2019; Urbach and Röglinger, 2019) since

they need to develop from traditional manufacturers of physical products to providers of individual service solutions (Govindarajan and Immelt, 2019; Lerch and Gotsch, 2014). Furthermore, they need to evolve from product-centred to customer-oriented organizations to stay competitive (Buschmeyer et al., 2016). Furthermore, they need to master the integration of short-term implications of digital technologies and long-term investments for their manufacturing infrastructure as their physical product will remain part of their offering to the customer (Piccinini et al., 2015b). Also, they need to master a cultural change to reconcile a zero-error-attitude for physical products with an agile trial-and-error mindset for the development of digital innovations (Vogelsang et al., 2019).

The Ford Motor Company is a prominent example that the success of this DT endeavour cannot be taken for granted. Their aspiration to become a smart mobility provider in 2014 failed primarily since they neglected to align their DT efforts with their traditional manufacturing business (Morgan, 2019). This case is not an exception. On average 28% of organizations' revenue (for organizations with more than $7 billion revenue even 46%) is at stake within in the next five years, because organizations still struggle with DT (Davenport and Westerman, 2018; Weill and Woerner, 2018). One major reason is that organizations such as Procter & Gamble often lose sight of their actual stable business model in their desire to become the most digital organization on the planet (Davenport and Westerman, 2018). However, DT is not just about the integration of technology but also involves organizational and cultural changes (Davenport and Westerman, 2018). Overall, experts estimate that 70% of DT projects do not deliver the desired outcome (Libert et al., 2016; Tabrizi et al., 2019), as most organizational leaders struggle to completely understand the impact of DT (Berghaus and Back, 2017). Furthermore, they lack a clear vision of their transformed organization (Kane et al., 2016). While digital mature organizations have a DT strategy and leverage technologies to change the way they do business, struggling organizations focus on the short-term implementation of individual technologies (Kane et al., 2015). Thus, the absence of a DT strategy is a common cause for failure (Onay et al., 2018), which entails, inter alia, projects that do not contribute to the desired target state, inefficient usage of investments, or an increasing transformation project backlog (Sebastian et al., 2017). Accordingly, organizations need a DT strategy that addresses all organizational aspects and creates an organization-wide shared common understanding of DT (Onay et al., 2018).

Hence, there have been calls from research and practice to structure the field of DT (Bordeleau and Felden, 2019). Various research approaches discuss the development of DT strategies (Chanias, 2017; Hess et al., 2016; Matt et al., 2015). Other scientific approaches derive action fields (Gimpel et al., 2018; Gimpel and Röglinger, 2017), success factors (Holotiuk and Beimborn, 2017), or challenges (Heavin and Power, 2018; Piccinini et al., 2015b) that organizations need to consider during their DT. Another research stream provides Maturity Models (MM) that outline a development path towards a desired target state (Berghaus and Back, 2016a; Klötzer and Pflaum, 2017; Lichtblau et al., 2015; Schuh et al., 2017; Schumacher et al., 2019). In contrast, professional literature provides various frameworks that present transformation paths and MMs for affected areas including tools that support organizations in assessing their status quo (Azhari et al., 2014; Gill and van Boskirk, 2016; PWC, 2016; Zimmermann et al., 2015).

Although we appreciate existing approaches, they are either too high-level (Matt et al., 2015), i.e., provide too little detail, or too general, i.e., do not consider industry-related characteristics (Berghaus and Back, 2016a) to deliver necessary insights for organizations in the manufacturing industry. Frameworks that focus on the manufacturing industry are often limited to single dimensions, e.g., IT infrastructure (Borangiu et al., 2019). Even multi-dimensional frameworks for the manufacturing industry are limited to a certain perspective, e.g., they focus on the operational shopfloor level (Leineweber et al., 2018) or take a solely technological lens (Schumacher et al., 2016). Hence, academia lacks an approach for structuring DT in the manufacturing industry that provides an integrated view on various organizational levels. Against this backdrop, we address the following research question:

*How can digital transformation in manufacturing organizations be approached in a structured manner?*

To answer our research question, we follow the well-established procedure model of Becker et al. (2009), which is based on design science research principles (Hevner et al., 2004), to develop a Digital

Transformation Maturity Model (DTMM) as an artefact. We derive our DTMM deductively and inductively by conducting a structured literature review, interviews with industry experts, and focus group discussions. To evaluate our artefact, we draw on the evaluation activities proposed by Sonnenberg and Vom Brocke (2012). Our artefact adds to the descriptive knowledge of DT and serves practitioners as an initial step to approach their DT in a structured manner.

The remainder of this paper is structured in line with the procedure model as per Becker et al. (2009): In Section 2, we provide our theoretical background along with related work *(comparison of related MMs*). Section 3 describes our research methodology *(determination of the development strategy* and *iterative MM development process)*. In Section 4, we present the DTMM as the core of our work. Our evaluation activities are presented in Section 5. In Section 6, we summarize our results and contribution, with an outlook on future research.

## 2 Theoretical Background and Related Work

While digitalization can be referred to the adoption of digital technologies (Berger et al., 2018; Legner et al., 2017), DT entails the "combined effects of several digital innovations bringing about novel actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace or complement existing rules of the game within organizations, ecosystems, industries or fields" (Hinings et al., 2018). As we focus on the effects that concern particular organizations, we define DT as organizational transformation that describes a paradigmatic shift in terms of a multi-dimensional change, which affects, inter alia, customer experience, business models, operational processes, and organizational structures (Chanias et al., 2019; Gimpel et al., 2018; Hess et al., 2016; Morakanyane et al., 2017; Warner and Wäger, 2019) due to digital innovations in the organization's ecosystem and related industries.

Following this definition, the aim of DT is not solely to implement cutting-edge technologies but to become digital mature, i.e., adopting structures, practices, values, and beliefs that help organizations to thrive in an increasingly digital environment (Kane, 2017a). Accordingly, DT is about the organizational response to digital trends, whereby more digital does not necessarily mean better (Grover and Kohli, 2013; Kane et al., 2015). Accordingly, the introduction of digital technologies is neither the only nor the most important dimension of DT (Kane, 2017a). In opposition to established concepts like business transformation and organizational turnarounds, DT describes a gradual and continuous process that may never end due to the ever-faster and ongoing changes in digitalisation and the business environment (Gimpel et al., 2018; Kane, 2017a). Consequently, digital maturity describes a desirable vision, which can never be completely achieved (Kane, 2017a).

Organizations strive for digital maturity because immaturity contributes to the risk of digital disruption. The identification of relevant dimensions of DT (Hess et al., 2016) and corresponding organizational capabilities (Vial, 2019) represents a first step and necessary prerequisite to increase digital maturity. We refer to capabilities as an organization's ability to perform tasks and utilize resources that support their adaption to dynamic markets (Hatum et al., 2010; Helfat and Peteraf, 2003; Henriette et al., 2016; Kane, 2017a; Teece, 2007), e.g., by strengthening their innovativeness through reinforced entrepreneurial thinking (Berghaus and Back, 2017). Based on these dimensions and capabilities, organizations need to develop a system of aligned activities (Berghaus and Back, 2017; Kane et al., 2016) such as the definition of a future target state and the derivation of strategies to reach that state (Andriole, 2017; Kane et al., 2015). A DT strategy supports organizations to identify promising activities and also facilitates their prioritization and implementation through resource allocation (Matt et al., 2015; Yeow et al., 2018).

Well-established IT strategies cannot be used for DT since their aim is limited to the alignment of digital technologies to business needs. Digital business strategies are also not suitable as they neglect organizational implications to develop and run a digital business (Bharadwaj et al., 2013). DT strategies, in contrast, primarily address the question of how organizations need to transform themselves to stay competitive under consideration of fast emerging digital technologies (Chanias et al., 2019; Hess et al., 2016; Kane et al., 2017b). Matt et al. (2015) state that the DT strategy needs to be aligned with the operational, functional, and corporate strategy. Considering financial aspects, they propose changes in value creation and organizational structure to exploit the full potential of emerging digital technologies. Based on these

insights, Hess et al. (2016) outline different options for the development of a DT strategy concerning technology adoption, e.g., early adopter.

To make digital maturity measurable, Andersen and Ross (2016) and El Sawy et al. (2016) conduct case studies to identify success factors. One of their key findings is that digital leaders do not transform their organizations at once but continuously adjust select action fields to the requirements of the fast-changing environment. To provide a solid foundation for DT in the first place, multiple contributions deal with the identification of affected action fields. Gimpel and Röglinger (2017) distinguish five layers of the enterprise architecture, i.e., business model, processes, people and application systems, data, and infrastructure, which organizations need to transform concerning changes of customer needs and the application of digital technologies. Gimpel et al. (2018) structure DT into six action fields, i.e., customer, value proposition, operations, data, organization, and transformation management. Other works focus on the illumination of select action fields such as customer (Piccinini et al., 2015a; Setia et al., 2013), operational processes and business models (Berman, 2012; Westerman et al., 2014), and people (Bouée, 2015; Singh and Hess, 2017). On a fine-grained level, Warner and Wäger (2019) identify dynamic capabilities that support organizations to master their DT endeavour. Rossmann (2018) describe a digital mature organization by defining eight capability dimensions (e.g., strategy, leadership, and technology) for which they outline underlying items (e.g., executives support the implementation of the digital strategy as an item for leadership). Although the presented approaches elaborate on DT from different perspectives, they lack an integrated view that supports organizations in the manufacturing industry in determining their organization's digital maturity in terms of their status quo and desired target state.

MMs can depict a sequence of discrete levels, i.e., dimensions and capabilities (Poeppelbuss and Röglinger, 2011), that represents an anticipated or desired evolution path from an initial state towards a future target state (Becker et al., 2009). The literature distinguishes between descriptive (assessing status quo and deriving future target state), comparative (benchmarking), and prescriptive MMs (enabling the development of a roadmap) (Bruin et al., 2005). Thereby, MMs measure and guide an organization's continuous improvement of different organizational resources such as technology, processes, or people in a specific domain (Poeppelbuss et al., 2011). Commonly accepted assumptions of MMs are that transformation paths emerge linearly and maturity rises with increasing capabilities (Becker et al., 2009). While some publications explicitly state that one capability is superior to another, the process of maturation can also be defined as the development towards the better (Poeppelbuss et al., 2011).

In the IS domain, several MMs deal with DT: Berghaus and Back (2016a) examine DT from an organizational perspective and describe eight dimensions (e.g., strategy, organization, and customer experience) and 25 underlying sub-dimensions (e.g., digital commitment and strategic innovation as sub-dimensions of strategy). In contrast to competing MMs, they do not outline predefined maturity levels but assign them through cluster analysis. Azhari et al. (2014) define eight dimensions along with five general maturity levels that mostly address similar aspects like Berghaus and Back (2016a). For each dimension, they describe the target state of a completely transformed organization. Other MMs explicitly address DT in the context of manufacturing and focus on select topics such as products (Anderl and Fleischer, 2015), production (Anderl and Fleischer, 2015; Sjödin et al., 2018; Weber et al., 2017), logistics (Sternad et al., 2018), and organizational aspects (Canetta et al., 2018; Fettig et al., 2018). Klötzer and Pflaum (2017) present two distinct multi-dimensional MMs for the DT of internal operations and value creation to customers. Schumacher et al. (2019) structure DT into nine dimensions (e.g., technology and products) along with underlying maturity items (e.g., utilization of additive manufacturing) and integrate their MM into a procedure model towards digitalization in the manufacturing industry. With a focus on cultural aspects, Schuh et al. (2017) provide a multi-dimensional MM towards a learning and agile organization. Besides technology, Leineweber et al. (2018) also address cultural aspects concerning the organization and the employees. Although we do not question the value of these contributions, the majority lacks details about the applied research methodology. Also, they often do not present details about maturity levels. Even though MMs are a valid approach to support organizations in their DT, none of the identified MMs provides a structured and integrated view on various organizational levels that supports organizations from the manufacturing industry in their DT.

Hence, organizational leaders in the manufacturing industry still struggle to structure DT and, thus, often fail to develop successful DT strategies. Although implications are intensively discussed in the literature, the field of DT remains opaque. Academia still lacks a framework that provides an integrated view along various organizational levels for organizations in the manufacturing industry. To address this knowledge gap, we develop a multi-dimensional MM, which provides structure and support for stakeholders to determine their organization's status quo and future target state regarding DT. Based on that, our DTMM may serve as a foundation for the development of a DT strategy.

# 3 Research Methodology

In this work, we apply the design science research paradigm, which is established and well-accepted in IS research (Hevner et al., 2004; March and Smith, 1995). In contrast to other research approaches, design science research provides a rigour research methodology for the development of novel artefacts that aim to support users and organizations (Hevner et al., 2004; March and Smith, 1995). To develop our DTMM, we follow the procedure model as per Becker et al. (2009). To evaluate our artefact, we follow the evaluation activities as per Sonnenberg and Vom Brocke (2012), which comprise four steps (EVAL1 to EVAL4): EVAL1 aims to ensure the novelty and importance of the research problem. EVAL2 aims to validate the design specification of the artefact. EVAL3 strives to test the performance of the artefact in an artificial setting. EVAL4 requires validating instantiations in naturalistic settings. Following a structured research process and performing continuous evaluation activities, we ensure the rigorous development and evaluation of a viable MM (Poeppelbuss and Röglinger, 2011). The applied procedure model includes eight steps (Figure 1):

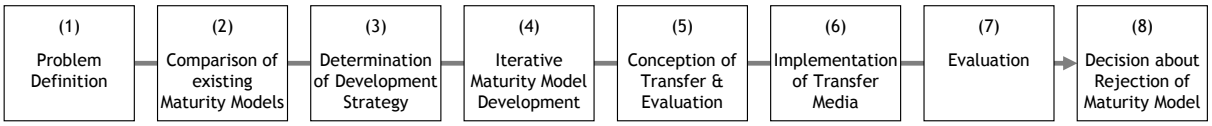


*Figure 1. Maturity Model Procedure as per Becker et al. (2009)*

The *(1) problem definition* comprises the determination of the application area and the problem relevance. The second step requires the *(2) comparison of existing MMs* to outline the relevance for the development of a MM by pointing towards a research gap in existing publications. The third step comprises the *(3) determination of the development strategy* and its documentation. Thereby, Becker et al. (2009) differentiate between four strategies, i.e., design of new model design, enhancement of an existing model, a combination of models to form a new one, and the transfer of existing models to new application domains (Becker et al., 2009). The central step of the procedure model comprises the *(4) iterative MM development*. The *(5) conception of transfer and evaluation* includes the evaluation of the model and defines how to make the MM accessible for intended users. Within the *(6) implementation of the transfer media,* the MM is made accessible to defined user groups in an appropriate way. Based on the application of the MM, the *(7) evaluation* examines whether the MM delivers the aspired solution of the problem (Becker et al., 2009). Based on the evaluation, the *(8) decision about the rejection of the MM* is conducted.

We focus on step 1 to 4, whereas step 5 to 8 will be part of future research. In Section 1 and 2, we outlined the need for an appropriate DTMM, i.e., *(1) problem definition*, and the lack and insufficiency of existing approaches, i.e., *(2) comparison of existing MMs*. Next, we present our development choices and procedure, i.e., *(3) determination of the development strategy* and *(4) iterative MM development*:

As for the *(3) determination of the development strategy,* there exists no MM in literature, which identifies all relevant dimensions for the DT in manufacturing. Hence, we develop a novel, descriptive MM as an artefact based on the insights of existing MMs and additional literature. Instead of defining general maturity levels, we strive for dimension-specific development paths that outline capabilities dedicated to the characteristics of specific dimensions as proposed by van Steenbergen et al. (2010). Therefore, we aim to provide individual insights for the broad range of different organizational dimensions.

In addition to Becker et al. (2009), we thus consider van Steenbergen et al. (2010) within the *(4) iterative MM development* phase, as they provide additional guidance for the development of dimension-specific

development paths. To develop a valid model for research and practice, we use a multi-methodological approach, including literature reviews and expert interviews together with co-author and scientific focus group discussions. For our iterations, we distinguish between a conceptual-to-empirical and empirical-to-conceptual approach (Nickerson et al., 2013). The deductive conceptual-to-empirical approach draws on literature and the researchers' knowledge. In contrast, within the inductive empirical-to-conceptual approach, we consider the practical perspective and adjust the artefact accordingly (Nickerson et al., 2013). Our iterative MM development phase comprises four iterations (Figure 2).

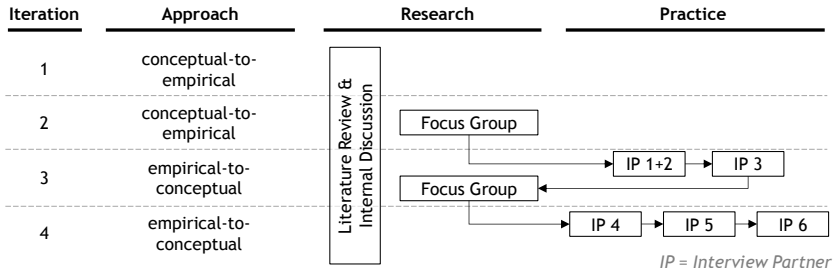


*Figure 2. Iterative Development Process of the Digital Transformation Maturity Model*

In line with van Steenbergen et al. (2010), we deductively derive dimensions within our *first iteration* (conceptual-to-empirical). For this, we conduct a structured literature review to identify frameworks that deal with DT (Table 1). Thereby, the search term *Industry 4.0* comprises technological developments in the context of manufacturing companies, such as the Internet of Things or cyber-physical systems (Lasi et al., 2014). Our search includes abstract, title, and keywords as this search strategy is supposed to deliver contributions focusing on the target topic (Bandara et al., 2011). Although our search string does not exclude frameworks that focus on other industries, e.g., Valdez-de-Leon (2016), we assure that we only consider publications that address in particular the manufacturing industry, e.g., Piccinini et al. (2015b), or provide industry-independent insights, e.g., Matt et al. (2015), within our screening process. To assure a high quality of results, we initially limit our review to journals and conferences proceedings, which are classified at least as 'recognised academic business research journals' within the sections *General Management* and *Business & Information Systems Engineering* of the *VHB JOURQUAL 3*[1]. We exclusively review articles in English and German. Subsequently, we analyse the abstracts of the remaining articles to select those that primarily focus on DT. In the last step, we extend our approach with a forward and backward search of promising articles and conduct a full-text screening to identify those articles that structure DT into different dimensions. This step left us with 17 frameworks from a wide range of different approaches, e.g., literature reviews (Holotiuk and Beimborn, 2017), exploratory interviews and focus group discussions (Berghaus and Back, 2016b), Delphi studies (Piccinini et al., 2015b), case studies (Gimpel et al., 2018), and practitioner-oriented publications (Azhari et al., 2014).

To achieve valid results, we followed the three-step coding approach of Wolfswinkel et al. (2013): (1) We start by extracting an initial list of 342 seminal items that are not distinct and show no uniform level of granularity. Thus, we cluster the initial list of 342 items into dimensions of uniform granularity. (2) To enhance clarity and accessibility, we cluster these dimensions into focus areas. (3) As we supplement our findings with existing frameworks, e.g., Gimpel and Röglinger (2017), we create awareness for the interrelations between the focus areas. We iteratively refine the focus areas and dimensions until we achieve consensus among all co-authors.

| Criterion | Characteristic |
|---|---|
| Databases | Science Direct, EBSCOhost, ProQuest, AIS e-Library |
| Search Field | Title, Abstract, Keywords |
| Search Term | ("Digital Transformation" OR "Digitalization" OR "Digitization" OR "Industry 4.0" OR "Industrie 4.0" OR "Digital Strategy") AND (transformation) |

*Table 1. Criteria of our Structured Literature Review*

[1] Ranking based on the evaluation of the members of the German Academic Association for Business Research

Within our *second iteration*, we strive for deductively deriving capabilities for each identified dimension (conceptual-to-empirical). Therefore, we review MMs that we gathered during the comparison of existing MMs' (overview in Section 2) in addition to the results of our structured literature review, i.e., the 17 frameworks. Whenever this approach does not provide suitable capabilities, we draw on additional knowledge acquired via forward and backward search. To increase the validity of the proposed capabilities, we cross-check our capabilities with other sources. The derivation of capabilities also contributes to the refinement and specification of our dimensions. Furthermore, we discuss our artefact with a focus group of researchers and use the gained insights for revising our artefact. The focus group included one associate professor, seven research assistants, and three students from two different universities. All members shared an IS background. Focus group discussions are an effective method to collect feedback within the development phase of an artefact and to challenge its utility (Tremblay et al., 2010).

To include a practical perspective on DT, we refine our artefact in the course of interviews with industry experts within our *third iteration* (empirical-to-conceptual). Expert interviews collect information from potential users of an artefact (Rowley, 2012). The discussion of our framework helps to refine particular dimensions and capabilities. Table 2 provides details of our Interview Partners (IP), which we ensure to hold a strategic and DT-related position that guarantees an extensive overview of their companies' activities and DT objectives. Therefore, we require experts to have experience with organizational transformation efforts and the digitalization of processes in an interdisciplinary environment. To assure applicability for organizations with various backgrounds, we select experts from organizations that differ in their manufacturing sector, company size, and DT progress. The interviews last about 90 to 120 minutes each and are hosted by at least two co-authors. First, we present the motivation and background of our study. Second, we discuss our model stepwise. Third, we ask for the experts' overall thoughts and discuss particular dimensions and capabilities in detail. After the interviews, we consolidate and integrate the experts' insights into our model. To close the feedback loop, we again consult the same focus group to discuss our artefact's adjustments.

| IP | Job Title | Industry | Employees (2018) | Revenue (2018) |
|---|---|---|---|---|
| 1 | Product Line Director | Automotive | > 110,000 | EUR 17.5 bn. |
| 2 | Director of Global Industrial Strategy | | | |
| 3 | Senior Manager Digitalization | Mechanical Engineering | > 2,300 | EUR 0.5 bn. |
| 4 | Head of Digital Business | Optics and Optoelectronics | > 27,000 | EUR 5.8 bn. |
| 5 | Chief Enterprise Architect | Information Technology | > 32,000 | EUR 4.1 bn. |
| 6 | Chief Technology Officer | Car Wash Manufacturing | > 2,300 | EUR 0.4 bn. |

*Table 2. Details on Industry Experts*

As the *third iteration* still implied major changes, we discuss the DTMM with three industry experts within our *fourth iteration* (empirical-to-conceptual). This iteration leads to only minor changes, i.e., adjustment of the nomenclature. As the four co-authors and the questioned experts agree that the artefact is concise, robust, and comprehensive, we refrain from conducting another iteration and end the development process. To validate the usefulness of our artefact, we include semi-structured questions (Myers and Newman, 2007; Schultze and Avital, 2011) in our interviews, which ask the experts about the applicability of our artefact and also challenge the general approach of our research project. The questions are in line with established evaluation criteria as per Sonnenberg and Vom Brocke (2012). We summarize our evaluation results in Section 5.

# 4 Digital Transformation Maturity Model

In this section, we present our DTMM as the core of our work. Our DTMM consists of focus areas, dimensions, and capabilities, which help organizations to identify necessary structural changes and changes in value creation to successfully perform DT (Matt et al., 2015). We present our results as follows: Firstly, we describe the overarching structure of our DTMM and explain how to read it. Secondly, we describe each focus area and associated dimensions in detail. To provide a high-level structure for DT dimensions, we analyse extant frameworks and architectures which describe organizational levels. We follow Gimpel and Röglinger (2017) to illustrate six focus areas and their relations (Figure 3):

To exploit the full potential of digital technologies, organizations need to adjust their *Infrastructure* and develop capabilities to leverage the growing amount of *Data*. Corresponding changes affect organizations' *People & Culture* and offer opportunities to improve *Processes*. The adaption of the *Business Model* to *Customer* needs plays a key role for DT.

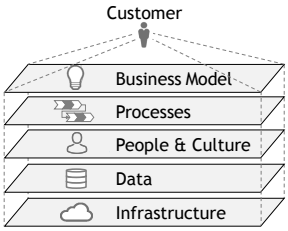


*Figure 3. Focus Areas of the Maturity Model as per Gimpel and Röglinger (2017)*

To face the challenges of today's business environment, organizations need to address all focus areas within an integrated view. Even though organizations can select a specific focus area as a starting point (Berghaus and Back, 2017), the organizational levels are interrelated. Thus, organizations need to introduce an organization-wide transparent and accepted DT strategy (Rossmann, 2018), which is aligned with the organizational purpose and other organizational strategies (Matt et al., 2015). This implies dividing the complex organizational DT as a whole into manageable projects, defining corresponding roles and decision-making processes, and measuring the progress of the transformation process continuously. Considering the purpose of the DTMM, the focus areas are not limited to certain parts of the organization but should take a comprehensive view of the relevant aspects of an organization. For example, *People & Culture* does not only address the human resources department but the organization as a whole.

Our DTMM (Table 3) comprises capabilities for 26 dimensions that are clustered into the six focus areas. For each dimension, we outline the corresponding capabilities. The relevance of a capability depends on the particular context of the application, the organization-specific business strategy, and the underlying business model. Even though none of the capabilities is per se 'better' than another one, the acquisition of capabilities contributes to maturity since organizations have the freedom to choose the most appropriate among their acquired capabilities for a specific context. Accordingly, on the lowest level, organizations possess only the capability that is outlined within the first column. On the second level, organizations have additionally acquired the capability, which is stated within the second column, and so on. The sequence of the capabilities refers to the target of organizations to become more data-driven, agile, and customer-oriented during their DT. To enhance scientific documentation, we outline references that we used to derive the capabilities for each dimension within Table 3 (references stated in italic provide a MM, other references provides different characteristics).

In the following, we provide a brief description of each dimension of a focus area. To foster clarity and readability, we describe the focus areas from technical matters to strategic aspects:

An organization's **Infrastructure** serves as a foundation for organizational structures, processes, and business models. While in the past the focus of IT was to support and maintain the availability of operational processes, today agility, interoperability, and scalability are desirable characteristics of the *IT Architecture* (Bilgeri et al., 2017; Piccinini et al., 2015b). Accordingly, organizations need to replace function-specific legacy systems by service-oriented architectures that are continuously adapted to business needs (Bilgeri et al., 2017; Piccinini et al., 2015b). Implementing cloud platforms and inter-organizational infrastructures raise new challenges for *IT Security*. Since novel business models are built upon data-driven processes, it is crucial to sustain operations and build trust in the organization (Gimpel et al., 2018). Hence, isolated IT security activities may not be sufficient anymore. Organizations need to identify their critical assets, secure their processes end-to-end, and start to consider the security of their infrastructure by design. Since DT is driven and enabled by digital technologies, the corresponding transition of the *IT Department*, i.e., from a functional unit towards an internal service provider, increases organizational agility.

| Focus Area | Dimension | Capabilities | | | | | | References |
|---|---|---|---|---|---|---|---|---|
| Infrastructure | **IT Infrastructure** | Function-specific Infrastructure | Service-oriented Architecture | Cloud Platform | Inter-organizational Infrastructure | | | (Berghaus and Back, *2016b*, 2017; *Colli et al., 2019*; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; *Klötzer and Pflaum, 2017*; Piccinini et al., 2015b; *Schuh et al., 2017*) |
| | **IT Security** | Isolated IT Security Activities | Security of Highly Critical Assets | Security of Processes | Security by Design | | | (D'Arcy et al., 2009; Musman et al., 2011; Purdy, 2010; Regal et al., 2018; Silva et al., 2012; Subashini and Kavitha, 2011) |
| | **IT Department** | Functional IT | Business Integrated IT | IT as Service Provider | IT as Driver of Change | | | (Berghaus and Back, 2016a, 2017; Coltman et al., 2015; El Sawy et al., 2016; Holotiuk and Beimborn, 2017; Klötzer and Pflaum, 2017; Piccinini et al., 2015b; Wheeler, 2002) |
| Data | **Data Collection** | No Collection | Manual Collection | Partially Automated Collection | Fully Automated Collection | | | *(Neff et al., 2014; Schumacher et al., 2019; Schuh et al., 2017)* |
| | **Data Aggregation** | Raw Data | Target Data | Pre-processed Data | Transformed Data | | | *(Fayyad et al., 1996; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; Schuh et al., 2017)* |
| | **Data Analysis** | No Analysis | Descriptive Analysis | Diagnostic Analysis | Predictive Analysis | Prescriptive Analysis | | (Ardolino et al., 2018; Gimpel et al., 2018; Porter and Heppelmann, 2015) |
| | **Data Integration** | No Integration | Partial Integration | Integration with Major Business Entities | Integration with Whole Enterprise | Integration Beyond Enterprise | | *(Colli et al., 2019;* Gimpel et al., 2018*; Neff et al., 2014; Schumacher et al., 2019; Sternad et al., 2018)* |
| People & Culture | **Digital Skills** | No Digital Skills | Recruiting Digital Skills | Educating Digital Skills | Developing Digital Leaders | | | (Berghaus and Back, 2016a; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; Kagermann et al., 2013; Kane et al., 2017b; *Schuh et al., 2017*; Schwarzmüller et al., 2018) |
| | **Workplace Environment** | Desk Space | Meeting and Social Space | Collaborative Space | Spaces beyond the Building | | | (Berghaus and Back, 2016a, *2016b*, 2017; El Sawy et al., 2016; Gimpel et al., 2018; Harris, 2015; Waber et al., 2014) |
| | **Organizational Structure** | Function-oriented hierarchical Structures | Cross-functional Projects | Product-/Process-oriented Organization | Independent, self-organized Teams | | | (Berghaus and Back, *2016b*; Bilgeri et al., 2017; El Sawy et al., 2016; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; Kane et al., 2016; Libert et al., 2016a; Mankins and Garton, 2017; Schwarzmüller et al., 2018; Yoo et al., 2012) |
| | **Innovation Culture** | Inhibition of Innovation | Openness towards Change | Acknowledgement of Experimentation | Aspiration to Improvements | Entrepreneurial Thinking | | (Berghaus and Back, 2016a, *2016b*; Bilgeri et al., 2017; El Sawy et al., 2016; Gimpel et al., 2018; Hartl and Hess, 2017; Holotiuk and Beimborn, 2017; Kane et al., 2015, 2016; Piccinini et al., 2015b) |
| | **Leadership** | Top-Down Governance | Transformational Leadership | Servant Leadership | Coaches & Sponsors | | | (Andriole, 2017; Baldomir and Hood, 2016; Bass, 1990; Berghaus and Back, *2016b*, 2017; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; Hartl and Hess, 2017; Kane et al., 2016; Oldham and Da Silva, 2015; Spreitzer, 1995; Schwarzmüller et al., 2018) |
| Processes | **Process Control** | Instinct-driven Decisions | Data-based Decisions | Autonomous Decisions | | | | (*Colli et al., 2019*; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; Kane et al., 2016*; Klötzer and Pflaum, 2017*; Müller et al., 2018; *Schuh et al., 2017*) |
| | **Production Flexibility** | Rigid Production Systems | Adaptive Production Systems | Component-driven Production | Modular Production across Value-adding Network | | | (*Anderl and Fleischer, 2015*; Gimpel et al., 2018; *Lichtblau et al., 2015*) |
| | **Product Assembly** | Small Proportion of Identical Parts | High Proportion of Identical Parts | Modular Construction of Products | Modular Products | | | (*Anderl and Fleischer, 2015*; Gimpel et al., 2018; Schumacher et al., 2019; *Schuh et al., 2017*) |
| | **Business Processes Flexibility** | Rigid Processes | Flexibility within Individual Processes | Interaction of Processes | Interaction across the Value-adding Network | | | (Gimpel et al., 2018; *Schumacher et al., 2019; Schuh et al., 2017*) |
| | **Inter-organizational Collaboration** | Linear Supply Chain | Provider Network | Partner Network | Digital Ecosystem | | | (Berghaus and Back, 2016a, *2016b*, 2017; Bilgeri et al., 2017; El Sawy et al., 2016; Gimpel et al., 2018; Ibarra et al., 2018; *Klötzer and Pflaum, 2017*; Libert et al., 2016b) |
| Business Model | **Offering** | Product | Standard Service | Novel, additional Services | Product-as-a-Service | Result-as-a-Service | | (*Anderl and Fleischer, 2015*; Bilgeri et al., 2017; Ehret and Wirtz, 2017; Gimpel et al., 2018; Govindarajan and Immelt, 2019; Ibarra et al., 2018; *Klötzer and Pflaum, 2017*; Lerch and Gotsch, 2014; Michalik et al., 2018; *Neff et al., 2014*; Richter et al., 2017; Übelhör, 2019; Weking et al., 2018) |
| | **Pricing Strategy** | (Fixed) one-time Price | Periodic Fee | Usage-based Billing | Performance-based Billing | | | (*Colli et al., 2019*; Ehret and Wirtz, 2017; *Fleisch et al., 2015*; Gassmann et al., 2014; Müller et al., 2018; Rapaccini, 2015; Scherrer et al., 2017; Weking et al., 2018) |
| | **Target Market** | Existing Customers in existing Markets | New Customers in existing Markets | New Customers in additional Markets | Creation of new Markets | | | (Arnold et al., 2017b; Ibarra et al., 2018; Kiel et al., 2017; Weking et al., 2018; Übelhör, 2019) |
| | **Sale Channel** | Traditional Channels | Web-based Channels | Product as Point-of-Sales | | | | (*Fleisch et al., 2015*; Kiel et al., 2017; Poeppelbuss and Durst, 2017; *Schumacher et al., 2019*; Übelhör, 2019) |
| | **Distribution Channel** | Physical Delivery of Product | Physical Delivery of Service | Digital Delivery of Service | | | | (Arnold et al., 2016, 2017a; Fleisch et al., 2015; Lim et al., 2018; Michalik et al., 2018; Mittag et al., 2018; Poeppelbuss and Durst, 2017; Porter and Heppelmann, 2015; Scherrer et al., 2017; *Schumacher et al., 2019*) |
| Customer | **Customer Insights** | No Information | Anonymous Information | Segment-specific Information | Personalized Information | | | (*Berghaus and Back, 2016b*; Gimpel et al., 2018; Westerman et al., 2014) |
| | **Customer Integration** | No Integration | Integration of Feedback | Integration in Early Design Process | Design Process as Co-Creation | Ideation Phase as Co-Creation | Partner-like Collaboration | (Arnold et al., 2016; Exner et al., 2018; *Fleisch et al., 2015*; Holotiuk and Beimborn, 2017; Kiel et al., 2017; Übelhör, 2019) |
| | **Customer Interaction** | Personal Interactive Interaction | Self-Service | Digital, Semi-automated Interaction | Automated Interaction | | | (Beverungen et al., 2019; *Fleisch et al., 2015*; Müller et al., 2018; Scherrer et al., 2017; *Schumacher et al., 2019*; Übelhör, 2019) |
| | **Customer Experience** | Isolated Touchpoints | Aligned Touchpoints | Personalized Experience | | | | (Berghaus and Back, 2016a, *2016b*; Berman, 2012; Bilgeri et al., 2017; Gimpel et al., 2018; Holotiuk and Beimborn, 2017; Müller et al., 2018; Piccinini et al., 2015b; Westerman et al., 2014) |

*Table 3. Digital Transformation Maturity Model*

To exploit the full potential provided by novel digital technologies, the IT Department increasingly needs to act as a driver of change that identifies business needs and implements suitable solutions to solve them (El Sawy et al., 2016).

**Data** is often described as the new currency (Bilgeri et al., 2017) and can be the foundation for value creation and competitive advantages (Bharadwaj et al., 2013; Gimpel et al., 2018). The adoption of digital technologies provides various opportunities for *Data Collection*, which is a key activity for data-driven organizations and business models (Lim et al., 2018). However, since data does not provide any value per se, organizations need to develop additional capabilities (Lim et al., 2018). *Data Aggregation* outlines the steps to acquire valuable knowledge from data (Fayyad et al., 1996). The value of data depends on the kinds of insights organizations derive from *Data Analysis* (Ardolino et al., 2018). While descriptive analysis supports decisions, e.g., via visualization, prescriptive analysis proposes suitable decision alternatives and their corresponding impact. To capture the potential value of data, the acquired knowledge needs to be integrated into processes and decisions. Therefore, *Data Integration* into major business entities or even beyond the enterprise borders, i.e., with partners and customers, improves the planning and execution of decisions (Porter and Heppelmann, 2015).

To leverage digital technologies and the huge amounts of data, organizations need to initiate structural and cultural changes in terms of **People & Culture** (Andersen and Ross, 2016). While the handling of digital technologies like artificial intelligence provides new abilities, organizations need to acquire employees with *Digital Skills* (Schwarzmüller et al., 2018). At the same time, organizations need to continuously develop their employees' skill set to keep pace with ever-increasing environmental changes. Therefore, they need to develop digital leaders, which drive that change and identify new opportunities (Kane et al., 2017b). Since digital talents are rare, *Workplace Flexibility* will help organizations to retain such leaders and attract new employees. This dimension describes the degree to which the working environments contributes to efficient collaboration within the organizational borders and beyond. The performance of the organization and its ability to continuously adapt to a changing environment also depends on its organizational structures (Libert et al., 2016; Schwarzmüller et al., 2018). *Organizational Structure* describes the transformation from a solely hierarchical work approach towards more independent and self-organized teams that dynamically adapt to changing requirements. To adopt novel technologies and quickly react to changing customer needs, organizations need to develop an *Innovation Culture* that fosters innovation and agility and contributes to a learning organization (Gimpel et al., 2018). *Leadership* shapes the organizational culture (Kane et al., 2017b) and is, therefore, an essential part of the DT. Organizational leaders increasingly need to empower their employees and enable them to drive projects by themselves.

Besides organizational structures, organizations need to adapt their **Processes** to successfully face the challenges of today's business environment (Holotiuk and Beimborn, 2017). The use of digital technologies and data builds the foundation for autonomous *Process Control* (Gimpel et al., 2018; Holotiuk and Beimborn, 2017). To become agile, organizations strive for *Business Process Flexibility*, i.e., increase flexibility within individual processes and ensure adaptability between processes within and beyond the organizational borders (Gimpel et al., 2018). As product lifecycles become shorter and the individualization of products becomes increasingly important, organizations need to efficiently produce small batch sizes to stay competitive (Gimpel et al., 2018). While *Production Flexibility* represents the adaptability of the production equipment to changing product characteristics, *Product Assembly* describes the degree to which organizations can adapt their product design to customer needs (Schuh et al., 2017). Since digital business models rely on data-driven services which enhance physical products, organizations need to cooperate with their value-adding network to provide the best possible solution to their customers (Berghaus and Back, 2017). Thereby, the nature of *Inter-organizational Processes* transforms from a linear supply chain to digital ecosystems (Arnold et al., 2017), in which partners and customers are integrated in an increasingly interactive and collaborative way (Ibarra et al., 2018).

Digital technologies enable organizations to create new **Business Models** that deliver additional value to customers (Bilgeri et al., 2017). Due to servitization, the *Offering* changes. Former manufacturers of physical products integrate additionally data-driven services and provide results as a service to satisfy customer needs (Bilgeri et al., 2017). Accordingly, the risk of achieving a certain result shifts from the

customer to the provider. This transformation implies that the product remains the property of the provider, who needs to develop new *Pricing Strategies* to capture the value from its offering. New offerings provide the opportunity to extend the *Target Market* in terms of addressing new customers, additional markets, or even creating new markets. While customers may continue to buy the physical product via traditional or web-based channels, digital capabilities increasingly enable the physical product to serve as a *Sales Channel* for supplementary services (Übelhör, 2019). While the distribution of the traditional product will remain physical, the *Distribution Channel* for additional services can be increasingly detached from a physical location (Lim et al., 2018).

To maximise customer value and generate competitive advantages, organizations increasingly need to align their operations and activities to **Customer** needs. Hence, organizations collect and analyse customer data to generate *Customer Insights*, which serve as a foundation to offer individual solutions (Gimpel et al., 2018). *Customer Integration* describes the degree to which the customer is part of the design and development process of a product. With rising maturity, customers evolve from consumers to partners, especially concerning collaboration, as well as co-design and development (Berghaus and Back, 2017; Übelhör, 2019). Digital technologies offer the opportunity to perform operational parts of *Customer Interaction* in automated and autonomous ways (Beverungen et al., 2019). *Customer Experience* is characterized by the subjective feeling of customers towards an organization and its offerings (Gimpel et al., 2018). To retain customer loyalty, organizations need to offer a consistent and personalised experience throughout all customer touchpoints.

# 5 Evaluation and Application

We evaluated and validated our DTMM as follows: Firstly, as part of our development process, we continuously evaluated our artefact by conducting focus group meetings and expert interviews. Secondly, we asked the same stakeholders to challenge evaluation criteria from design science research (Sonnenberg and Vom Brocke, 2012) and MM development (Poeppelbuss and Röglinger, 2011). Thirdly, we give some 'food for thought' on how to apply the DTMM and embed it within a DT strategy.

Within our iterative development process, we conducted interviews with two focus groups and six industry experts, which helped us to revise our artefact. In the following, we present select annotations:

- As the adoption of digital technologies is a central driver of DT (Gimpel and Röglinger, 2017; Matt et al., 2015), we discussed its inclusion as a focus area with both focus group members and industry experts. Striving for long-lasting insight, we aimed to create an artefact which is independent of short-term technology trends. For some dimensions, however, the utilization of technology is implicitly considered (e.g., cloud platform).
- Within our first focus group meeting, some researchers pointed out the need for a distinctive and intuitive nomenclature. As the prior version of our DTMM still comprised overlapping capabilities (e.g., basic and partial data integration) or different rationales within one dimension (e.g., for the dimension data integration: time such as real-time integration, and scope such as partial integration), we revised the artefact accordingly. Also, our capabilities, dimensions, and focus areas should be comprehensible without further explanations or requiring a digitalization background. Therefore, we replaced technical terms like two-speed IT. To close the feedback loop, we consulted the same focus group within our third iteration.
- Initially, our artefact included the overarching focus area 'DT management'. With capabilities like the definition of roles and responsibilities, our experts stated that these are notable characteristics of an organization. However, they argued not to integrate the management into the DTMM as it is more of a prerequisite for change. Hence, we abandoned this focus area.
- During the interviews, we adjusted the way how to read our DTMM. Based on the insights of the experts, we concluded that not a certain capability represents the highest maturity level for each dimension. In contrast, the highest maturity level means that organizations have acquired all capabilities within a dimension and, thus, have the freedom to choose one or several capabilities that fit best within the current situation. Regarding the dimension 'business process flexibility, for instance, an organization which achieved the capability 'interaction of processes' is also able to implement

'rigid processes'. As flexibility might increase the possibility of errors, it could be reasonable to also create some 'rigid processes' for critical tasks in addition to interacting processes. This means that, depending on the current situation, organizations need to choose and combine certain capabilities to achieve their target state. Moreover, the experts pointed out that although we develop a DTMM, not all capabilities necessarily have a digital nature.

To evaluate the procedure of building our artefact, we additionally added semi-structured questions to our interviews which are in line with evaluation criteria as per Sonnenberg and Vom Brocke (2012), i.e., EVAL 1-4. We enriched the interview results with insights from our literature review and our focus group meeting with researchers. Table 4 gives an overview of our results.

| Evaluation Criteria | Evaluation Method | Findings |
|---|---|---|
| EVAL1: Novelty and importance of the problem | Literature Review, Expert Interview, Focus Group Discussion | As DT significantly differs from traditional organizational transformations, our literature review revealed that the majority of organizations lacks a holistic DT strategy. Due to the opacity within this fast-moving field, organizations still struggle to understand the implications of DT (*novelty*). A common understanding, however, is a prerequisite to identify relevant action fields to transform an organization successfully. The experts confirmed the insufficiency of existing approaches to structure the field. Being researchers in the field of digitalization, the focus group also emphasized the need for descriptive knowledge on DT (*importance*). |
| EVAL2: Understandability, and suitability | Expert Interview, Focus Group Discussion | The industry experts and focus group members stated that a MM is suitable for representing capabilities, dimensions, and focus areas of a DT in a structured, comprehensible, and intuitive manner (*understandability, suitability*). In particular, they pointed out the benefit of our idea of using descriptive capability names to support intended users, rather than providing only numerical scales. Thereby, our capability definition offers a flexible and company-specific configuration of capabilities and corresponding transformation paths. |
| EVAL3: Ease of use, operationality, and robustness | Expert Interview, Focus Group Discussion | To test our artefact's applicability in an artificial setting, we asked our focus group and industry experts to challenge our capabilities' sequence and granularity. The interviewees confirmed the suitability and understandability of our method to classify their activities (*ease of use*). However, the experts remarked that the user-friendliness could benefit from providing additional descriptions and examples of the capabilities, as well as introducing the DTMM stepwise as at first sight stakeholders might be overstrained. As we see this as part of our model's implementation in terms of a management tool, it exceeds the scope of this work. As for *operationality*, our experts stated that our artefact could be integrated as part of existing DT strategies (cf. the end of this section for details) to evaluate the status quo and target state of an organization. IP2 suggested to introduce the DTMM via workshops or even implement it as part of a management tool to provide additional guidance. To provide stable results (*robustness)*, we defined capabilities that are independent of short-term technology trends. |
| EVAL4: Applicability and fidelity with real-world phenomena | Expert Interview | To validate the DTMM's usefulness in a naturalistic setting, we asked our interview partners to classify their organization's status quo using our DTMM. Since the determination of the respective status quo was feasible and reflected the organizations' situation, the experts confirmed the *fidelity with real-world phenomena*. Besides, we asked the experts about the *applicability* of our approach. The answers were manifold: The experts would use the DTMM, inter alia, to assess the status quo and develop their targets state (all experts), to discuss action fields with the top-management to raise funding (IP6), and as a foundation to develop DT key performance indicators, e.g., the degree of process autonomy (IP2). Besides managers, the artefact supports stakeholders on all focus areas, e.g., product and business model developer (IP4). Independent of specific use cases, our experts concluded that the DTMM offers an extensive view on relevant dimensions and capabilities for the DT. |

*Table 4. Details on Evaluation Criteria*

Finally, as part of our evaluation, we also discussed with our experts how the DTMM contributes to concrete activities and an overall DT strategy. As proposed in the scientific literature (Schuh et al., 2017; Schumacher et al., 2019), the DTMM should be an integral part of a transformation path. With our DTMM at hand, stakeholders first have to determine the status quo of their organization. Based on the definition of long-term strategic objectives, the target state, i.e., associated dimensions and capabilities, can be determined. Comparing the status quo with the future target state supports organizations in deriving company-specific projects. Subsequently, individual projects need to be prioritized, sequenced and carried out. To monitor the DT and to measure the degree to which projects have achieved their objectives, the dimensions and capabilities of our DTMM should be subject to continuous re-evaluation.

# 6 Conclusion

We motivate our study by arguing that the fast emergence and adoption of digital technologies and associated effects on the business environment force industrial organizations to digitally transform themselves. The lack of descriptive knowledge, however, hampers scientific progress and practical applications. Against this backdrop, we follow the 'design science research'-based procedure model as per

Becker et al. (2009) to develop a DTMM as an artefact. Our DTMM includes 26 dimensions structured along six focus areas to support organizational stakeholders in determining their organizations' status quo and desired target-state regarding DT. We developed our artefact within several iterations, which build on an extensive literature review, internal discussions, and insights from scientific focus group discussions and interviews with industry experts. The evaluation of our DTMM is in line with the evaluation activities as per Sonnenberg and Vom Brocke (2012).

Our DTMM contributes to the descriptive knowledge of DT. Our findings build on current discussions on DT strategies and related action fields, e.g., Matt et al. (2015), Hess et al. (2016), and Gimpel et al. (2018), and extend existing frameworks in detail and scope. Also, we address the limitations of existing frameworks, e.g., by providing an integrated view on various organizational levels, as described in Section 1. By summarizing, enriching, and structuring academic literature in this field, we provide an overview of and common nomenclature for DT dimensions and capabilities. Our DTMM includes details on various focus areas, dimensions, and capabilities for DT. Although we do not address the connection between the focus areas in detail, our integrated view, along with established organizational levels, creates awareness for these interrelations and supports the development of DT strategies. Thereby, we argue that maturity in the context of DT does not exclusively comprise the adoption of digital technologies but also includes other rationales, e.g., flexibility.

Regarding the professional literature, we extend high-level transformation paths and MMs, e.g., PWC (2016) and Azhari et al. (2014). While these frameworks provide a foundation for initially grasping DT, they lack a deep-dive into dimensions and capabilities which are necessary to address DT entirely and in detail. Moreover, existing frameworks and MMs are not based on a structured development process, but rather represent loose collections of terms. Our DTMM, in turn, is the result of a rigorous research process. With this, we hope to provide a profound basis for future research within this fast-moving field.

Our DTMM is also meant to support intended users in transforming their organizations: In general, our artefact allows managers independent of their current maturity level to capture their organization's status quo concerning DT. Based on the organization's objectives, users can derive their future target state and associated capabilities within each dimension and focus area. This, in turn, enables the establishment of a transformation roadmap and the subsequent derivation of individual projects which contribute to a DT strategy to reach the desired target state. Our artefact supports managers in making informed decisions about the goal-oriented selection and prioritization of DT projects, and, at the same time, increases the transparency of associated decisions. In sum, our artefact helps to reduce an organization's uncertainty in dealing with DT and enables them to stay competitive in a dynamic environment.

As with any research project, our DTMM is beset with limitations which stimulate future research. Firstly, we recognize that digital technologies and the business environment constantly evolve and change over time. We account for this by creating dimensions and capabilities on an abstract level of granularity to create long-lasting insights. However, the DTMM should be subject to continuous re-evaluation and adjustment in the future. Secondly, although we follow a procedure model and conduct a multi-methodological approach, the development of the DTMM might suffer from potential bias concerning literature selection and the author's judgement. Also, our findings may be biased by the small number of interviewed experts, the experts' judgement, and the interview structure. Hence, our artefact may benefit from further validating activities. In particular, the application within real-world use cases could be useful to access our DTMM's real-world fidelity. Thereby, our DTMM should not serve as a stand-alone tool but rather be integrated into a digital transformation process. Thirdly, some DT projects may require combining certain capabilities. Hence, our work could be extended through subsequent development steps proposed by van Steenbergen et al. (2010) to identify interrelated dimensions and capabilities. Fourthly, our results are tailored to the specific characteristics of organizations from the manufacturing industry, e.g., *Physical Delivery of Product* within the dimension *Distribution Channel* or *Linear Supply Chain* within the dimension *Inter-organizational Collaboration*. However, we also include dimensions that seem to fit for organizations in general, e.g., *Leadership* or *Innovation Culture*. Hence, particular aspects of our DTMM may also support organizations in other industries. Thus, future research should challenge the applicability of our results with organizations from other industries.

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