An Approach for a Digital Maturity Model for SMEs Based on Their Requirements

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1 Introduction

"Digitalization" and "digital transformation" are currently some of the most used buzzwords in consulting, economics, and management sciences. The media constantly seems to report that Germany is at risk of losing touch with the latest trends, but, according to the digital economy and society (DESI) index of the European Commission, Germany is placed slightly above average with countries such as Finland, Sweden, the Netherlands, and Denmark leading the field (European Commission 2019). Some might speak of "Digital Darwinism" (Kreutzer and Land 2015), suggesting that technology and society are changing faster than businesses can adjust.

The bigger the company, the higher their perception of digital maturity (Lichtblau et al. 2018; Brandt 2018). Taking a deeper look, it is particularly the German SMEs that will have to adapt their current business models to new consumption patterns and disruptive technologies or risk losing their competitive advantages in a globalized marketplace. Only one in four companies uses digital marketing or sales concepts, reorganized workflows to prepare for the digital age, or digitalized their products and services (Zimmermann 2019).

A possible and efficient solution to correctly determine the status quo of a company's state of digitalization can be the use of a digital maturity model (DMM). Maturity models are rather practical tools that have been present in different areas of actions, e.g., project management (Cook-Davies 2002: 16–20), for quite some time but have become extremely popular in recent years in the context of

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digital transformation (Hess 2019). In our understanding, a DMM serves to clarify the current state of digitalization of a company based on different questions and variables, sometimes compared to other companies in the same sector or cross-sectoral and recommends further actions to improve the company's state of digitalization.

Although the Internet is currently being flooded with practical tools provided by different stakeholders, there is little theoretical consensus on what a DMM is. The problem here lies within the lack of clarity of tools and literature as well as objectivity when it comes to the application, execution, and analysis of a DMM in practice. Therefore, we seek to provide insight into what requirements SMEs have and how they can be integrated into future DMMs.

2 Theoretical Background

A common opinion or standard procedure is not apparent regarding either maturity models or the degree of DT.

Digital Transformation

Various definitions of DT have been presented (e.g., BMWi 2015; Bowersox et al. 2005; Bouée and Schaible 2015; PwC 2013). In our understanding, DT can be seen as follows:

> . . .the networking of actors such as businesses and customers across all value-added chain segments, and the application of new technologies. As such, DT requires skills that involve the extraction and exchange of data as well as the analysis and conversion of that data into actionable information. This information should be used to calculate and evaluate options, in order to enable decisions and/or initiate activities. In order to increase the performance and reach of a company, DT involves companies, business models, processes, relationships, products, etc. (Schallmo et al. 2017)

Maturity Models

Becker et al. (2009b: 2–3) state that many maturity models often deal with similar topics, deriving from the field of business informatics or considering the use of information technologies in companies or other organizations. For example, there have been around 30 different maturity models in the domain of "project management" (Cook-Davies 2002: 16–20) and even 150 maturity models for "IT service capability, strategic alignment, innovation management, program management, enterprise architecture, or knowledge management maturity" (Bruin et al. 2005: 3).

The authors criticize that only in rare cases is it even disclosed how the development of a new maturity model was motivated, in which steps it was developed, who

was involved in these steps, and whether and how it was evaluated that the new model fulfilled its function (Becker et al. 2009b: 2–3).

Degree of Maturity

Basically, the degree of maturity of a research object deals with the fulfillment of certain objectives, characteristics, or indicators (Becker et al. 2009a: 213). The characteristic values or dimensions necessary to achieve a degree of maturity are generally predefined (CMMI Product Development Team 2011: 464); the point in time can be arbitrary (Pfeifer-Silberbach 2005) but is usually the actual state of a company and its products, services, business model, and processes considering the point in time of the measurement.

Digital Maturity Models

Considerable research has been done on maturity models focusing on digital capabilities in the areas of IT management (Becker et al. 2009b) and business processes (Tarhan et al. 2016; Williams et al. 2019). Maturity models for digitization in companies must summarize certain characteristics in particular dimensions at a specific time (Becker et al. 2009a; Pfeifer-Silberbach 2005; CMMI Product Development Team 2011: 464). They serve to determine the current state and the degree of digital maturity in the context of DT (e.g., regarding competence, performance, and level of experience) and allow recommendations for future actions deriving from the current degree of maturity.

Small and Medium Enterprises and Their Requirements

According to the Institut für Mittelstandsforschung (2020), SMEs are companies that employ fewer than 500 persons and have an annual turnover not exceeding 50 million euros.

SMEs are also typically seen as long-term, stable, and independent (Bundesverband der Deutschen Industrie e. V. 2015). Therefore, they have their own needs and requirements, especially when it comes to new and radically changing issues like DT. They do not rely much on theoretical approaches and prefer quick and easy pragmatic solutions. Their requirements must consist of practical facts and recommendations for action.

Furthermore, Arendt (2008: 93–108) found that knowledge and skills were the biggest barriers for SMEs with regard to digital initiatives. Zimmermann (2019: 11) adds data security and governance as well as Internet infrastructure.

3 Research Questions and Research Design

Research Questions

Based on the previous sections, we propose the following research questions:

- What are their main requirements for the creation of a DMM to support SMEs?
- What DMMs exist?
- What does a suitable maturity model for SMEs look like?

Research Design

Our research design consists of three parts. First, we collected practical qualitative data by interviewing SMEs for their requirements regarding DMMs. Second, we conducted a systematic literature review (SLR) to gain insight into existing approaches for DMM. In the last step, we compared theoretical and practical results to see how DMMs for SMEs can be improved in the future.

For the qualitative data, we used action research as this method helps to "address complex real-life problems and the immediate concern of practitioners" (Avison et al. 1999: 95), and we can test and refine a DMM approach for SMEs with the help of SMEs' feedback.

In the context of the InnoSÜD research project "Digitaler Reifegrad@Mittelstand" at the University of Applied Sciences Neu-Ulm, in various workshops and interviews with regional SMEs, we are currently in the process of obtaining data and requirements for developing and testing an SME-oriented DMM. The goal of the InnoSÜD university network is to use innovative transfer formats to facilitate a sustainable and effective exchange between science, business, and society. The focus is on topics that are important for the region, such as transformation management. In this case, the transfer refers to SMEs. With the support of the Institute for Digital Transformation of the University of Applied Sciences Neu-Ulm, they should determine their digital maturity to be able to derive a digitization strategy and implement it in their own company.

We interviewed five regional SMEs on the topics of digital maturity and DT in their companies to determine the necessary requirements for an SME-oriented DMM.

The central questions asked were:

- What is the status quo of your company regarding the DT?
- Where do you see the biggest problem field in your company regarding the DT?
- Where do you see the greatest need for action regarding digitalization in your company?
- What are your expectations for determining digital maturity?

Furthermore, we conducted an SLR to gain insight into existing approaches for DMMs as "[s]ystematic reviews are undertaken to clarify the state of existing research and the implications that should be drawn from this" (Feak and Swales 2009: 3). This formal and methodical approach aims to reduce bias in choosing literature selectively and to increase the reliability of the chosen literature (Tranfield et al. 2003).

For the SLR, we used the keywords "*Digitalisierung*," "digitalization," "*Digitaler Reifegrad*," "digital maturity," "*Reifegradmodell*," "maturity model," "digital assessment," "digital readiness," and "digital fit" to retrieve sources from the Internet as well as Web of Science, SpringerLink, Ebsco, Emerald, ScienceDirect, and Wiley databases.

To refine the review, we applied the following exclusion criteria. First, we only kept sources for analysis that were available in German or originated in Germany, Austria, or Switzerland. We conducted our workshops and interviews in Southern Germany (Bavaria and Baden-Wurttemberg), and our objective was to rely on available additional data with a minimum of cultural-related bias as DT and maturity might be perceived differently in other areas of the world.

Second, we focused on maturity models with the core topic of DT. As mentioned above, maturity models are present in various areas of action, but our focus is on digitalization and DT.

Third, sources had to be generally or at least cross-sectionally applicable. To achieve transparency and possible comparison among the different SMEs interviewed, it was not possible to rely only on industry-specific DMMs.

Sources were further examined using the following criteria:

- Group: Who designed the model?
- Sector: What are the main target sectors of the maturity model?
- Methodology: How was the survey conducted, and how were data collected?
- Model structure: How is the model structured? How many questions, dimensions, rating levels (degrees of maturity) does it consist of?

The results are summarized in Table 3 in the appendix of this chapter. As a last step, we present the following four DMMs and compare them to SME requirements from the interviews:

- Digitaler Reifegrad of Schweizer KMU, (Wyss 2017)
- Industrie 4.0 Readiness Modell, (Digital in NRW n.d.)
- Industry 4.0/Digital Operations Self-Assessment, (Geissbauer et al. 2016)
- Potentialanalyse Arbeit 4.0, (Offensive Mittelstand – Gut für Deutschland 2018)

These were chosen because (1) the questions were simple, understandable, and minimally complex so that they could be used in a workshop context; (2) each of them comes from a different group; and (3) they all include recommendations for further actions and therefore seem to have a good overall fit for an application to SMEs.

4 Findings

We analyzed four DMMs and examined how they meet the requirements of SMEs deriving from interviews and workshops of the InnoSÜD research project "Digitaler Reifegrad@Mittelstand." None of the existing models met all of the requirements. Consequently, suggestions for improving future model constructs can be derived.

Requirements for SMEs Based on "Digitaler Reifegrad@Mittelstand"

The results of the workshops are summarized in Table 1. We clustered the SMEs' responses into various dimensions, such as (digital) strategy; the interaction with partners and suppliers via a partner interface; the company's processes, employees, and used technologies; the interaction with customers via a customer interface; and the company's products and services.

The most important areas for improvement are internal processes, products, and services and the overall digital strategy. Processes are often "highly analog" and "still use a lot of paper," which "impedes the processing of important data" internally and toward customers, partners, and suppliers. In this context, IT systems are very old or the IT infrastructure is not harmonized.

Regarding products and services, the potential of new technologies, such as artificial intelligence or mobile apps, to upgrade existing products and expand the service portfolio has already been detected, but these initiatives progress slowly due to a lack of capacity and knowledge of the company's employees.

This leads to the third core topic: digital strategy. The companies know that "something has to be done" but often "do not know where to start." Determining the digital maturity is seen as a good way to discover "potentials and recommendations for further actions" as well as to create a "digitalization roadmap including priorities."

Table 1 Required dimensions for digital maturity models provided by SMEs

Requirements/dimensions	SME 1	SME 2	SME 3	SME 4	SME 5
Strategy		●		●	●
Partner interface			○	●	●
Processes	●		●	●	●
Employees	○	○		○	●
Technologies		○	○	●	●
Customer interface		○	○	●	●
Products and services		○	●	●	●

●—Strong need for further actions (top priority)
○—Need for further actions
Blank—No immediate need for further actions

Existing Approaches for Digital Maturity Models

Table 3 in the appendix of this chapter summarizes the results of the SLR. In general, there is a large number of maturity models, which are based on different dimensions and are therefore neither generally comparable nor applicable. Studies differ in terms of the industries and sectors, company sizes, and the number of participating companies.

A wide variety of methodologies have been applied from (online) questionnaires and online self-checks (e.g., Hochschule Neu-Ulm [(HNU)], minnosphere GmbH 2017; Techconsult n.d.; Mittelstand 4.0 Kompetenzzentrum Kaiserslautern n.d.) over conceptual modeling (Westerman et al. 2012) and literature reviews (Back et al. 2016, 2017) toward more qualitative methods, such as interviews (Geissbauer et al. 2016), focus groups, workshops (e.g., Acatech n.d.; H&D 2016), and assessments (fme AG n.d.).

We see the following main groups as creators of DMMs:

- Consulting firms use DMMs as a practical supporting tool for providing information and consultancy services to companies needing to improve their digital strategy. Their objective is profit-orientated, like the companies they are consulting, operating in one or various industry sectors.
- Associations are representations of a sum of companies with the intention to inform and strengthen the industry sector in which the respective companies are operating. Digital maturity should help create benchmarks and comparisons for the members.
- Universities and research institutes, in this context, have the goal to inform, educate, and support the public, e.g., companies, citizens, etc., on actual topics like digitalization, DT, and digital maturity.
- Big companies, e.g., Deutsche Telekom (Techconsult n.d.), sometimes create their own DMM to improve their status quo with regard to DT and to collect market data.

We also encountered various combinations of the groups, e.g., an association contracting a research institute for conducting a survey on digital maturity (e.g., IMPULS-Stiftung 2015), a university partnering with a company for transforming research results into a product or service (e.g., Universität St. Gallen and Crosswalk AG 2016, 2017), or a company using their knowledge for their own consulting branch (e.g., Rockwell Automation 2014).

Moreover, the model structures differ largely in the number of dimensions, questions, and rating levels. While some DMMs only deal with three (Rockwell Automation 2014), others consist of up to nine different dimensions (e.g., Frauenhofer Austria Research GmbH 2017) while the majority presents five central fields of action. The number of questions range from 15 (Digital in NRW. (n.d.).) to 166 (Offensive Mittelstand – Gut für Deutschland 2018). The number of different degrees of maturity is usually in between three and six rating levels. Only one DMM (Industrie- und Handelskammer [(IHK)] München & Oberbayern n.d.) offers 11 different maturity degrees.

Furthermore, not all information on dimensions, questions, and rating levels have been publicly available, which complicates detailed comparison of existing approaches.

Comparing SME Requirements to Existing Approaches

As Table 2 shows, none of the four analyzed DMMs fully considers every dimension of digitalization mentioned by the interviewed SMEs during the InnoSÜD research project "Digitaler Reifegrad@Mittelstand." The four existing models, however, all consider to some extent the aspects of the company (processes, employees, and technologies) as well as the overall digital strategy. The latter as well as the internal processes have been detected as the most important areas of improvement by the interviewees as well. The partner interface and sometimes the customer interface are neglected in some of the analyzed existing approaches.

Nevertheless, an approach for a DMM for SMEs should consist of all of the requirements mentioned in Tables 1 and 2. For the upcoming data collection process, the questionnaire has to include questions to determine the digital maturity of all aspects of digitalization.

5 Contributions

This study aims to determine the requirements that are currently lacking in DMMs for companies through analysis and a deductive method. The results give readers a deeper look into the requirements of SMEs in relation to DMMs. These results and

Table 2 Existing digital maturity models vs. SME requirements

Requirements/ dimensions	Industrie 4.0-readiness-Modell	Digitaler Reifegrad von Schweizer KMU	Industry 4.0/Dig. operations self-assessment	Potentialanalyse 4.0
Strategy	○	●	●	○
Partner interface		○		○
Processes	○	●	●	●
Employees	○	●	●	●
Technologies	○	●	●	●
Customer interface		●	●	○
Products and services	○	●		●

●—Included in the model
○—Partly included in the model
Blank—Not included in the model

the indication that requirements are lacking in current DMMs can be used in the development of future DMMs.

6 Practical Implications

First of all, practitioners will get an overview of and deeper insights into existing DMMs. In addition, they will find the analysis of the requirements of SMEs for DMMs and first approaches to build a model that meets the requirements of SMEs.

7 Limitations

This chapter aimed to report our current research-in-progress regarding the necessary requirements for standardized DMMs to meet stakeholder interests. We see the following limitations to this paper. Due to our focus on the German-speaking area, the results may not be generalizable on a global level.

Furthermore, it is debatable whether companies are willing to publish their data on digital maturity for a common goal. Although it would be helpful to create more transparency in the context of benchmarking, they could interpret this as an exposure of their own shortcomings, endangering their market position.

8 Recommendations for Further Research

Practitioners should be even more included in further research as the model could intensively be tested and more company data would be available for comparison. It would be interesting to create an overall accessible and anonymized database to be able to strengthen which dimensions are truly necessary for a DMM. This database would allow researchers to get insights from different industries, regions, or countries; practitioners would get a reliable benchmarking tool providing recommendations for further actions inside their companies.

Annex

Table 3 Digital maturity models

Maturity model	Group	Sector	Methodology	Structure
Industry 4.0 Maturity Model Frauenhofer Austria Research GmbH (2017)	University/ Research institute	Industry, production, manufacturing	Questionnaire, software supported calculation, visualization and report in a roadmap	9 dimensions 62 questions 5 rating levels
The Connected Enterprise Maturity Model Rockwell Automation (2014)	Consulting, Company	Industry, production, manufacturing	Five steps: assessment, secure and updated network and controls, defined and organized working data capital, analytics, collaborations	3 dimensions ? questions 5 rating levels
Industry 4.0/Digital Operations Self-Assessment Geissbauer et al. (2016)	Consulting	Industry, production, manufacturing	Interviews and surveys	7 dimensions ? questions 4 rating levels
The Digital Advantage MIT Center for Digital Business and Capgemini Consulting (Westerman et al. 2012)	Consulting	Industry, production, manufacturing	Conceptual model but refers to data (no references) with MNCs	? dimensions ? questions 4 rating levels
Digital Maturity & Transformation Study Universität St. Gallen, and Crosswalk AG (Back et al. 2016, 2017)	University/ Research institute, Company	Cross-sectoral	Literature review, expert interviews, focus groups	9 dimensions 64 questions 5 rating levels
IDT-Quickcheck—Digitales Reifegrad-Analysetool Hochschule Neu-Ulm (HNU), minnosphere GmbH (2017)	University/ Research institute, Company	Cross-sectoral	Online self-assessment, based on answering 10 core questions on the current status and the planned status in 3 years	5 dimensions 50 questions 5 rating levels
Digitalisierungsindex Deutsche Telekom (Techconsult n.d.)	Company	Cross-sectoral (selection at the beginning)	Online self-check to determine your own degree of digitalization	5 dimensions 71 questions 5 rating levels
Industrie 4.0-Readiness-Modell IdW Köln for VDMA IMPULS-Stiftung, with FIR e.V. Aachen IMPULS-Stiftung (2015)	University/ Research institute, Association	Cross-sectoral with focus on technological aspects	Online self-check to determine the individual industry 4.0 maturity level	6 dimensions 27 questions 6 rating levels

(continued)

Table 3 (continued)

Maturity model	Group	Sector	Methodology	Structure
Readiness Check Mittelstand 4.0 Kompetenzzentrum Kaiserslautern (n.d.)	Consulting	Cross-sectoral	Online self-check	5 dimensions 25 questions 5 rating levels
Leitfaden Industrie 4.0 Industrie- und Handelskammer (IHK) München and Oberbayern (n.d.)	Association	Cross-sectoral with focus on technological aspects	Online self-check for digital maturity level with a total of 19 main questions	4 dimensions 19 questions 11 rating levels
Quick Check Industrie 4.0 Reifegrad Digital in NRW (n.d.)	University/ Research institute	Cross-sectoral with focus on technological aspects	Online questionnaire with five possible answers to each question for self-evaluation	9 dimensions 15 questions 5 rating levels
Industrie 4.0-Readiness-Index H&D (2016)	Consulting	Cross-sectoral with focus on technological aspects	Cooperative maturity analysis in cooperation with the respective company	5 dimensions ? questions ? rating levels
Industrie 4.0-Maturity-Index Acatech (n.d.)	University/ Research institute	Cross-sectoral	Identification of status quo of industry 4.0 in companies via workshops	4 dimensions ? questions 6 rating levels
Digitaler Reifegrad von Schweizer KMU Hochschule Luzern (Wyss 2017)	University/ Research institute	Cross-sectoral with focus on SMEs	Study/survey	7 dimensions 54 questions 5 rating levels
Digital Maturity and Value Assessment Mc Kinsey (n.d.)	Consulting	Public sector	Survey—representative sample of authorities/ departments	4 dimensions 76 questions 3 rating levels
Digital Maturity Model tmforum (n.d.)	Association	Cross-sectoral	Online presentation with different implementation ideas	5 dimensions 110 questions ? rating levels
fme Reifegradmodell für die dig. Transformation fme AG (n.d.)	Consulting	Cross-sectoral	Assessment	5 dimensions 25 questions 5 rating levels

(continued)

Table 3 (continued)

Maturity model	Group	Sector	Methodology	Structure
Potentialanalyse 4.0 Offensive Mittelstand – Gut für Deutschland (2018)	Association	Cross-sectoral with focus on SMEs	Self-check with implementation support	6 dimensions 166 questions 3 rating levels

? means the number of questions/dimensions is unknown here and in the lower columns

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