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ORGANISATIONAL DIGITAL TRANSFORMATION OF SMEs—DEVELOPMENT AND APPLICATION OF A DIGITAL TRANSFORMATION MATURITY MODEL FOR BUSINESS MODEL TRANSFORMATION

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One of the most challenging difficulties for incumbent organisations, especially small- and medium-sized enterprises (SMEs), is to manage digital transformation driven by technological change. Incumbent organisations' responses to digital transformation have been extensively studied in the current literature. However, most research neglects digital transformation in SMEs. There are hardly any valid developed measures for the maturity of digital transformation. We present a holistic digital transformation maturity model based on an extensive literature review, qualitative computer-assisted data analysis, and empirical findings. The digital transformation maturity model focuses on small- and medium-sized enterprises' unique features and characteristics. We proved the practical applicability and relevance of the digital transformation maturity model in an extensive study involving various organisations, particularly German SMEs ($n = 310$). Organisations can use this model to assess themselves initially and, through this process, gain a comprehensive understanding of the multiple forms of digital transformation.

Keywords: Organisational Digital Transformation, German Mittelstand, SMEs, Maturity Model, Business Model Transformation, Organizational Change

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Introduction

The increasing rapid diffusion of digital technologies makes digitalisation a strategic imperative for most organisations (Verhoef *et al.*, 2021). Responding to digitalisation, organisations need to digitally transform themselves by developing and integrating digital technologies across all business units, from structures and products to processes and business models (Ceipek *et al.*, 2021). Therefore, digital transformation can be understood as a holistic transformation process of organisations and entire industries driven by technological developments entailing far-reaching strategic, organisational, and socio-cultural changes (Petry, 2016, p. 22). Digital transformation in organisations leads to significant changes that organisations need to manage (Hanelt *et al.*, 2020). On the one hand, organisations can reduce transaction costs and increase revenue by introducing digital technologies. They can generate novel value creation and capture mechanisms by introducing new business models and gaining competitive advantages (Remane *et al.*, 2017; Soluk and Kammerlander, 2021; Yoo *et al.*, 2010). On the other hand, introducing digital technologies is a time-consuming, often threatening, uncertain, and potentially costly process (Soluk and Kammerlander, 2021).

Nevertheless, digital transformation is essential not only for large organisations but also for small- and medium-sized enterprises (SMEs) with their immense importance to the economy. However, they also face specific characteristics (e.g., lack of technological assets) and peculiarities (e.g., resource constraints) that hinder digital transformation (De Massis *et al.*, 2018; Kammerlander and Ganter, 2015; Nambisan *et al.*, 2017).

Concerning the debate on how organisations can adapt successfully to digital transformation, we aim to develop a structured digital transformation maturity model that encompasses the challenges and opportunities presented by holistic digital transformation. In addition, the model enables small- and medium-sized enterprises to determine the level of their digital transformation maturity as a starting point to consider possible actions in their digital transformation journey. However, research indicates that only a limited number of digital transformation maturity models exist for SMEs (Schallmo *et al.*, 2019; Schallmo and Williams, 2021). Furthermore, to the authors' knowledge, no holistic digital transformation maturity model, specifically regarding SME characteristics and constraints.

Theoretical Background

Digital transformation

Today, organisations face the challenge of transforming their whole organisational structures and processes in all business units due to the increasing use of novel

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digital technologies (Hinings *et al.*, 2018; Kohli and Melville, 2018; Nambisan *et al.*, 2017; Williams *et al.*, 2019).

The resulting changes have fundamentally altered customer expectation and behaviour (e.g., the anticipation of novel ways to interact and engage with customers), putting immense pressure on established firms and disrupting numerous markets (Haffke *et al.*, 2016; Verhoef *et al.*, 2021; Vial, 2019). However, digital technologies offer a broad spectrum of new opportunities; many firms are struggling to explore and exploit the potential of new digital technologies and innovations (Kane *et al.*, 2015, 2018; Singh *et al.*, 2019). Given the importance of digital transformation in maintaining organisational competitive advantage, several excellent reviews have taken stock of the rapidly growing literature (Verhoef *et al.*, 2021; Vial, 2019). Nevertheless, it is striking that many studies focus on individual areas of application fields of digital transformation. Yet, the literature misses a consensus on a generally accepted definition (Schallmo and Williams, 2021; Verhoef *et al.*, 2021; Vial, 2019; Williams *et al.*, 2019).

We identified three topic-relevant definitions by conducting a broad search of scientific and practice-oriented publications, each having a different focus. For example, Petry (2016) distinguishes between a purely technical understanding and a holistic view of digital transformation. In the technical sense, digitisation prepares information for processing or storage in a digital technology system. From a holistic perspective, digitalisation is a transformation process of organisations or entire industries driven or enabled by technological developments. This transformation entails far-reaching strategic, organisational, and sociocultural changes (Petry, 2016, p. 22). Building on this, Verhoef *et al.* (2021, p. 889) derived a multidisciplinary understanding of digital transformation as “a change in how a firm employs digital technologies, to develop a new digital business model that helps to create and appropriate more value for the firm”. Finally, Vial (2019, p. 118) defines digital transformation in more conceptually tangible terms. Here, digital transformation is “a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies”.

All three definitions encompass that digital transformation leads to a holistic change in organisations forcing them to involve various organisational levels and units by considering different technical and human factors. For a successful change, a clear recognition and identification of these factors are necessary. Digital transformation is constantly changing how organisations use digital technologies to improve business performance, accompanied by a shift in business strategy toward differentiated value creation with digital resources (Firk *et al.*, 2021). As a result, organisations need to adapt their core competencies, which poses significant strategic challenges (Firk *et al.*, 2021). Therefore,

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digital transformation should be a substantial core of the top management agenda. Managers need a valid measurement instrument to analyse the state of digital transformation in their organisation to target strategic decisions more effectively.

Furthermore, digital transformation is not limited to a specific organisation area but transcends functional and departmental boundaries requiring a holistic change (Bharadwaj *et al.*, 2013; Firk *et al.*, 2021). A valid measurement tool for capturing digital transformation maturity in organisations should enable a holistic view and make it possible to look at different organisational areas to enable an organisation-wide change.

Due to new market demands and the emergence of new forms of competition, a valid measurement tool for organisations is required to capture digital transformation activities. In addition, as digital transformation creates time pressure, organisations need help to adapt their intra- and inter-organisational structures and processes (Firk *et al.*, 2021).

Research indicates that organisations lack a methodical approach that allows them to assess the status of their digital transformation activities and record the necessary implementation steps. A maturity model is a tool that helps to solve this problem, as it supports managers in assessing the organisation concerning digital transformation systematically and in identifying development prospects (Becker *et al.*, 2009).

The managerial challenges associated with a holistic digital transformation lead to the question as to what a valid, practice-oriented measurement instrument might look like. The tool's aim should be a straightforward evaluation of an organisation's digital maturity, revealing steps required to shape its digital transformation efforts and processes.

Small- and medium-sized enterprises (SMEs)

Even though digital transformation poses challenges for all organisations, a specific focus should lay on small and medium-sized enterprises as they are the driving force in many economies. In Germany, around 99% of all companies are small- and medium-sized enterprises (Institut für Mittelstandsforschung, 2016). They significantly contribute to the country's economic growth (Mittal *et al.*, 2018; Soluk and Kammerlander, 2021). Despite its medium- and long-term benefits, studies show that digital transformation goes ahead with significant challenges for SMEs. They struggle with introducing digital innovations (Hinings *et al.*, 2018; Yoo *et al.*, 2012). To remain competitive in an increasingly digital environment, SMEs must overcome these challenges (Soluk and Kammerlander,

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2021). However, the adoption of digital technologies in SMEs differs from that in large organisations. Research highlights the need for new theory-building models and specific approaches for small and medium-sized enterprises (Soluk and Kammerlander, 2021). Nevertheless, the question arises, how SMEs differ from large organisations. Therefore, we first identify the specific requirements of German SMEs.

According to the European Commission, SMEs are enterprises that employ less than 250 employees and have an annual turnover not exceeding EUR 50 million and/or have an annual balance sheet total not exceeding EUR 43 million (European Commission, 2003). More country-specific, the IfM Bonn distinguishes German SMEs from large enterprises using quantitative criteria such as annual turnover (\leq € 50 million) and the number of employees ($<$ 500 employees) (Institut für Mittelstandsforschung, 2016). As this paper focuses on German SMEs, we will follow the more focused definition of the IfM Bonn for the remainder of this research work. Research shows that SMEs differ from large organisations concerning eight overarching areas: constrained resources (Brunswicker and Vanhaverbeke, 2015; De Massis *et al.*, 2018; Mittal *et al.*, 2018), lack of technological (Mittal *et al.*, 2018; Tchouwo *et al.*, 2021), product specialisation (De Massis *et al.*, 2018; Mittal *et al.*, 2018; Pfohl, 2013), standards (Mittal *et al.*, 2018), organisational (De Massis *et al.*, 2018; Mittal *et al.*, 2018; Pfohl, 2013), employee involvement (Bos-Brouwers, 2010; Uhlaner *et al.*, 2013), alliances (Agostini and Nosella, 2018; Brunswicker and Vanhaverbeke, 2015), and collaboration (Agostini and Nosella, 2018; De Massis *et al.*, 2018; Mittal *et al.*, 2018). Table 1 gives a detailed overview of the SME criteria and the impact on the digital transformation maturity model.

Table 1. SME criteria and impact on digital transformation maturity model.

Criteria	Description	Impact on SME-specific digital transformation maturity model
Constrained resources	Concerning their company size, SMEs often lack the resources to look for new ways outside their core competencies. They are often constrained in their resources. Thus, they may lack resources and capabilities essential for transformation. (Brunswicker and Vanhaverbeke, 2015; De Massis <i>et al.</i> , 2018; Lee <i>et al.</i> , 2010; Mittal <i>et al.</i> , 2018)	Concerning the scarcity of resources, there is a need for stronger dovetailing between investments and strategy in SMEs. Conclusion: there is a need not only for a focus on long-term investment decisions but also for openness to invest in smaller digital initiatives as early as possible, thus creating a culture of error that allows for the abandonment and failure of projects.

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Table 1. (Continued)

Criteria	Description	Impact on SME-specific digital transformation maturity model
Lack of technological assets	<p>Due to resource constraints, SMEs often lack the technical assets required for digital transformation. Accompanied by that is often a lack of IT integration, particularly in SMEs compared to multinationals, so that software (including data analysis tools) used to maintain SME data sets is tailored to the specific problems of SMEs. Furthermore, SMEs are often not early adopters because they are afraid of investing in the wrong technologies or adopting unsuitable processes. (Brunswick and Vanhaverbeke, 2015; De Massis <i>et al.</i>, 2018; Lee <i>et al.</i>, 2010; Mittal <i>et al.</i>, 2018)</p>	<p>SMEs should emphasise their IT-Infrastructure, the lack of technological assets, the insecurity regarding technical decisions, and the increasing relevance of IT-Security.</p>
Product specialisation	<p>Due to limited technical and financial resources, SMEs' research and development areas are not very advanced. However, SMEs often have highly specialised products that enable them to develop outstanding expertise and remarkable efficiency to differentiate themselves from their competitors. (De Massis <i>et al.</i>, 2018; Mittal <i>et al.</i>, 2018)</p>	<p>SMEs have a stronger focus on the digitalisation of their service offering. Hence, the model needs to consider innovative approaches to product development for more efficient and faster product development.</p>
Standards	<p>However, unlike large organisations that adhere more strictly to standards like, e.g., ISO standards, these standards in SMEs are rare, partly due to the resources required to prepare and conduct certifications. As a result, SMEs often must consider industry standards. (Mittal <i>et al.</i>, 2018)</p>	<p>The organisation's strategic direction is highly dependent on the personality and skills of the entrepreneur. SMEs have few opportunities to compensate for wrong decisions. As a result, they emphasise formulating and implementing a digital strategy to shape the digital transformation systematically.</p>
Organisational culture	<p>The organisational structure in SMEs is less complicated and much more informal than in large organisations. Thus, SMEs tend to be more flexible and less formalised, making decisions more quickly. SME decisions are primarily based on the "gut feeling" of the manager/decision-maker. Therefore, SME managers/decision-makers may not be confident in their decisions, leading to a delay in implementing new digital technologies.</p> <p>However, at the same time, the organisational culture is often not flexible enough to experiment and consider initiatives to introduce new digital technologies.</p>	<p>Managers are the decisive drivers of change processes concerning their position in the organisation. Therefore, the model needs to emphasise the owner's importance as the primary driver of change processes.</p>

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Table 1. (Continued)

Criteria	Description	Impact on SME-specific digital transformation maturity model
Employee involvement	<p>(De Massis <i>et al.</i>, 2018; Mittal <i>et al.</i>, 2018; Pfohl, 2013)</p> <p>The opportunities and possibilities of employees differ in SMEs and large organisations. For example, employees in SMEs are more likely to be generalists and less likely to develop high levels of expertise in a particular field as they have day-to-day responsibilities in a variety of areas. Employees of large organisations, on the other hand, are more likely to be highly specialised and thus considered experts in specific areas.</p> <p>(Bos-Brouwers, 2010; Mittal <i>et al.</i>, 2018; Uhlaner <i>et al.</i>, 2013)</p>	<p>SMEs, in particular, need to create an open error culture. Because of staff shortages, SMEs need to retain employees and actively take them on the digital journey. To remain interesting for employees in the future, SMEs should create innovative workplaces.</p> <p>Due to the increase in the importance of the centralisation of knowledge, strengthening faster and more efficient exchange in SMEs is increasingly necessary. In this regard, SMEs particularly need support and professionalisation of existing structures and processes through new digital technologies.</p>
Alliances	<p>Alliances and networks in SMEs often have an inter-organisational and boundary-spanning element. Hence, strategic and multi-actor alliances are drivers of innovation and help SMEs access necessary resources, extend their technological competencies, and build legitimacy and reputation. Nevertheless, SMEs regularly struggle with finding the right partners and making purposively good use of external relationships for innovation.</p> <p>(Agostini and Nosella, 2018; Brunswicker and Vanhaverbeke, 2015)</p>	<p>Due to their constraints, SMEs need more significant involvement of external partners for their product development and digital transformation activities.</p>
Collaboration	<p>SMEs often lack collaborations with universities and other research institutions. Since they have little access to shared knowledge, they can learn only to a limited extent from their own experience. Moreover, the knowledgeability of SMEs often concentrates mostly on one area of expertise, whereas in large organisations the knowledge base is broader. Contrary, SMEs are often well connected with other SMEs, regularly exchanging information to learn from each other.</p> <p>(Agostini and Nosella, 2018; De Massis <i>et al.</i>, 2018; Mittal <i>et al.</i>, 2018)</p>	<p>SMEs need to monitor the emergence and relevance of new digital technologies, as these can drastically affect competition and the industry. Therefore, SMEs need a more substantial and, above all, broader analysis of new potential competitors, e.g., by startups.</p>

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Maturity model

Particularly in information systems, maturity models have proven to be instruments that help to monitor the status quo of distinct objects or areas and provide guidance for suitable improvements on an evolutionary path (Becker *et al.*, 2009; Fraser *et al.*, 2002; Mettler, 2010). Maturity models are composed of various criteria and dimensions that show an anticipated path to reaching the desired stage of development, starting with an initial stage and ending with the whole maturity level (Becker *et al.*, 2009; Berghaus, 2016). Therefore, maturity models are suitable tools for systematically developing or improving new technologies within an organisation. A requirement of maturity models is a clear definition of features and characteristics of the individual development stages providing the user with an overview of what is specifically required to reach the next maturity stage.

There are various maturity models in research, even for a specific domain, such as the enterprise architecture maturity model (Becker *et al.*, 2009). To measure the digitalisation of organisations, it is essential to focus our model on the specific domain of digital transformation. Whether they are general maturity models or maturity models developed for a particular domain, both are suitable tools to identify the organisation's necessary changes (Berghaus, 2016; Hölzle *et al.*, 2017). Nevertheless, there are some differences regarding the maturity model for digital transformation.

Digital transformation maturity model

Research emphasises the following differences between the general and maturity digital transformation models (Williams *et al.*, 2019). First, the maturity model for digital transformation should relate to technological areas of activity such as information technology and business intelligence. Second, the model needs to focus primarily on terms related to digitalisation. However, the model does not only refer to new types of technologies but rather involve a wide range of topics in the organisation, e.g., the introduction of new technologies, the evaluation and transformation of business areas, products, and customer experiences (Westerman *et al.*, 2011; Yoo *et al.*, 2012). Digital transformation maturity models indicate, therefore, how organisations need to develop and how to realign the existing business model for the future (Nambisan *et al.*, 2017; Westerman *et al.*, 2011). Unfortunately, however, digital transformation maturity models have rarely been studied in an academic context (Berghaus and Back, 2015).

Objectives of the study

Digital transformation as technology-driven change is crucial for organisations, especially SMEs. Hence, for SMEs, it is crucial examining which prerequisites

are essential for achieving or improving actions for digitalisation. Furthermore, measuring their digitalisation status quo is critical for SMEs to derive further steps to an organisational holistic digital transformation. Research highlights a need for new theory-building models and specific approaches for SMEs. Therefore, the study aims to develop a maturity model specifically for digital transformation that supports small and medium-sized enterprises in assessing and improving their level of digital maturity. As mentioned before, adopting digital technologies in SMEs differs from large organisations as shown in Table 1.

Therefore, our digital transformation maturity model focuses on German SMEs, making it possible to measure their status quo, providing them guidance for actions needed, and derive the effectiveness of existing efforts.

Method

Methodological development

For the development of the digital transformation maturity model, we proceeded with the following five phases mentioned by De Bruin *et al.* (2005): scope, design, populate, test, and deploy.

Scope

The literature review was divided into a broad, higher-level literature search to collect existing digital transformation definitions and to derive a thematic-relevant meaning, followed by a literature review to analyse digital transformation maturity models. Since there is no uniform definition of digital transformation, creating a consistent understanding of the term among the authors was essential. We derived several meanings based on our previous research and an overarching literature review. Intending to develop a maturity model for digital transformation, the definition should highlight which areas digital transformation encompasses. After identifying possible relevant definitions, we discussed them with scholars outside the research team to gain a shared understanding of digital transformation. Following the derived topic relevant definitions (i.e., Petry, 2016; Verhoef *et al.*, 2021; Vial, 2019), we understand the digital transformation from a holistic perspective as a transformation of organisations and entire industries driven or enabled by technological developments leading to far-reaching strategic, organisational, and sociocultural changes.

Due to the variety of existing maturity models, we reviewed existing models for digital transformation in the first step. In this context, the dimensions and the corresponding items were evaluated concerning their suitability regarding the

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scope and established criteria using a literature review of German and English publications.

For this second part, the literature analysis was conducted using Web of Science and Google Scholar database considering the following search terms: “maturity model” (or “assessment” or “framework”) and “digital transformation” (or “business transformation”, or “enterprise transformation”, or “digitalisation”) and “organisation” (or “SME”, or “small and medium-sized business”, or “organisational change”, or “organisational transformation”). The analysis led to a total of 94 relevant academic and practice-oriented articles focusing on organisations’ digital transformation. However, the review revealed that only six models focus on the digital transformation of small and medium-sized enterprises, indicating a significant need for further research on this topic (Hölzle *et al.*, 2017). Additionally, the review showed that digital transformation receives far more attention in practice-oriented publications than in academic ones.

Design

The results from the literature review were validated using a computer-assisted qualitative data analysis (CAQDAS) based on the software Leximancer, which identified the relevant dimensions in articles and publications based on the word frequency and the spatial proximity or coexistence of the different words. Leximancer systematised the recognised terms into higher-level “themes” and visualised them in a map (Leximancer, 2016).

The manual and computer-assisted literature analysis enabled the identification of relevant dimensions, including strategy, customers, products and services, processes, organisation, IT infrastructure and technology. Furthermore, the model was supplemented by the dimension environment, as the literature on digital transformation emphasises the increasing relevance of the interaction of organisations with their corporate environment.

After the extensive manual and computer-assisted qualitative literature review, we established a specification list consisting of seven overall dimensions and 19 sub-dimensions to measure SMEs’ digital transformation (see Appendix Table A.1 for the German items and Table A.2 for the translation).

Populate

We created a table of initial items based on the literature review and the computer-assisted qualitative data analysis to measure the digital transformation maturity stages. Afterward, we discussed the dimensions, sub-dimensions, and items with experts. As a result, we derived 148 items anchored on a Likert scale ranging from

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1 “strongly disagree” to 5 “strongly agree” to improve the reliability and consistency of responses and enable more straightforward mapping.

Test

In the following step, we developed a first prototype of the digital transformation maturity model and tested it by business leaders and employees from SMEs. Then, we conducted in-depth qualitative interviews with the participants. Finally, the feedback was incorporated and considered in the final implementation phase.

To test the model in its real-world application, we developed the *Digitalcheck Mittelstand*. The *Digitalcheck Mittelstand* encounters the specific criteria of SMEs in mind (see Table A.6) and is adapted to their requirements.

Deploy

During the deployment phase, the developed digital transformation maturity model was published as an online questionnaire under the name *Digitalcheck Mittelstand* in May 2019. The *Digitalcheck Mittelstand* was part of the publicly funded project, “_Gemeinsam Digital, das Mittelstand 4.0-Kompetenzzentrum Berlin”, and is now part of the publicly funded transfer project “Mittelstand-Digital Zentrum Berlin”. Both are sub-projects of the “Mittelstand-Digital” initiative funded by the German Federal Ministry for Economic Affairs and Energy. In this initiative, several German universities and the leading SME organisations support the digital transformation of small and medium-sized enterprises. After making the model available online, we further tested the model in workshops with various SMEs. Finally, after another one-year testing period, we iterated the model again. Incomprehensible items excluded, the final model consisted of the last seven dimensions, 19 subdimensions, and 96 items, with 70 items remaining constant throughout the period. Hence, we will focus on these 70 items.

Format layout

As noted previously, participants could indicate in German on a 5-point Likert scale the extent to which they agreed with the statements, from “1—do not agree” to “5—fully agree”. Furthermore, the additional option, “I do not know,” so that participants had a greater incentive to complete the questionnaire as fully as possible. Focusing on the digital transformation of German SMEs, the questionnaire, so far, is only available in German and free of charge to interested organisations on the project website. To enable generalisability of the maturity level of digital transformation, we tested the model across all SME sizes and without thematic

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or industry focus. Concerning a reliable assessment of the digital transformation maturity level in German SMEs, the user is advised that an intuitive evaluation of all questions is correct and essential at the beginning of the questionnaire. The *Digitalcheck Mittelstand* questionnaire was distributed in various newsletters from project partners' mailings and social media (e.g., Twitter, LinkedIn, Facebook). The data collection took place between May 2019 and August 2021.

After completing the survey, all participants receive a standardised evaluation report. The report shows which of the five pre-defined maturity stages (dreamers, beginners, up-and-comers, secret favourites, trailblasers) the organisation belongs to. Additionally, the maturity stages graphical representation is explained in more detail by short explanations for each dimension. Finally, each organisation receives recommendations per dimension for reaching the next maturity stage based on their respective digital maturity.

Furthermore, the questionnaire contained control variables concerning questions about the company's size and localisation, the participant's position in the organisation, the industry, the gender of the participant, and questions concerning a self-assessment regarding experiences with digitalisation in the organisation and experienced restraints.

Sample

The final sample comprises 310 participants. Because of the free access, we could not guarantee that only SMEs use the model. Accordingly, we also have a few large organisations in our sample. The sample shows a reasonable distribution of company size with a focus on the target group of SMEs (see Table 2). Following

Table 2. Demographic information of participants.

Demographic characteristics	Participants	
	<i>n</i> = 310	Percent (%)
Gender		
Male	188	61
Female	114	37
Other	8	2
Position		
<i>Head of department</i>	71	22
Male	37	12
Female	32	9
Other	2	1
<i>Executive board</i>	142	46
Male	103	33

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Table 2. (Continued)

Demographic characteristics	Participants		
	<i>n</i> = 310	Percent (%)	
<i>Team leader</i>	Female	38	12
	Other	1	0
	Male	21	7
<i>Employee</i>	Male	12	4
	Female	8	3
	Other	1	0
		76	25
	Male	36	12
Company size (number of employees)	Female	36	12
	Other	4	1
	<i>Micro</i>	67	22
	0–9	67	22
<i>Small</i>	10–49	79	25
	50–99	79	25
<i>Medium-sized</i>	100–249	131	42
	250–499	41	13
	500–2.499	71	23
	2.500–10.000	19	6
<i>Large</i>	>10.000	33	11
		28	9
		4	1
Experience with digital transformation by company size			
<i>Micro</i>		67	22
	High	11	4
	Medium	29	9
<i>Small</i>	Low	27	9
	High	79	25
	Medium	13	4
<i>Medium-sized</i>	Low	37	12
	High	29	9
	Medium	131	42
Large size	Low	13	4
	High	62	20
	Medium	56	18
Large size	Low	33	11
	High	6	2
	Medium	19	6
	Low	8	3

Note: Company size = based on IfM Bonn definition.

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the IfM Bonn classification, most organisations belong to the category of the micro (67 participants, 22%) and small enterprises (79 participants, 25%), as well as medium-sized enterprises (131 participants, 42%). 10% of the participating companies belong to large enterprises (33 participants, 10%). The participants come from various industries such as Construction (10%), Engineering (9%), Retail/Wholesale (7%), Management Consulting (6%), Medical/Health (6%), Consumer Goods (5%), Public Administration/Schools (4%). 43% did not indicate a particular industry. The sample shows that about half of the participants belong to the management of an organisation (142 participants, 46%). In addition, two-thirds of the participants are male (188 respondents, 61%), and about one-third are female (114 participants, 37%).

Results

Responses from SMEs with different numbers of employees

The responses from the different SMEs revealed that organisations assess themselves differently depending on their company size. Considering all dimensions SMEs with less than 10 employees scored an average of 2.95 out of 5 points. SMEs with 10–49 employees averaged 3.00 out of 5 points, and SMEs with 50–499 employees scored 2.75 out of 5 points.

SMEs with less than ten employees scored highest on item AO (“Our management is open to feedback.”; $M = 4.19$) and lowest on item V (“Our organisation consistently uses the analysis of large amounts of data to derive measures for product development.”; $M = 1.70$). SMEs with 10–49 employees scored highest on item BP (“Our hardware is rigorously secured.”; $M = 4.25$) and lowest on item V (“Our organisation consistently uses the analysis of large amounts of data to derive measures for product development.”; $M = 1.61$). SMEs with 50–499 employees scored highest on item BP (“Our hardware is rigorously secured.”; $M = 3.86$) and lowest on item V (“Our organisation consistently uses the analysis of large amounts of data to derive measures for product development.”; $M = 1.83$).

Table A.3 summarises the mean values and standard deviations of the 310 participants’ answers. Table A.4 summarises the mean values of each item by organisation size.

Additionally, the organisations rate their digitalisation experience as low. More than a third of the participants stated that they had less experience with digital transformation. Only just under one in ten rated their own experience as high. It is striking that half of the participants belong to the top management team, whereas more than half have been with the organisation for more than five years.

Explorative factor analysis

We performed an explorative factor analysis to gain a more coherent understanding of the measured items to identify underlying patterns.

Before conducting the factor analysis, we used Cronbach's alpha to test the reliability of the 70 constant remaining items, which demonstrated excellent reliability ($\alpha = 0.97$). Next, we applied the Kaiser–Meyer–Olkin test for factorability, proving our data marvellous (0.94). Finally, a 12-factor solution was identified based on the Kaiser criterion (eigenvalue > 1.0). The 12 factors accounted 57% of the cumulative variance related to the varimax rotation. The results of the explorative factor analysis are presented in Table A.5. In the following, we will briefly describe each of the identified factors.

Factor 1: *Employee Empowerment*. This factor consists of eleven items and explains 10.7% of the observed variance. The factor relates to fostering an open culture that encourages employees, the development of digital competencies, open communication, a culture of error, and the opportunity to shape the digital transformation actively.

Factor 2: *Data-Based Product Development*. This factor consists of ten items and explains 7.6% of the observed variance. It relates to collecting, analysing, and using customer data to strengthen customer relationships, adapt digital offerings, and develop data-based products geared explicitly towards customer needs.

Factor 3: *Adaptability of IT-Infrastructure*. This factor consists of seven items and explains 6.5% of the observed variance. It refers to a systematically selected, up-to-date, dynamically scalable, and adaptable IT-Infrastructure to all relevant business data via mobile applications and the systematic integration of customer data.

Factor 4: *Data Governance*. This factor consists of five items and explains 6.3% of the observed variance. It refers to the accessibility and quality of Data by real-time access to relevant data, considering the data's completeness, consistency, correctness, and timeliness.

Factor 5: *Digital Business Model Transformation*. This factor consists of four items and explains 5.1% of the observed variance. The items offer goods and services through digital channels to supplement the non-digital business model. Hence, it describes the digital service portfolio and encompasses transforming the existing business model to a digital one, focusing mainly on addressing customers via digital channels and on the digital offering.

Factor 6: *IT Security Enforcement*. This factor consists of six items and explains 4.7% of the observed variance. It refers to protecting IT-Infrastructure and

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Accessibility and Implementation of a Privacy Policy. It includes the existence of data protection-relevant specifications a comprehensible data protection policy based on clearly defined rights and role concepts. Whereby the central storage of data is taken into account, and this data's protection with an up-to-date IT infrastructure is a must.

Factor 7: *Digital Competency Advancement*. This factor consists of three items and explains 4.0% of the observed variance. First, this factor relates to employees' competencies in using digital technologies. It comprises the ability to solve problems associated with using digital technologies independently, adapts quickly to new digital technologies, and work confidently with digital solutions.

Factor 8: *Digital Strategy Implementation*. This factor consists of three items and explains 3.6% of the observed variance. First, the aspect revolves around the existence of a digital strategy. Hence, it comprises clear strategic considerations and an implementation plan for achieving the goals of digital transformation in the organisations and the communication of the added value associated with digital transformation by the firm's management.

Factor 9: *Digital Interface Establishment*. This factor consists of two items and explains 2.6% of the observed variance. The component involves the direct interfaces and standardised processes with affiliates defining standardised processes in cooperation with partners and establishing digital interfaces with cooperation partners.

Factor 10: *Knowledge Exploitation*. This factor consists of three items and explains 2.4% of the observed variance. First, it refers to generating knowledge from various sources to develop new digital products and services with the help of pilot projects and the acquisition of digital skills through interaction with external partners.

Factor 11: *Digital Process Support*. This factor consists of one item and explains 1.3% of the observed variance. The component includes discussing and using government funding opportunities for digital transformation in the organisation.

Factor 12: *Government Subsidy Evaluation*. This factor consists of two items and explains 2.3% of the observed variance. The factor constitutes the support of business processes by digital solutions.

Discussion

Development of a valid and reliable digital transformation maturity model

Based on a literature review of 94 maturity models and the extraction of relevant dimensions, sub-dimensions and items using CAQDAS, we derived the presented

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Digitalcheck Mittelstand. We further tested the *Digitalcheck Mittelstand* for validity and reliability based on data from 310 participants, mainly from SMEs. This study examined the reliability and validity of the digital transformation maturity model by conducting an exploratory factor analysis. The results show that the *Digitalcheck Mittelstand* has internal consistency reliability of 0.94. Furthermore, we identified twelve theoretically essential factors based on the factor analysis results. Therefore, organisations can use the digital transformation maturity model to measure their digital transformation status quo, deriving the effectiveness of existing efforts and providing them with actions needed for the digital transformation of the respective organisation.

The digital transformation maturity model mainly focuses on SMEs

Through a comprehensive analysis of the characteristics of SMEs, we examined the impact of digital transformation. Based on our overview (see Table A.6), we have implemented specific items, sub-dimensions, and dimensions in the model, particularly with SMEs in mind. The results and number of usages of the *Digitalcheck Mittelstand* show that SMEs adopt the model for their digital transformation.

User centricity and the human factor are crucial

Our analysis shows that SMEs that collect and analyse customer data, have a user-centric approach and use it to create customer profiles and customer segments can improve the relationship with their customers. However, data provide preliminary evidence, that using technologies for collecting and analysing customer data among SMEs still has room for improvement. For example, creating customer profiles or customer segments based on customer data is only partial. SMEs also offer an underdeveloped consistent customer experience across all channels. Overall, the results indicate that there is still room for improvement in digital technologies to strengthen customer relationships.

Potential for expansion in the digitalisation of products and services

The results yield that products and services in SMEs have so far been little digitised or supported by digital offerings. In addition, SMEs have so far made little use of the opportunity to sell their offerings via digital channels. It also shows that data is hardly used for innovative, customer-oriented product development. In addition, SMEs rarely launch products with minimal requirements on the market to obtain real market feedback as quickly as possible.

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Transformation of the business processes

Although business processes are often the initial focus of digitalisation, SMEs still have much potential for expansion in this area. The digitalisation of processes, especially with key partners, and the ongoing review of the potential for improvement distinguish SMEs with a higher digital maturity stage. The digitalisation of business processes is an essential prerequisite for a high level of maturity and benefits from a dynamic, scalable IT infrastructure. The results show that the foundations for handling data concerning up-to-dateness, completeness, correctness, and consistency are in place. Nevertheless, the core processes of value creation are less digitised. Automation of routine processes is, therefore, as expected, still not very pronounced. Nevertheless, the potential for digitising interfaces with partners remains high.

Overall, the *Digitalcheck Mittelstand* helps SMEs to assess the status quo of digital transformation in their organisation, to determine the current state of digitalisation, and, based on this, to take steps to develop further the organisational processes, products, and business model itself. Hence, the model provides organisations, especially SMEs, with a tool covering all relevant dimensions for holistic organisational change regarding digital transformation. Furthermore, it identifies obstacles and offers the opportunity to implement concrete action steps based on a comprehensive individual report.

The data provide convincing evidence that SMEs bring fundamental, essential prerequisites for digital transformation. In particular, this includes an open culture that embraces openness to new digital technologies throughout the organisation. Nevertheless, the systematic and strategic approach to digital transformation remains a challenge in day-to-day operations. The general picture emerging from the analysis is that digitalisation projects in SMEs are still focused on internal areas, such as process automation and the expansion of the IT infrastructure. Looking outward, which includes, for example, user-centric, data-driven product development, still plays a subordinate role.

Contributions

Our findings provide relevant insights for both scholars and managers. Managing the transition from the industrial age to the digital age is one of the most difficult challenges for SMEs, whose resources are usually limited (i.e., Eggert and Francis Park, 2018; Soluk and Kammerlander, 2021). Research shows that SMEs face major challenges in adapting to digital transformation and changing their business models (Hanelt et al., 2020; Soluk and Kammerlander, 2021). Hence, the proposed digital transformation maturity model provides significant contributions to academia:

Development of valid digital transformation maturity model

Studies reveal that “the application and evaluation of maturity models in a business context is still an open field of research” (Berghaus, 2016, p. 111). Thus, validly measuring digital transformation maturity, especially in SMEs, has not been considered in academic discourse. To the best of our knowledge, this study is the first to present a systematically developed and valid maturity model for digital transformation that leads to an empirically evaluated digital transformation maturity model for a holistic change of SMEs. Our results indicate that the developed digital transformation maturity model reflects an organisation’s status quo on digitalisation. In particular, we show that the digital transformation maturity model can be used by employees with different functional backgrounds and hierarchical levels. We thus respond to the call for research on how organisations can approach digital transformation.

Focus on small and medium-sized enterprises

Studies on digital transformation have mainly focused on large organisations’ responses to technology-driven change. Our literature review revealed that only few studies (i.e., Ceipek *et al.*, 2021; De Massis *et al.*, 2018; Soluk and Kammerlander, 2021) focus on SMEs. Therefore, the impact of digital transformation in SMEs has hardly been researched so far. However, SMEs should receive special attention as drivers of the economy. This study addresses this issue by developing a model that considers specific SME characteristics. Our model enables SMEs to assess their digital maturity in a systematic and structured manner. Regarding the response of SMEs (89%), the developed model is suitable for measuring the digital maturity stage in organisations, particularly SMEs.

Furthermore, the study provides not only scientific but also managerial contributions for managers:

Identification of relevant focal points in digital transformation maturity

The digital transformation presents numerous challenges, leading to a comprehensive and holistic change in the existing business model. The holistic change is accompanied by a realignment of IT, the introduction of new roles and structures in the organisation, and the development and implementation of a digital strategy. This study can help managers to better understand the status quo of their organisation’s digital transformation, its stages, and possible development steps. For example, the developed digital transformation maturity model highlights relevant topic areas of digital transformation. In addition, the study provides a valuable overview of the essential fields and focal points represented by the 12 factors that SMEs need to consider when developing their digital maturity.

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Creation of a sound level of knowledge

Our findings provide organisations with comprehensive knowledge about digital transformation due to holistic organisational insights. Furthermore, the digital transformation maturity model explicitly focuses on a holistic transformation of organisations. A better knowledge enables organisations to differentiate between unplanned and radical organisational change instead of evolutionary change, allowing a more open mindset towards digital transformation decisions.

Identifying a valid starting point for digital transformation activities in the organisation

Managers and decision-makers need to transform their organisational processes and structures to meet the challenges of digital transformation. Although organisational change is not a new topic, many organisations, especially SMEs, have difficulty recognising and understanding the changes associated with digital transformation. Decision-makers and managers are often unable to classify the degree of digitalisation of their organisation to derive appropriate action steps. The *Digitalcheck Mittelstand* helps decision-makers in organisations to gain holistic insights into their organisation's digital transformation to better coordinate and steer their initiatives. In addition, by better understanding their digital transformation status quo, SMEs can develop digital products more expediently manner, better understand and implement collaboration with customers, and promote and strengthen partnerships and alliances in a targeted way. Our findings provide organisations, and SMEs particularly, with the opportunity to use a structured, systematic, valid model to measure the digital transformation stage in their organisation. Also, practitioners can benefit from our findings, as the model enables holistic change and highlights essential dimensions that need consideration when further developing their digital maturity.

Limitations and Future Research

There are some limitations to consider when interpreting the results.

Self-assessment tool

The *Digitalcheck Mittelstand* is a self-assessment tool. The data is based on the experiences and assessments of the participants and cannot be objectively verified. They may therefore be subject to bias. Future research could supplement the

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analysis with expert assessments and examination of their behaviour in applying the digital transformation model to correct the bias tendency.

Self-assessment bias by employees

Given the holistic approach of the model, the question arises whether managers and especially employees of SMEs can answer questions on each dimension. Although our multiple respondent design reduces the common method bias, expanding the sample to the organisational level or answers from various employees from one organisation may be necessary for future research to validate the model further. However, it is essential to keep in mind that employees can answer strategic questions, for example, even without concrete insights into the respective dimensions, because they have first-hand experience. For example, they can judge whether an organisation openly communicates a digital strategy, whether the business model has been adapted to new circumstances in recent years, whether investments have been made in useful and labour-saving technologies, and whether collaboration with external partners has taken place. In many respects, therefore, an organisation's employees are just as well suited to answer questions about digital transformation as its executives, especially since their empirical values open up a broader perspective on the topic.

Dynamics of digital transformation

Our digital transformation maturity model focus primarily on the internal view of the organisation. However, we know that external factors (e.g., information intensity and environmental uncertainty) also influence the adaptation of SMEs, and thus their status quo to the digital transformation (Soluk and Kammerlander, 2021). Hence, future research might consider the influence of external dynamics on digital transformation and, consequently, digital maturity. We also acknowledge that despite the systematic development of the digital transformation maturity model based on the literature and computer-based qualitative data analysis, the digital transformation maturity model and its underlying items must be adapted continuously due to the dynamics of digital transformation. Therefore, future research could start here and test other external dynamic effects.

Generalisability

Since the digital transformation maturity model is not explicitly designed for a particular type of organisation but reflects a holistic view of the organisation

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independent of the development and testing activities, the question of generalisability remains open. Regardless of whether the digital transformation maturity model aims for a specific purpose area or a general application. Hence, accompanied by that, even if the model focuses on SMEs, it is not only applicable for them but can also reveal holistic change potentials in larger organisations.

Conclusion

While IT-specific maturity models provide valuable insights for determining the maturity of a technology-oriented process, they do not capture the specific requirements of holistic digital transformation processes, particularly for SMEs (Mettler, 2010). This study derived and examined the relevance of a holistic approach to digital transformation and the significance of the human factor in digital transformation projects. An open organisational culture, as well as the positioning of executives on digital transformation, is essential. At the same time, the interplay of culture and leadership illustrates the necessary duality of bottom-up and top-down driven transformation toward digital maturity. Furthermore, we provide empirical proof that a valid digital transformation maturity model is needed to assist SMEs in deriving further steps to an organisational holistic digital transformation. Our developed digital transformation maturity model helps SMEs capture the status quo of their digital transformation, keeps track of the progress made over time, and enables managers and scholars to pursue a holistic approach to digital transformation.

Appendix

Table A.1. List of items and corresponding Item Codes in German (original query).

Item code	Dimension	Sub-dimension	Item
A	Strategie	Digitale strategie	Unser Unternehmen hat klare strategische Überlegungen zur Digitalisierung festgelegt.
B	Strategie	Digitale strategie	Unser Unternehmen hat einen schrittweisen Umsetzungsplan zur Zielerreichung definiert.
C	Strategie	Geschäftsmodell	Neben dem bestehenden Geschäftsmodell werden digitale Geschäftsmodelle umgesetzt.
D	Strategie	Geschäftsmodell	Bei der Geschäftsmodellinnovation werden Partner aktiv eingebunden.

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Table A.1. (Continued)

Item code	Dimension	Sub-dimension	Item
E	Strategie	Geschäftsmodell	Die kontinuierliche Anpassung des Geschäftsmodells wird als Kernaufgabe der Unternehmensführung verstanden.
F	Strategie	Investition	Unser Unternehmen investiert gezielt in den Ausbau digitaler Kompetenzen.
G	Strategie	Markt und Wettbewerb	Unser Unternehmen interagiert mit externen Partnern um Zugang zu digitalen Fähigkeiten zu erlangen.
H	Strategie	Markt und Wettbewerb	Es werden regelmäßig Startups betrachtet, die unser Geschäftsmodell beeinflussen können.
I	Strategie	Markt und Wettbewerb	Durch die Vernetzung mit externen Partnern, werden gemeinsam Innovationen geschaffen.
J	Strategie	Markt und Wettbewerb	Die Aktivitäten unserer Wettbewerber werden insbesondere im Kontext der Digitalisierung fortlaufend beobachtet.
K	Kunden	Kundendaten	Unser Unternehmen nutzt digitale Technologien, um Kundendaten zu sammeln.
L	Kunden	Kundendaten	Unser Unternehmen analysiert systematisch Kundendaten mit Hilfe digitaler Technologien.
M	Kunden	Kundenerlebnis	Unser Unternehmen schafft ein auf allen Kanälen konsistentes Kundenerlebnis.
N	Kunden	Kundenerlebnis	Unser Unternehmen bietet den Kunden mehrere digitale Kanäle zur Kommunikation an.
O	Kunden	Kundenbeziehung	Unser Unternehmen nutzt umfassend gesammelte Kundendaten zur Erstellung von Kundenprofilen.
P	Kunden	Kundenbeziehung	Unser Unternehmen nutzt konsequent die gesammelten Kundendaten zur Erstellung von Kundensegmenten.
Q	Kunden	Kundenbeziehung	Unser Unternehmen setzt digitale Technologien zur Stärkung der Kundenbeziehung ein.
R	Produkte und Dienstleistungen	Digitales Leistungsangebot	Auf Grundlage einer fortlaufenden Datenanalyse werden unsere digitalen Angebote angepasst.
S	Produkte und Dienstleistungen	Digitales Leistungsangebot	Die Angebote unseres Unternehmens werden konsequent über digitale Kanäle angeboten.
T	Produkte und Dienstleistungen	Digitales Leistungsangebot	Digitale Angebote unterstützen unsere bestehenden Produkte/Dienstleistungen.

(Continued)

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Table A.1. (Continued)

Item code	Dimension	Sub-dimension	Item
U	Produkte und Dienstleistungen	Produktinnovation	Unser Unternehmen entwickelt auf Grundlage von Daten innovative, konsequent auf die Kunden ausgerichtete Produkte/ Dienstleistungen.
V	Produkte und Dienstleistungen	Produktinnovation	Unser Unternehmen nutzt konsequent die Auswertung von großen Datenmengen, um Maßnahmen für die Produktentwicklung abzuleiten.
W	Produkte und Dienstleistungen	Produktinnovation	Unser Unternehmen nutzt verschiedene Quellen für die Entwicklung neuer Produkte/ Dienstleistungen.
X	Produkte und Dienstleistungen	Produktinnovation	Unser Unternehmen bringt Produkte mit minimalen Anforderungen auf den Markt, mit dem Ziel, schnellstmöglich reales Marktfeedback zu erhalten.
Y	Produkte und Dienstleistungen	Produktinnovation	Unser Unternehmen arbeitet bei größeren Vorhaben mit Pilotprojekten, um Risiken zunächst auf definierte Bereiche zu reduzieren.
Z	Prozesse	Digitale Geschäftsprozesse	Die verschiedenen Schritte der Geschäftsprozesse sind in unserem Unternehmen digital abgebildet.
AA	Prozesse	Digitale Geschäftsprozesse	Unser Unternehmen stellt sicher, dass gespeicherte Daten vollständig sind.
AB	Prozesse	Digitale Geschäftsprozesse	Unser Unternehmen stellt sicher, dass gespeicherte Daten korrekt sind.
AC	Prozesse	Digitale Geschäftsprozesse	Unser Unternehmen stellt sicher, dass gespeicherte Daten konsistent sind.
AD	Prozesse	Digitale Geschäftsprozesse	Unser Unternehmen stellt sicher, dass gespeicherte Daten aktuell sind.
AE	Prozesse	Digitale Geschäftsprozesse	Auf alle relevanten Prozessdaten kann in Echtzeit zugegriffen werden.
AF	Prozesse	Digitale Geschäftsprozesse	Impulse aus der digitalen Strategie führen häufig zu Innovationen in den Geschäftsprozessen.
AG	Prozesse	Digitale Geschäftsprozesse	Unser Unternehmen überprüft fortlaufend, ob die Kernprozesse durch den Einsatz von digitalen Lösungen verbessert werden können.
AH	Prozesse	Digitale Geschäftsprozesse	Die Mehrheit unserer Geschäftsprozesse wird durch digitale Lösungen unterstützt.

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Table A.1. (Continued)

Item code	Dimension	Sub-dimension	Item
AI	Prozesse	Digitale Geschäftsprozesse	Routineprozesse sind durch die Nutzung von digitalen Technologien vollständig automatisiert.
AJ	Prozesse	Digitale Schnittstellen	Es sind im Rahmen der Zusammenarbeit mit Partnern standardisierte Prozesse definiert.
AK	Prozesse	Digitale Schnittstellen	Es sind konsequent digitale Schnittstellen mit unseren Kooperationspartnern eingerichtet.
AL	Organisation	Führung	Unsere Unternehmensführung kommuniziert unternehmensweit die Vorteile, die durch die Realisierung von digitalen Projekten erzielt werden.
AM	Organisation	Führung	Herausforderungen, die mit Umsetzung der digitalen Strategie verbunden sind, werden von der Unternehmensführung an die Mitarbeiter klar kommuniziert.
AN	Organisation	Führung	In unserem Unternehmen agieren Führungskräfte als wesentliche Treiber bei der Umsetzung der digitalen Strategie.
AO	Organisation	Führung	Unsere Führungskräfte sind offen für Feedback.
AP	Organisation	Datenschutz	Unser Unternehmen hat eine verständliche Datenschutzrichtlinie.
AQ	Organisation	Datenschutz	Unser Unternehmen schult unsere Mitarbeiter umfassend über datenschutzrelevante Vorgaben.
AR	Organisation	Kultur	In unserem Unternehmen wird bei allen Mitarbeitern unternehmerisches Handeln aktiv gefördert.
AS	Organisation	Kultur	Unsere Unternehmenskultur erlaubt ein schnelles Ausprobieren von neuen Ideen.
AT	Organisation	Kultur	In unserem Unternehmen gibt es eine offene Fehlerkultur.
AU	Organisation	Kultur	Unsere Mitarbeiter sind offen gegenüber digitalen Technologien.
AV	Organisation	Kultur	Es gibt Möglichkeiten für alle Mitarbeiter, die digitale Transformation mitzugestalten.
AW	Organisation	Kultur	Unsere Unternehmenskultur fördert die Bereitschaft Risiken einzugehen.

(Continued)

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Table A.1. (Continued)

Item code	Dimension	Sub-dimension	Item
AX	Organisation	Interne Zusammenarbeit/ Vernetzung	Unser Unternehmen nutzt digitale Technologien um effizientere Arbeitsweisen zu ermöglichen.
AY	Organisation	Interne Zusammenarbeit/ Vernetzung	Unser Unternehmen ermöglicht ein einfaches mobiles Arbeiten.
AZ	Organisation	Interne Zusammenarbeit/ Vernetzung	Unser Unternehmen setzt agile Projektmanagementmethoden bei Softwareentwicklungsprojekten konsequent ein.
BA	Organisation	Personal	Unsere Mitarbeiter sind in der Lage, mit der Nutzung digitaler Technologien einhergehende Probleme selbstständig zu lösen.
BB	Organisation	Personal	Bei der Einstellung von neuen Mitarbeitern sind die vorhandenen digitalen Fähigkeiten/ Kenntnisse ein wichtiges Auswahlkriterium.
BC	Organisation	Personal	Unsere Mitarbeiter stellen sich schnell auf neue digitale Technologien ein.
BD	Organisation	Personal	Unser Unternehmen schult unsere Mitarbeiter umfassend zu neuen eingesetzten Technologien.
BE	Organisation	Personal	Unsere Mitarbeiter sind sicher im Umgang mit digitalen Lösungen.
BF	Organisation	Personal	Wir haben ausreichend Mitarbeiter, die die Fähigkeiten besitzen, mit Hilfe softwarebasierter Tools statistische Auswertungen großer Datenmengen vorzunehmen.
BG	IT-Infrastruktur/ Technologie	Technologien	Unsere IT-Infrastruktur ermöglicht es systematisch Kundendaten aus verschiedenen Quellen zu integrieren.
BH	IT-Infrastruktur/ Technologie	Technologien	Unsere IT-Architektur erlaubt dynamische Anpassungen in der IT-Infrastruktur.
BI	IT-Infrastruktur/ Technologie	Technologien	Unsere IT-Infrastruktur ermöglicht es sehr dynamisch neue Funktionalitäten bei bestehenden Anwendungen umzusetzen.
BJ	IT-Infrastruktur/ Technologie	Technologien	Unsere bestehenden Systeme sind so skalierbar, dass neue Anwendungen schnell angebunden werden können.
BK	IT-Infrastruktur/ Technologie	Technologien	Unser Unternehmen hat systematisch neue digitale Technologien eingeführt.

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Table A.1. (Continued)

Item code	Dimension	Sub-dimension	Item
BL	IT-Infrastruktur/ Technologie	IT-Sicherheit	Wir aktualisieren unsere IT-Infrastruktur regelmäßig, um sich ändernden Anforderungen gerecht zu werden.
BM	IT-Infrastruktur/ Technologie	IT-Sicherheit	Unser Unternehmen setzt konsequent ein definiertes Rechte- und Rollenkonzept um.
BN	IT-Infrastruktur/ Technologie	IT-Sicherheit	Unser Unternehmen legt Wert darauf, dass Daten zentral gespeichert werden.
BO	IT-Infrastruktur/ Technologie	IT-Sicherheit	Unser Unternehmen ermöglicht den Zugriff auf alle relevanten Geschäftsdaten über mobile Anwendungen.
BP	IT-Infrastruktur/ Technologie	IT-Sicherheit	Unsere Hardware wird konsequent geschützt.
BQ	Umwelt	Umwelt	Unser Unternehmen nutzt umfassend staatliche Fördermöglichkeiten zur Digitalisierung.
BR	Umwelt	Umwelt	Unser Unternehmen beschäftigt sich regelmäßig mit staatlichen Fördermöglichkeiten zur Digitalisierung.

Note: Original query of *Digitalcheck Mittelstand*.

Table A.2. List of items and corresponding Item codes—English translation.

Item code	Dimension	Sub-dimension	Item
A	Strategy	Digital strategy	Our organisation has defined clear strategic deliberations on digital transformation.
B	Strategy	Digital strategy	Our organisation has defined a step-by-step implementation plan to achieve our goals.
C	Strategy	Business model	Digital business models are implemented alongside the existing business model.
D	Strategy	Business model	Partners are actively involved in business model innovation.
E	Strategy	Business model	The continuous adaptation of the business model is seen as a core task of corporate management.
F	Strategy	Investments	Our organisation invests purposefully in the expansion of digital competencies.
G	Strategy	Market and competition	Our organisation interacts with external partners to gain access to digital capabilities.

(Continued)

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Table A.2. (Continued)

Item code	Dimension	Sub-dimension	Item
H	Strategy	Market and competition	Startups that can impact our business model are regularly examined
I	Strategy	Market and competition	Through networking with external partners, innovations are created jointly.
J	Strategy	Market and competition	The activities of our competitors are continuously monitored, particularly in the context of digital transformation.
K	Customers	Customer data	Our organisation uses digital technologies to collect customer data.
L	Customers	Customer data	Our organisation systematically analyses customer data using digital technologies.
M	Customers	Customer experience	Our organisation creates a consistent customer experience across all channels.
N	Customers	Customer experience	Our organisation offers customers multiple digital channels for communication.
O	Customers	Customer relationship	Our organisation uses extensively collected customer data to create customer profiles.
P	Customers	Customer relationship	Our organisation consistently uses the customer data we collect to create customer segments.
Q	Customers	Customer relationship	Our organisation uses digital technologies to strengthen customer relationships.
R	Products and Services	Digital service portfolio	Our digital offerings are adapted based on ongoing data analysis.
S	Products and Services	Digital service portfolio	Our organisation's offerings are consistently provided via digital channels.
T	Products and Services	Digital service portfolio	Digital offerings support our existing products/services.
U	Products and Services	Product innovation	Our organisation uses data to develop innovative products/services that are consistently focused on customers.
V	Products and Services	Product innovation	Our organisation consistently uses the analysis of large amounts of data to derive measures for product development.
W	Products and Services	Product innovation	Our organisation uses various sources for the development of new products/services.
X	Products and Services	Product innovation	Our organisation brings products to market with minimal requirements, intending to get real market feedback as quickly as possible.

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Table A.2. (Continued)

Item code	Dimension	Sub-dimension	Item
Y	Products and Services	Product innovation	Our organisation works with pilot projects for larger projects to reduce risks to defined areas initially.
Z	Processes	Digital business processes	The various steps of the business processes are digitally mapped in our company.
AA	Processes	Digital business processes	Our organisation ensures that stored data is complete.
AB	Processes	Digital business processes	Our organisation ensures that stored data is accurate.
AC	Processes	Digital business processes	Our organisation ensures that stored data is consistent.
AD	Processes	Digital business processes	Our organisation ensures that stored data is up to date.
AE	Processes	Digital business processes	All relevant process data can be accessed in real-time.
AF	Processes	Digital business processes	Impulses from the digital strategy often lead to innovations in business processes.
AG	Processes	Digital business processes	Our organisation continuously reviews whether core processes can be improved through the use of digital solutions.
AH	Processes	Digital business processes	Digital solutions support the majority of our business processes.
AI	Processes	Digital business processes	Routine processes are fully automated through the use of digital technologies.
AJ	Processes	Digital interfaces	Standardised processes are defined within the framework of cooperation with partners.
AK	Processes	Digital interfaces	Digital interfaces are consistently established with our cooperation partners.
AL	Organisation	Leadership	Our management communicates company-wide the benefits achieved through the realisation of digital projects.
AM	Organisation	Leadership	The management clearly communicates to employees challenges associated with implementing the digital strategy.
AN	Organisation	Leadership	In our organisation, executives act as key drivers in the implementation of the digital strategy.
AO	Organisation	Leadership	Our management is open to feedback.
AP	Organisation	Data privacy	Our organisation has an understandable privacy policy.

(Continued)

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Table A.2. (Continued)

Item code	Dimension	Sub-dimension	Item
AQ	Organisation	Data privacy	Our organisation provides our employees with comprehensive training on data protection requirements.
AR	Organisation	Culture	In our organisation, all employees are actively encouraged to act in an entrepreneurial manner.
AS	Organisation	Culture	Our corporate culture allows us to try out new ideas quickly.
AT	Organisation	Culture	There is an open error culture in our organisation.
AU	Organisation	Culture	Our employees are open to digital technologies.
AV	Organisation	Culture	There are opportunities for all employees to help shape the digital transformation.
AW	Organisation	Culture	Our corporate culture promotes a willingness to take risks.
AX	Organisation	Internal collaboration/ networking	Our organisation uses digital technologies to enable more efficient ways of working.
AY	Organisation	Internal collaboration/ networking	Our organisation makes it easy to work on the go.
AZ	Organisation	Internal collaboration/ networking	Our organisation consistently applies agile project management methods to software development projects.
BA	Organisation	Employees	Our employees can independently solve problems associated with the use of digital technologies.
BB	Organisation	Employees	When hiring new employees, existing digital skills are an essential selection criterion.
BC	Organisation	Employees	Our employees adapt quickly to new digital technologies.
BD	Organisation	Employees	Our organisation provides comprehensive training to our employees on new technologies in use.
BE	Organisation	Employees	Our employees are confident in using digital solutions.
BF	Organisation	Employees	We have sufficient employees who can perform statistical analyses of large amounts of data using software-based tools.
BG	IT-Infrastructure/ technology	Technologies	Our IT infrastructure makes it possible to integrate customer data from various sources systematically.

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Table A.2. (Continued)

Item code	Dimension	Sub-dimension	Item
BH	IT infrastructure and technology	Technologies	Our IT architecture allows dynamic adjustments in the IT infrastructure.
BI	IT infrastructure and technology	Technologies	Our IT infrastructure makes it possible to implement new functionalities for existing applications in a very dynamic way.
BJ	IT infrastructure and technology	Technologies	Our existing systems are scalable so that connecting new applications is quickly possible.
BK	IT infrastructure and technology	Technologies	Our organisation has systematically introduced new digital technologies.
BL	IT infrastructure and technology	IT-security	We regularly update our IT infrastructure to meet changing requirements.
BM	IT infrastructure and technology	IT-security	Our organisation consistently implements a defined rights and roles concept.
BN	IT infrastructure and technology	IT-security	It is essential to our organisation that data is stored centrally.
BO	IT infrastructure and technology	IT-security	Our organisation enables access to all relevant business data via mobile applications.
BP	IT infrastructure and technology	IT-security	Our hardware is rigorously secured.
BQ	Environment	Environment	Our organisation makes extensive use of government funding opportunities for digitisation.
BR	Environment	Environment	Our organisation regularly deals with government funding opportunities for digitisation.

Note: Own translation of the items (original query in German).

Table A.3. Means and standard deviations of the item codes.

Item code	<i>M</i>	<i>SD</i>
A	2.71	1.21
B	2.54	1.22
C	2.75	1.30
D	2.86	1.20
E	3.45	1.24
F	3.16	1.17
G	2.87	1.35
H	2.02	1.18

(Continued)

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Table A.3. (Continued)

Item code	<i>M</i>	SD
I	2.80	1.27
J	2.84	1.24
K	2.83	1.30
L	2.26	1.22
M	2.49	1.16
N	3.32	1.24
O	2.02	1.06
P	2.13	1.07
Q	2.57	1.23
R	2.21	1.19
S	2.46	1.28
T	2.66	1.35
U	2.39	1.17
V	1.79	1.02
W	2.96	1.22
X	1.99	1.08
Y	2.74	1.36
Z	2.75	1.25
AA	2.93	1.24
AB	3.30	1.20
AC	3.21	1.22
AD	3.21	1.14
AE	2.94	1.29
AF	2.67	1.22
AG	2.90	1.18
AH	2.89	1.25
AI	2.55	1.22
AJ	2.70	1.12
AK	2.55	1.18
AL	3.26	1.26
AM	3.18	1.18
AN	3.45	1.24
AO	3.87	1.06
AP	3.57	1.23
AQ	3.34	1.26
AR	3.16	1.19
AS	3.26	1.20

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Table A.3. (Continued)

Item code	<i>M</i>	SD
AT	3.35	1.13
AU	3.49	1.02
AV	3.37	1.20
AW	2.85	1.14
AX	3.34	1.18
AY	3.21	1.31
AZ	2.21	1.23
BA	2.73	1.04
BB	2.96	1.11
BC	3.03	1.06
BD	2.95	1.19
BE	3.01	1.05
BF	2.40	1.15
BG	2.60	1.24
BH	2.91	1.15
BI	2.82	1.16
BJ	2.78	1.18
BK	2.80	1.21
BL	3.46	1.20
BM	3.50	1.28
BN	3.74	1.30
BO	2.91	1.36
BP	3.91	1.13
BQ	2.52	1.28
BR	2.34	1.25

Table A.4. Mean score per item by organisation size.

Item code	Means				
	Micro	Small	Medium	Large	Overall
A	2.99	2.76	2.49	2.91	2.71
B	2.76	2.42	2.40	2.91	2.54
C	3.04	2.95	2.50	2.67	2.75
D	3.12	3.08	2.62	2.82	2.86
E	3.66	3.68	3.26	3.21	3.45
F	3.33	3.39	2.90	3.27	3.16

(Continued)

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Table A.4. (Continued)

Item code	Means				Overall
	Micro	Small	Medium	Large	
G	2.91	2.91	2.82	2.94	2.87
H	2.27	1.99	1.87	2.18	2.02
I	2.85	2.80	2.71	3.09	2.80
J	3.03	2.90	2.69	2.88	2.84
K	2.58	3.06	2.82	2.85	2.83
L	2.18	2.14	2.32	2.52	2.26
M	2.70	2.47	2.36	2.64	2.49
N	3.34	3.44	3.29	3.15	3.33
O	2.01	1.96	1.98	2.33	2.02
P	2.18	1.90	2.14	2.52	2.13
Q	2.49	2.43	2.62	2.85	2.57
R	2.37	2.29	2.07	2.21	2.21
S	2.66	2.51	2.31	2.58	2.46
T	2.69	2.86	2.53	2.67	2.66
U	2.37	2.47	2.32	2.55	2.39
V	1.70	1.61	1.83	2.24	1.79
W	2.85	3.09	2.84	3.33	2.96
X	2.06	1.97	1.94	2.06	1.99
Y	2.37	2.72	2.86	3.06	2.74
Z	2.73	3.00	2.56	2.88	2.75
AA	3.04	3.20	2.69	2.97	2.93
AB	3.49	3.52	3.08	3.27	3.30
AC	3.30	3.48	3.05	3.06	3.21
AD	3.25	3.35	3.11	3.21	3.21
AE	3.07	3.27	2.67	2.97	2.94
AF	2.64	2.87	2.50	2.88	2.67
AG	2.85	3.05	2.81	2.97	2.90
AH	2.82	3.04	2.78	3.09	2.89
AI	2.61	2.70	2.39	2.70	2.55
AJ	2.51	2.87	2.66	2.85	2.70
AK	2.49	2.67	2.44	2.82	2.55
AL	3.75	3.49	2.89	3.21	3.26

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Table A.4. (Continued)

Item code	Means				
	Micro	Small	Medium	Large	Overall
AM	3.66	3.44	2.79	3.15	3.18
AN	3.84	3.73	3.14	3.21	3.45
AO	4.19	4.19	3.56	3.70	3.87
AP	3.28	3.62	3.65	3.76	3.57
AQ	3.09	3.39	3.36	3.67	3.34
AR	3.81	3.38	2.69	3.21	3.16
AS	3.67	3.58	2.92	3.00	3.26
AT	3.72	3.67	3.00	3.24	3.35
AU	3.94	3.67	3.18	3.39	3.49
AV	3.94	3.57	3.01	3.21	3.37
AW	3.42	3.06	2.52	2.52	2.85
AX	3.48	3.62	3.08	3.42	3.34
AY	3.27	3.34	3.04	3.48	3.21
AZ	2.19	2.20	2.20	2.27	2.21
BA	2.94	2.82	2.53	2.91	2.73
BB	3.22	3.04	2.70	3.30	2.96
BC	3.21	3.16	2.89	2.88	3.03
BD	2.91	3.15	2.73	3.45	2.95
BE	3.30	3.05	2.82	3.09	3.01
BF	2.30	2.44	2.39	2.55	2.40
BG	2.57	2.63	2.53	2.88	2.60
BH	2.81	3.04	2.81	3.18	2.91
BI	2.76	2.84	2.79	3.03	2.82
BJ	2.78	2.90	2.69	2.82	2.78
BK	2.73	2.77	2.76	3.09	2.79
BL	3.15	3.81	3.37	3.61	3.46
BM	3.12	3.57	3.60	3.73	3.50
BN	3.51	3.91	3.65	4.15	3.74
BO	2.75	3.13	2.79	3.15	2.91
BP	3.55	4.25	3.86	4.00	3.91
BQ	2.18	2.59	2.60	2.73	2.52
BR	2.00	2.37	2.42	2.64	2.34

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Table A.5. Varimax rotation of items and variance.

Item code	Factors											
	1	2	3	4	5	6	7	8	9	10	11	12
A								0.53				
B								0.70				
C					0.48							
D												
E												
F	0.40											
G										0.43		
H												
I												
J												
K												
L		0.50										
M												
N					0.48							
O		0.79										
P		0.75										
Q		0.43										
R		0.45										
S					0.72							
T					0.69							
U		0.63										
V		0.65										
W										0.43		
X		0.42										
Y										0.40		
Z												
AA				0.66								
AB				0.79								
AC				0.76								
AD				0.75								
AE				0.59								
AF												
AG												
AH												0.50
AI												
AJ									0.46			
AK									0.57			
AL	0.60								0.41			

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Table A.5. (Continued)

Item code	Factors											
	1	2	3	4	5	6	7	8	9	10	11	12
AM	0.64											
AN	0.67											
AO	0.66											
AP						0.70						
AQ						0.64						
AR	0.78											
AS	0.74											
AT	0.70											
AU	0.54											
AV	0.73											
AW	0.69											
AX												
AY												
AZ		0.44										
BA							0.64					
BB												
BC							0.57					
BD												
BE							0.69					
BF		0.43										
BG			0.49									
BH			0.72									
BI			0.74									
BJ			0.73									
BK			0.60									
BL			0.46				0.42					
BM							0.55					
BN							0.44					
BO			0.44									
BP							0.54					
BQ											0.79	
BR											0.80	
Proportion variance (%)	10.7	7.6	6.5	6.3	5.1	4.7	4.0	3.6	2.6	2.4	2.3	1.3
Cumulative variance (%)	10.7	18.3	24.8	31.0	36.1	41.0	44.8	48.4	51.0	53.3	55.7	57.0

Note: Factor loadings < 0.40 (positively or negatively) have been excluded.

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Table A.6. SME characteristics and application in the digital transformation maturity model.

Criteria	Description	Impact on SME-specific digital transformation maturity model	Application
Constrained resources	Concerning their company size, SMEs often lack the resources to look for new ways outside their core competencies. They are often constrained in their resources. Thus, they may lack resources and capabilities essential for transformation. (Brunswick and Vanhaverbeke, 2015; De Massis <i>et al.</i> , 2018; Lee <i>et al.</i> , 2010; Mittal <i>et al.</i> , 2018)	Concerning the scarcity of resources, there is a need for stronger dovetailing between investments and strategy in SMEs. Conclusion: there is a need not only for a focus on long-term investment decisions but also for openness to invest in smaller digital initiatives as early as possible, thus creating a culture of error that allows for the abandonment and failure of projects.	Dimension: strategy Sub-dimension: investment
Lack of technological assets	Due to resource constraints, SMEs often lack the technical assets required for digital transformation. Accompanied by that is often a lack of IT integration, particularly in SMEs compared to multinationals, so that software (including data analysis tools) used to maintain SME data sets is tailored to the specific problems of SMEs. Furthermore, SMEs are often not early adopters because they are afraid of investing in the wrong technologies or adopting unsuitable processes. (Brunswick and Vanhaverbeke, 2015; De Massis <i>et al.</i> , 2018; Lee <i>et al.</i> , 2010; Mittal <i>et al.</i> , 2018)	SMEs should emphasise their IT-Infrastructure, the lack of technological assets, the insecurity regarding technical decisions, and the increasing relevance of IT-Security.	Dimension: IT-infrastructure/ technology Sub-dimension: technology Sub-dimension: IT-security
Product specialisation	Due to limited technical and financial resources, SMEs' research and development areas are not very advanced. However, SMEs often have highly specialised products that enable them to develop outstanding expertise and remarkable efficiency to differentiate themselves from their competitors. (De Massis <i>et al.</i> , 2018; Mittal <i>et al.</i> , 2018)	SMEs have a stronger focus on the digitalisation of their service offering. Hence, the model needs to consider innovative approaches to product development for more efficient and faster product development.	Dimension: products and services Sub-dimension: digital service offering; product innovation

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Table A.6. (Continued)

Criteria	Description	Impact on SME-specific digital transformation maturity model	Application
Standards	<p>However, unlike large organisations that adhere more strictly to standards like, e.g., ISO standards, these standards in SMEs are rare, partly due to the resources required to prepare and conduct certifications. As a result, SMEs often must consider industry standards. (Mittal <i>et al.</i>, 2018)</p>	<p>The organisation's strategic direction is highly dependent on the personality and skills of the entrepreneur. SMEs have few opportunities to compensate for wrong decisions. As a result, they emphasise formulating and implementing a digital strategy to shape the digital transformation systematically.</p>	<p>Dimension: strategy Sub-dimension: digital strategy</p>
Organisational culture	<p>The organisational structure in SMEs is less complicated and much more informal than in large organisations. Thus, SMEs tend to be more flexible and less formalised, making decisions more quickly. SME decisions are primarily based on the "gut feeling" of the manager/decision-maker. Therefore, SME managers/decision-makers may not be confident in their decisions, leading to a delay in implementing new digital technologies.</p> <p>However, at the same time, the organisational culture is often not flexible enough to experiment and consider initiatives to introduce new digital technologies. (De Massis <i>et al.</i>, 2018; Mittal <i>et al.</i>, 2018; Pfohl, 2013)</p>	<p>Managers are the decisive drivers of change processes concerning their position in the organisation. Therefore, the model needs to emphasise the owner's importance as the primary driver of change processes.</p>	<p>Dimension: organisation Sub-dimension: leadership</p>
Employee Involvement	<p>The opportunities and possibilities of employees differ in SMEs and large organisations. For example, employees in SMEs are more likely to be generalists and less likely to develop high levels of expertise in a particular field as they have day-to-day responsibilities in a variety of areas. Employees of large organisations, on the other hand, are more likely to be highly</p>	<p>SMEs, in particular, need to create an open error culture. Because of staff shortages, SMEs need to retain employees and actively take them on the digital journey. To remain interesting for employees in the future, SMEs should create innovative workplaces.</p> <p>Due to the increase in the importance of the centralisation of knowledge, strengthening</p>	<p>Dimension: organisation Sub-dimension: culture Sub-dimension: internal collaboration; networking Dimension: processes</p>

(Continued)

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Table A.6. (Continued)

Criteria	Description	Impact on SME-specific digital transformation maturity model	Application
	specialised and thus considered experts in specific areas. (Bos-Brouwers, 2010; Mittal <i>et al.</i> , 2018; Uhlaner <i>et al.</i> , 2013)	faster and more efficient exchange in SMEs is increasingly necessary. In this regard, SMEs particularly need support and professionalisation of existing structures and processes through new digital technologies.	Sub-dimension: digital processes; digital interfaces
Alliances	Alliances and networks in SMEs often have an inter-organisational and boundary-spanning element. Hence, strategic and multi-actor alliances are drivers of innovation and help SMEs access necessary resources, extend their technological competencies, and build legitimacy and reputation. Nevertheless, SMEs regularly struggle with finding the right partners and making purposively good use of external relationships for innovation. (Agostini and Nosella, 2018; Brunswicker and Vanhaverbeke, 2015)	Due to their constraints, SMEs need more significant involvement of external partners for their product development and digital transformation activities.	Dimension: products and services Sub-dimension: digital service offering; product innovation
Collaboration	SMEs often lack collaborations with universities and other research institutions. Since they have little access to shared knowledge, they can learn only to a limited extent from their own experience. Moreover, the knowledgeability of SMEs often concentrates mostly on one area of expertise, whereas in large organisations the knowledge base is broader. Contrary, SMEs are often well connected with other SMEs, regularly exchanging information to learn from each other. (Agostini and Nosella, 2018; De Massis <i>et al.</i> , 2018; Mittal <i>et al.</i> , 2018)	SMEs need to monitor the emergence and relevance of new digital technologies, as these can drastically affect competition and the industry. Therefore, SMEs need a more substantial and, above all, broader analysis of new potential competitors, e.g., by startups.	Dimension: strategy Sub-dimension: market and competition Dimension: environment

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