

Thordsen, Tristan; Bick, Markus

**Article — Published Version**

## A decade of digital maturity models: much ado about nothing?

Information Systems and e-Business Management

**Provided in Cooperation with:**

Springer Nature

*Suggested Citation:* Thordsen, Tristan; Bick, Markus (2023) : A decade of digital maturity models: much ado about nothing?, Information Systems and e-Business Management, ISSN 1617-9854, Springer, Berlin, Heidelberg, Vol. 21, Iss. 4, pp. 947-976, <https://doi.org/10.1007/s10257-023-00656-w>

This Version is available at:

<https://hdl.handle.net/10419/311071>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by/4.0/>



# A decade of digital maturity models: much ado about nothing?

Tristan Thordsen<sup>1</sup> · Markus Bick<sup>1</sup>

Received: 11 August 2022 / Revised: 11 September 2023 / Accepted: 21 September 2023 /  
Published online: 24 October 2023  
© The Author(s) 2023

## Abstract

The topic of digital maturity has evolved into a full-grown hype in the last decade. It is widely assumed that the level of an organization's digital maturity is directly linked to its performance. Digital Maturity Models (DMMs) have been designed specifically to assess an organization's digital status quo and to provide concrete measures to increase its level of digital maturity. Given this relevance, a multitude of these models have emerged. Still, the development and application of DMMs is controversially discussed within the academic community leading to great uncertainty regarding their value for both theory and practice. In this systematic literature review, we seek to paint a comprehensive picture of the research field by identifying and contrasting the main contentious opinions among IS scholars. An analysis of detailed information regarding the research area – encompassing extensive DMM literature, academic discussion, and feedback – shows that various critical voices question the actual practical and theoretical value of DMMs, underlining the absence of objective evaluation criteria of these models and pointing out the lack of empirical data to prove the suggested relationship between maturity and performance. Based on our experience in this field, we provide a first synthesis of eleven years of DMMs and derive a research agenda.

**Keywords** Digital maturity model · Digital transformation · Literature review

---

✉ Tristan Thordsen  
tthordsen@escp.eu

Markus Bick  
mbick@escp.eu

<sup>1</sup> ESCP Business School Berlin, Berlin, Germany

## 1 Introduction

Following the omnipresent maxima that firms taking advantage of the manifold chances of digital transformation are “likely to dominate the competition, while those ineffectively dealing with the challenges are likely to be digital prey” (Cho et al. 2021, p. 387), today’s organizations have set out on an ongoing journey to increase their level of digital maturity. Achieving digital maturity is widely perceived as synonymous with reaping the benefits of new technologies to attain increased competitiveness (Lichtblau et al. 2015) and business performance (Eremina et al. 2019). Digital Maturity Models (DMMs) have been designed specifically to guide firms on a predefined path through the process of digital transformation (Williams et al. 2019) to “capitalize on the digital technologies” and “to overcome existential threats and gain access to game-changing opportunities” (Reddy et al. 2022, p. 223).

Today, we look back on more than a decade of Digital Maturity Models (DMMs). Since the emergence of the first model in 2011 (presumably Friedrich et al. 2011), the topic of digital maturity has evolved into a full-grown hype around the globe. Over the past eleven years, the Google query “digital maturity” has more than decupled (Google Inc. 2021). Despite their remarkable popularity among managers and the continuous emergence of new approaches, the use of Digital Maturity Models (DMMs) is controversially discussed within the academic community (Berger et al. 2020; Rader 2019; Teichert 2019). It becomes apparent that this subject bears both high practical and theoretical relevance. Design and application of DMMs are located directly at the intersection of theory and practice.

A systematic analysis of corresponding literature shows that various critical voices question the expedience of present DMMs (Thordsen et al. 2020). It is found that experts disagree on the actual contribution of DMMs to practice and research, underlining the absence of objective evaluation criteria of these models and pointing out the lack of empirical data to prove the suggested relationship between maturity and performance (Teichert 2019). One could go as far as to claim that these severe points of criticism ultimately question the sheer reason of existence of these models. Consequently, scholars in the field of maturity models univocally agree that there is a clear gap of knowledge concerning these topics (Chaniias and Hess, 2016b) and call for further investigation with regard to how maturity models “add value in comparison to more traditional ways of diagnosing improvement opportunities” for organizations (Bititci et al. 2015, p. 3065). After roughly a decade of DMM research, today is a suitable point in time to engage in a synthesis of one of the currently most controversy discussed research domains of the IS discipline. Therefore, in this paper, we seek to paint a comprehensive picture of the status quo of the research field of DMMs, particularly regarding the main controversies among IS scholars. Consequently, the underlying research questions of this work are:

1. What are the main controversies regarding Digital Maturity Models in the discipline of IS?

More specifically, the aims of this paper are:

1. To portray the main controversies and perspectives for the research field of DMMs
2. To derive a first research agenda for the topic of DMMs

We are reaching these aims by first outlining current definitions of the concept of digital maturity and DMMs respectively. In this course, we elaborate on the general approach, nature, and specific components of the existing models. After having established a common ground, we present our qualitative research design, consisting in a systematic review of academic literature in the field of DMMs, followed by a deductive content analysis based on a set of predefined categories clustering the present discussions in the academic community (Mayring 2014). Then, we structure and present our findings. Subsequently, the results are put into context while we shed light on the main areas of dissent contrasting opposing points of view in the present literature. Finally, we provide a short synthesis and propose a research agenda revealing potential avenues for future research in the areas of interest. This research agenda is both natural outcome of the present discussion and main contribution of this work.

## 2 Digital maturity models

Even after nearly 50 years of research in the subject of maturity models in general, a jargon jungle of related concepts persists. Terms such as *framework*, *stages of growth model*, *stage model*, *change model*, and *maturity model* are used synonymously (Becker et al. 2010). Additionally, an examination of the relevant literature reveals that different interpretations of the term *Digital Maturity* exist (Hellweg et al. 2021). To date, there is no standard definition for this phenomenon (Aslanova and Kulichkina 2020). To lay a solid foundation for the following systematic literature review, we refer to these short definitions:

*Digital Maturity* is “the status of a company’s digital transformation” – it describes “what a company has already achieved with regard to transformation efforts” (Chanias and Hess, 2016a, p. 2). Here, efforts encompass implemented changes both from an operational perspective, as well as acquired capabilities with regards to the mastering of the organization’s digital transformation process.

The term *Digital Maturity Model* refers to normative reference frameworks that organizations apply to determine their present state of digital maturity and thus of their digital transformation across its various building blocks and levels (Williams et al. 2019). The concept of digital transformation has been defined by Berghaus and Back (2016, p. 2) as the “technology-induced change on many levels in the organization that includes both the exploitation of digital technologies to improve existing processes, and the exploration of digital innovation, which can potentially transform the business model”. In this context, DMMs are designed to lead organizations through the challenges of digital transformation (e.g., Teichert 2019).

The objective is to identify and prioritize concrete measures that will drive the progress towards a target level of digital maturity. Consecutive evolutionary phases

represent different degrees of maturity. According to the provided definition, software maturity models, such as the capability maturity model (CMM) (Paulk et al. 1993), IT maturity models, such as Nolan's stage model (Nolan and Koot, 1992), or business transformation models (e.g., Venkatraman 1994) cannot be considered DMMs as they are not treating the organization's digital transformation within a holistic approach across its many levels. It is said that assessing a firm's maturity is a critical step in achieving a higher degree of organizational performance (Bititci et al. 2015). Due to the simplicity of maturity models and their great practical use, a great variety of DMMs has been developed during the previous decade (Büyükoçkan and Güler 2020). It becomes apparent that DMMs are mainly designed for the following fields of application in medium and large organizations. The largest stake of the identified models serves a general business context (Catlin et al. 2015; Westerman et al. 2011). Education (Đurek et al., 2018; Jugo et al. 2017) and manufacturing (Colli et al. 2018; Gajsek et al. 2019) constitute the target sectors of another substantial portion of present DMMs. Remaining models address a broad spectrum of business fields such as services (Isaev et al. 2018), government (Fath-Allah et al. 2014) and telecommunications (Ochoa-Urrego and Peña, 2020).

## 2.1 Architecture of DMMs

One characteristic of DMMs is their assessment of the organization's status of digital transformation based on a set of predefined dimensions and consecutive maturity levels. Alongside which, they offer guidance for the organization's digital transformation. This design approach is referred to as a multidimensional orientation, which is suitable considering the great complexity of the phenomenon DMMs intend to depict (Ochoa-Urrego and Peña, 2020). Again, it becomes clear that the concept of digital transformation exceeds the simple integration of new technologies in the organizational processes and activities (Teichert 2019).

Figure 1 depicts an exemplary DMM, designed for telecommunication service providers (Valdez-De-Leon 2016). Here, dimensions and evolutionary stages can be identified on the first sight.

In average, DMMs encompass six dimensions across four to six evolutionary stages, respectively (Ochoa-Urrego and Peña, 2020). The following dimensions are most popular in present DMMs: *Technology*, *Digital Culture*, *Operational Processes*, and *Digital Strategy*. Also, the dimension of *Management* (leadership and performance respectively) is often referred to. Initially designed for software development by Paulk et al. (1993) the capability maturity model (CMM) serves a blueprint for the design of new IS maturity models (Aguiar et al. 2019; Becker et al. 2010). In this regard, it is also applied as main reference for basic terminology and vocabulary. DMMs rely on this classic maturity model in the number and naming of their evolutionary stages, too (e.g. Aguiar et al. 2019).

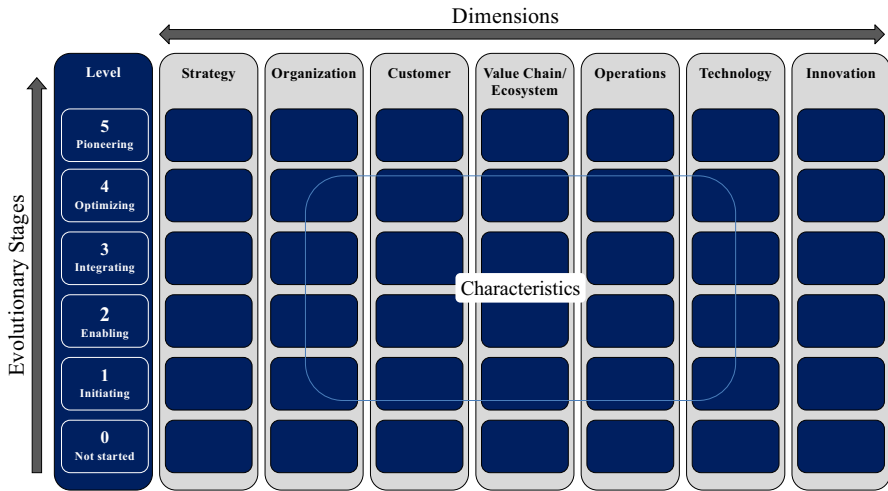


Fig. 1 Exemplary Digital Maturity Model for Telecommunication Providers (Valdez-De-Leon 2016) (adapted)

### 2.2 Stages of digital maturity

Certainly, there are substantial differences in the architecture and fields of application of DMMs (Hizam-Hanafiah et al. 2020). Nevertheless, remarkable similarities can be observed. In general, DMMs suggest resembling progressions to achieving digital maturity (Ochoa-Urrego and Peña, 2020). The following illustration depicts the typical path to an organization’s digital maturity as it is presented by existing DMMs (Fig. 2).

Inherently, the starting point of a digital organization is the creation of a *digital strategy*, which must be meticulously formulated and consistent with the overall organizational strategy (Chanias and Hess, 2016b; Matt et al. 2015; Ochoa 2016). In line with this intention, the initial stages of DMMs are related to the *strategic prioritization, flexible work, and management support of digital transformation* (e.g. Berghaus and Back 2016; Ifenthaler and Egloffstein 2020). Subsequent earlier stages of digital maturity underline particularly the strategic importance of *innovation*. In particular, DMMs stress the need for explicitly fostering *digital innovation and collaboration* and of course consequently evaluating *potential in new technologies*. Last, but not least, in these stages, *new business opportunities or models* are implemented. In this context, the vast majority of DMMs (designed for a business context) names the concept of *platformization* as a central term connecting the previously mentioned ideas (e.g. Berger et al., 2020; Catlin et al. 2015; Friedrich et al. 2011; Gill and VanBoskirk 2016; Westerman et al. 2012). The relevance of this concept for an organization’s digital transformation is underlined by current research identifying *platformization* as important “building block” in the digitalization of traditional industries (Pauli et al. 2021). In general, intermediary stages on the path towards digital maturity emphasize particularly on the *internal culture, organizational*

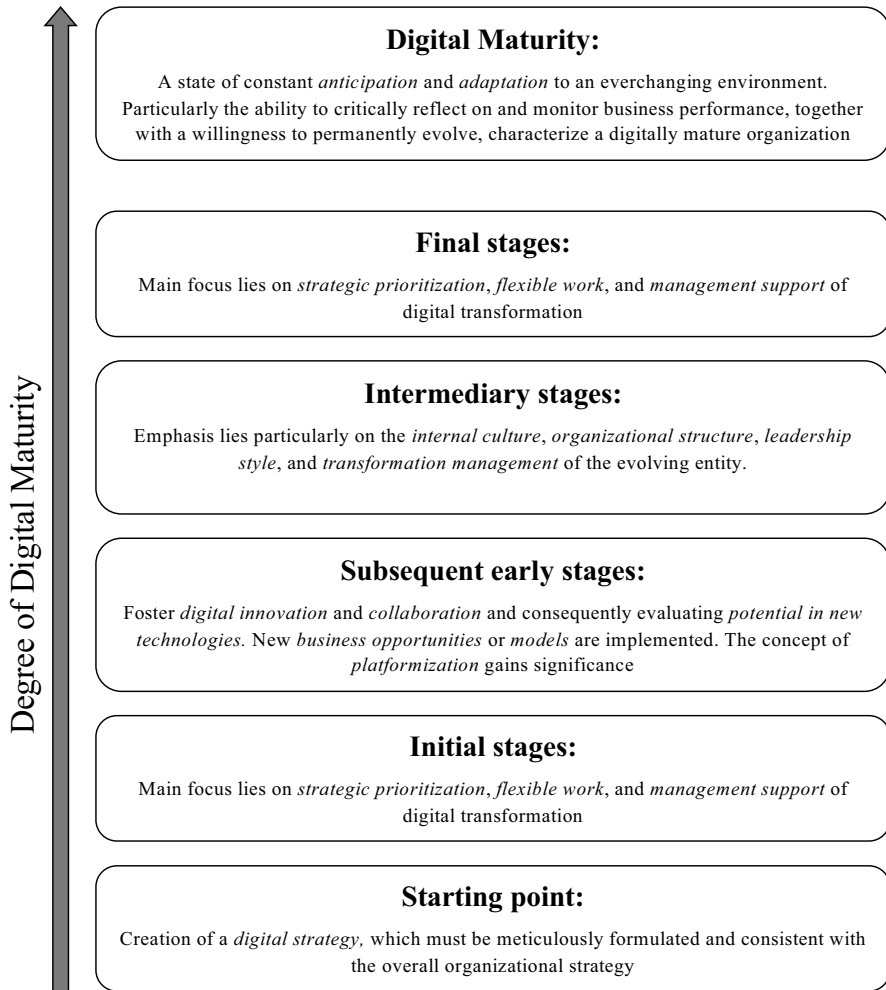


Fig. 2 Synthesis of typical evolutionary stages of current DMMs

*structure*, *leadership style*, and *transformation management* of the evolving entity (Muehlburger et al. 2019; Nguyen et al. 2019; Salvioti et al. 2019). Berghaus and Back aptly name this crucial phase “commit to transform” (2016, p. 8). Along this thought, a more radical change in the organization’s culture, roles and responsibilities comes along. Important internal capabilities here are an increased willingness to take risks combined with a pro-active error culture. As we are approaching the final stages on the way to maturity, *user-centeredness* is key (Berghaus and Back 2016; Catlin et al. 2015; Westerman et al. 2012). The personalization of customer experiences along with tailored products and services characterizes the transforming organization. This new orientation towards the customers is enabled by the data-driven enterprise. The alignment of processes and real-time analysis of customer

data using new technologies brings the organization closer to digital maturity. Due to the incredibly fast pace of technological innovation and constantly increasing customer expectations, digital maturity can be described as a state of constant anticipation and adaptation to an everchanging environment. Particularly the ability to critically reflect on and monitor business performance, together with a willingness to permanently evolve, characterize a digitally mature organization.

As said before, IS maturity models in general still hold a number of weaknesses (Becker et al. 2010). Especially the often-addressed lack of academic validity and rigor needs to be mentioned here (Teichert 2019). De Bruin et al. (2005) trace this point of criticism back to the poor theoretical base and limited empirical evidence associated with insufficient documentation on the development of the maturity models. Unfortunately, DMMs are no exception. The previously outlined flaws are also applicable for most present models (Thordsen et al. 2020). Now, having established a common ground for discussion – by outlining the central characteristics and weaknesses of DMMs – we can devote ourselves to addressing our explorative research design.

### 3 Research design

Our primary research goal is to comprehensively portray the main controversies leading the discussion in the academic community regarding DMMs. First, we must thus examine the status quo of the DMM literature by performing a systematic literature review in this research field. In this study, we exclude all models that are not explicitly related to assessing the status quo of an organization's digital transformation within a holistic approach as they cannot be considered DMMs. Software maturity models, such as the capability maturity model (CMM) (Paulk et al. 1993), IT maturity models, such as Nolan's stage model (Nolan and Koot, 1992), or business transformation models (e.g., Venkatraman 1994) are not taken into consideration. With regards to the emergence of the presumably first DMM in the year 2011 (Friedrich et al. 2011), we concentrate our research on the timeframe between 2011 and 2022, respectively.

In a next step we perform a deductive content analysis of the literature pool using a set of predefined categories along which the present discussions in the academic community are clustered. These categories have been derived from multiple sources, e.g., literature reviews, comments by reviewers and editors, discussions at scientific conferences with both researchers and practitioners, and informal talks along our field work (e.g., expert interviews). After having presented the findings of the deductive content analysis, we discuss the differing positions regarding DMMs in the academic community. Lastly, we derive a research agenda, addressing these areas of dissent.



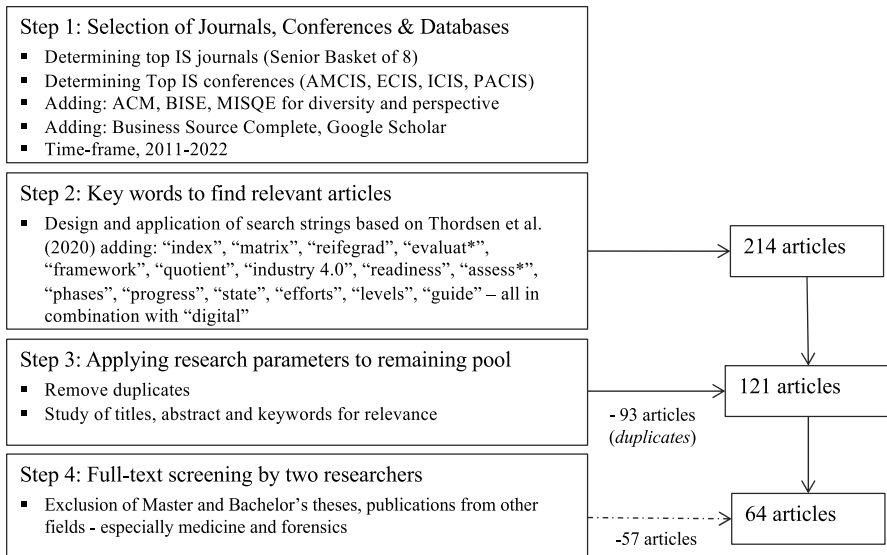
### 3.1 Systematic literature review

Based on the guidelines of Vom Brocke et al. (2009, p. 2206), in our systematic literature review, we focused on a eleven-year period (2011 to 2022) – to our best knowledge, reflecting the entire period since the emergence of the first DMM. We consulted ten leading IS journals (Senior Basket of 8 plus BISE and MISQE), four major IS conferences (AMCIS, ECIS, ICIS, PACIS) and two complementary databases (Business Source Premier and Google Scholar). In the selection of databases, outlets, and search phrases we draw on the experience of Thordsen and Bick (2020), who have previously engaged in the analysis of existing DMMs. The keywords of this systematic literature review were designed according to the PICO criteria (Population, Intervention, Comparison and Outcomes). Kitchenham and Charters (2007) deem these parameters as particularly suitable for a literature review in the discipline of IS. Furthermore, we identified synonyms and alternative spellings for the search phrases by consulting both experts and literature. Search strings for Business Source Premier are e.g.: (“maturity model” OR “stages of growth model” OR “stage model” OR “change model” OR “transformation model” OR “grid”) AND (“Transformation” OR “Digit\*”). In addition to the existing catchphrases identified by Thordsen et al. (2020), we derived the following keywords from eleven existing literature reviews in this field: “index”, “matrix”, “reifegrad”, “evaluat\*”, “framework”, “quotient”, “industry 4.0”, “readiness”, “assess\*”, “phases”, “progress”, “state”, “efforts”, “levels”, “guide” – all in combination with “digital” (Ochoa-Urrego and Peña, 2020; Schallmo et al. 2020; Teichert 2019). The search was first performed in titles, abstracts, and the publications’ keywords. It resulted in a total of 214 papers, of which 93 were duplicates. A detailed overview of the literature search process can be found in Fig. 3. After a full-text screening of the remaining 121 papers, we further excluded 55 works consisting of Master and Bachelor’s theses, publications from other fields – especially medicine and forensics. This step was performed by both authors in accordance with each other. To portray a comprehensive practical perspective, we decided to include the so-called grey DMM literature – publications by industry associations and management consultancy firms (Mahood et al. 2014). Finally, our pool of literature comprises 64 articles. It includes 29 journal articles, 19 conference articles, five book chapters and 11 publications by industry associations and management consultancy firms. A complete list of the identified papers and the type of study is provided in Table 2.

### 3.2 Qualitative content analysis

Derived from the underneath specified academic and practical sources, we have identified four leading questions that characterize the present discussion regarding DMMs in the field of IS:

1. How do DMMs contribute to practice?
2. How do DMMs contribute to theory?



**Fig. 3** Systematic literature review research process

3. What empirical evidence supports the positive relationship between digital maturity and firm performance?
4. How can existing DMMs be distinguished and assessed regarding their quality?

The underlying academic sources include in particular eleven literature reviews of this research field (Bordeleau and Felden 2019; Chaniyas and Hess, 2016a; Hizam-Hanafiah et al. 2020; Ochoa-Urrego and Peña, 2020; Ochoa 2016; Remane et al. 2017; Schallmo et al. 2020; Teichert 2019; Thordsen et al. 2020; Virkkala et al. 2020; Williams et al. 2019). Furthermore, we took into consideration comments by reviewers and editors (2017–2022) from the journals *Business Information Systems*, *Electronic Markets*, *MIS Quarterly*, and *Information Systems Frontiers* and IS conferences ECIS, ICIS, EMCIS, I3E, WM, and SKM. In this context, we gained additional valuable insights regarding the main controversies in the field of DMMs during informal talks and discussions with IS researchers from e.g., Freie Universität Berlin, the Technische Universität Dresden, and the Ludwig Maximilian Universität München. We complemented these insights with the expertise of practitioners (e.g., C-Level Executives of a multi-billion Euro media corporation) that we have interviewed along our field of work.

Accordingly, to portray current positions of the academic community, we used these questions to form predefined categories for our deductive qualitative content analysis of the 64 precisely identified DMM papers. We properly defined the coding categories, as suggested by Mayring (2014) for a comprehensive and transparent content analysis. After ten publications, we revised the description of the deductive categories and established coding rules and prime coding examples. Then, we defined respective prime coding samples (e.g., Table 1). The coding was

**Table 1** Coding rules and prime coding examples according to Mayring (2014)

Category	Prime example	Coding rule
(I) <i>Claimed contribution of DMMs to practice</i>	"This study (...) provides strategic components and guidelines to help organizations to move up from the current maturity level to the next one." (Korachi and Bounabat 2019)	Proposition of actions or guidelines related to the use of DMMs
(II) <i>Claimed contribution of DMMs to theory</i>	"In order to foster an understanding of the phenomenon and the development of a digital transformation strategy, this research derives typical stages in a digital business transformation process from empirical data" (Beghaus and Baek 2016)	Clear identification of theoretical contributions, exceeding the mere identification of digital transformation dimensions
(III) <i>Empirical evidence on positive relationship between digital maturity and firm performance</i>	"Digital maturity was shown to be statistically correlated with innovations ( $p=0.000$ ) and business revenue ( $p=0.009$ )" (da Costa 2022, p.175)	Empirical evidence or references supporting the positive impact of digital maturity on firm performance
(IV) <i>Differentiation and quality criteria of DMMs</i>	DMM should observe the following aspects: (i) the dimensions of digital maturity, (ii) the procedure for measuring digital maturity and (iii) the model's positioning in relation to existing theories (Menchini et al. 2022)	Offer at least one dimension along which DMMs can be assessed, differentiated, or standardized

performed by two researchers independently. They were in accordance in 81% of the cases (Krippendorff 2018). In the remaining cases, they reached an agreement after thoughtful discussion. To support the analysis the QCMap software's deductive coding functions were employed. The coding dimensions are defined in detail in the following sections.

## 4 Findings

In the following, the results of the deductive content analysis are displayed. Table 2 shows a comprehensive list of the literature pool and the respective characteristic of each publication with regards to the predefined categories.

The literature pool comprises 64 publications of which 53 are peer-reviewed – originating from academic journals, conferences, and books—and 11 are part of the so-called non-peer reviewed grey literature. 23 publications, of which nine are consultancy reports, derive concrete practical guidelines or actions to increase the digital maturity level of organizations. 46 of the analyzed papers outline theoretical contributions that go beyond the identification of relevant dimensions of digital maturity. All these publications are peer reviewed. Nine publications, of which five have been issued by consultancies, offer concrete empirical data on the positive relationship between the digital maturity and firm performance. 23 of the 64 works suggest concrete dimensions along which DMMs can be differentiated and assessed (Fig. 4).

The years 2019 (13 publications), 2021 (13 publications), and 2020 (12 publications) show the highest number of publications of our literature pool. In these years, all publications were peer-reviewed. Publications by industry associations and management consultancy firms can only be found between 2011 and 2018. The underneath overview shows both the total and the respective type of publication for each year since 2011.

Despite the large number of DMM publications from both scientific and practical backgrounds that have emerged in the past eleven years, the question of the DMM's overall relevance remains contested.

## 5 Discussion

Coming back to our introductory statement, in this paper, our aim is to identify the main controversies between academics in the field of DMM research and provide a synthesis after more than a decade since the emergence of the first model. Based on previous analysis of the relevant literature, we will address each of the four areas of dissent that are leading the discussion in the academic community and present the main perspectives. The following Table 3 provides a rough overview of the areas of dissent with the central pro and contra arguments identified during the qualitative content analysis.

**Table 2** Results of the qualitative content analysis according to Mayring (2014)

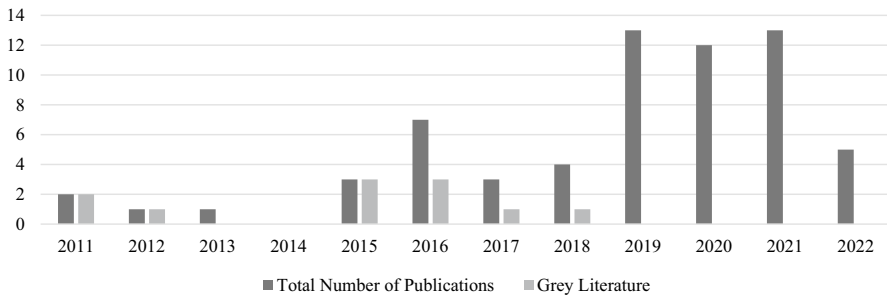
ID	Study	Type of literature	Type of study	Year	Claimed contributions to practice	Claimed contributions to theory	Empirical evidence on positive relationship between DM and firm performance	Differentiation and quality criteria of DMs
1	Friedrich et al	Grey	Consultancy Report	2011	X		X	
2	Westerman et al	Grey	Consultancy Report	2011	X			
3	Westerman et al	Grey	Consultancy Report	2012	X		X	
4	Becker et al	Academic	Book chapter	2013		X		
5	Catlin et al	Grey	Consultancy Report	2015	X		X	
6	Berger, R	Grey	Consultancy Report	2015	X			
7	Lichtblau	Grey	Consultancy Report	2015	X			
8	Arreola González et al	Grey	Consultancy Report	2016	X			
9	Berghaus and Back	Academic	Conference Paper	2016		X		
10	Berghaus and Back	Grey	Consultancy Report	2016			X	X
11	Chanas and Hess	Academic	Conference Paper	2016		X		X
12	Gill and VanBoskirk	Grey	Consultancy Report	2016	X		X	
13	Valdez-de-Leon	Academic	Journal article	2016	X			
14	Carvalho et al	Academic	Journal article	2017		X		
15	Ochoa et al	Academic	Journal article	2016		X		X
16	Deloitte Switzerland	Grey	Consultancy Report	2017	X			
17	Remane et al	Academic	Conference Paper	2017	X			X
18	Colli et al,	Academic	Journal article	2018	X			X
19	Deutsche Telekom	Grey	Consultancy Report	2018			X	
20	Mettler and Pinto	Academic	Journal article	2018		X		
21	Balaban	Academic	Journal article	2018		X		
22	Salviotti et al	Academic	Conference Paper	2019	X			
23	Rossmann	Academic	Conference Paper	2019	X		X	
24	Ifenhaler and Egloffstein	Academic	Journal article	2019	X			X

**Table 2** (continued)

ID	Study	Type of literature	Type of study	Year	Claimed contributions to practice	Claimed contributions to theory	Empirical evidence on positive relationship between DM and firm performance	Differentiation and quality criteria of DMs
25	Muehlburger	Academic	Conference Paper	2019		X		
26	Nguyen	Academic	Conference Paper	2019	X	X		X
27	Gajsek	Academic	Journal article	2019		X		
28	Korachi and Bounabat	Academic	Book chapter	2019	X	X		
29	Williams	Academic	Conference Paper	2019		X		X
30	Teichert	Academic	Journal article	2019		X		X
31	Bordeleau	Academic	Conference Paper	2019	X	X	X	X
32	Nikolova-Alexieva	Academic	Journal article	2019		X		
33	Marcos et al	Academic	Journal article	2019		X		
34	Tadeu, H.F.B, Duarte	Academic	Book chapter	2019		X		
35	Thordsen et al	Academic	Conference Paper	2020		X		X
36	Rafael	Academic	Journal article	2020				
37	Aslanova	Academic	Journal article	2020				
38	Büyükoçkan and Güler	Academic	Conference Paper	2020		X		X
39	Berger, S	Academic	Conference Paper	2020	X	X		X
40	Dobrinic	Academic	Conference Paper	2020	X			
41	Hizam-Hamafiah et al	Academic	Journal article	2020		X		
42	Schallmo	Academic	Conference Paper	2020	X	X		X
43	Gollhardt	Academic	Conference Paper	2020		X		
44	Levanituk et al	Academic	Conference Paper	2020	X			X
45	Ochoa-Urrego and Peña	Academic	Conference Paper	2020		X		X
46	Wagire	Academic	Journal article	2020		X		X
47	Kuusisto and Käiriäinen	Academic	Journal article	2021		X		X

Table 2 (continued)

ID	Study	Type of literature	Type of study	Year	Claimed contributions to practice	Claimed contributions to theory	Empirical evidence on positive relationship between DM and firm performance	Differentiation and quality criteria of DMs
48	Pavel	Academic	Journal article	2021	X	X		X
49	Caiado	Academic	Journal article	2021	X	X		X
50	Kerpedzhiev	Academic	Journal article	2021		X		
51	Gökalp and Martínez	Academic	Book chapter	2021		X		
52	Kafel et al	Academic	Journal article	2021		X		
53	Hellweg	Academic	Journal article	2021	X	X		X
54	Salume	Academic	Journal article	2021		X		
55	Wernicke et al	Academic	Journal article	2021		X		
56	Budd and Suau-Sanchez	Academic	Journal article	2021		X		
57	Borcan	Academic	Journal article	2021		X		
58	Enkel	Academic	Journal article	2021		X		
59	Schallmo	Academic	Conference Paper	2021		X		X
60	Ostmeier	Academic	Journal article	2022		X		
61	Menchini	Academic	Journal article	2022		X		X
62	Minh	Academic	Journal article	2022		X		X
63	Santiago da Costa	Academic	Conference Paper	2022			X	
64	Illin et al	Academic	Book chapter	2022		X		X



**Fig. 4** Frequency distribution of publications per year and type (2011–2022)

### 5.1 Claimed contribution of DMMs to practice

Above all, critics of DMMs question the practical value of the models (Bordeleau and Felden 2019; Schallmo et al. 2020). They mainly base their opinion on the nature of a model an extreme simplification of reality. They argue that to date the process of digital transformation is not well enough researched and understood (Ochoa 2016). It is thus not possible to build a comprehensive model covering all relevant fields of interest (Teichert 2019; Valdez-De-Leon 2016). Other scholars claim that the concept of a company’s digital transformation is simply too complex to be put into a valid model, particularly for large companies (Hess 2019). According to them, the interplay between all relevant dimensions for digital transformation cannot be simplified to the point where it can be illustrated in a model. Overall, sceptics are convinced that there is no predefined path for the organization’s digital transformation. Along this thought, they claim that the process of digitalization cannot be generalized – as existing DMMs suggest. The sketched perspectives imply that existing DMMs do not add value to practice as they are not able to portray the entire spectrum and dynamics of a company’s digital transformation (Teichert 2019; Valdez-De-Leon 2016).

Experts in favor of DMMs take a more pragmatic approach to the practical value of these tools. The scholars’ expectation towards a practical tool is not that it needs to be perfect. On the contrary, they believe that it is expedient for DMMs to provide a better overall understanding of the phenomenon of digital transformation and its peculiarities in different industries (e.g., Carvalho et al., 2019; Gill and VanBoskirk 2016; Remane et al. 2017). DMMs, along their dimensions, allow for a simpler access to, better comprehension of, and reflection on the topic of digital transformation (Ochoa-Urrego and Peña, 2020). These insights can then further be used to identify and prioritize relevant technological and strategic factors, dimensions, areas for action, or processes, leading to an acceleration of the organization’s transformation (e.g., Arreola González et al. 2016; Berghaus et al. 2016; Muehlburger et al. 2019). Moreover, even though the process of digital transformation is most complex, they claim that the use of DMMs can lead to the identification of certain underlying trends of digital transformation as well as to the derivation of typical stages of an organization’s digital transformation and the detection of potential advantages



**Table 3** Main controversies with respective pro and contra arguments identified in the present literature

Main controversies	Pro	Contra
1) Claimed contribution of DMMs to practice	<p>DMMs add value to practice as:</p> <ul style="list-style-type: none"> <li>• It is expedient for DMMs to provide a better overall understanding of the phenomenon of digital transformation (e.g. Carvalho et al. 2019; Gill and VanBoskirk 2016; Remane et al. 2017)</li> <li>• DMMs allow for a simpler access to, better comprehension of, and reflection on the topic of digital transformation (e.g. Ochoa-Urrego and Peña, 2020)</li> <li>• They serve as a catalyst on the journey to an organization's digital maturity (da Costa 2022; Salviootti et al. 2019)</li> <li>• Their application triggers productive and structured in-depth discussion among executives that may lead a change of behavior and to an increase of the management's commitment for the organizations digital (r) evolution (Teichert 2019; Westerman et al. 2012)</li> </ul>	<p>DMMs do not add value to practice as:</p> <ul style="list-style-type: none"> <li>• The phenomenon of digital transformation is not well enough researched and understood to build a model (Bordeleau and Felden 2019; Schallmo et al. 2020)</li> <li>• The models' theoretical foundation is often questionable (Ochoa 2016)</li> <li>• DMMs cannot grasp the entire spectrum of digital transformation in a model (Teichert 2019; Valdez-De-Leon 2016)</li> <li>• The process of digitalization cannot be generalized (Teichert 2019)</li> </ul>
2) Claimed contribution of DMMs to theory	<p>DMMs add value to theory as:</p> <ul style="list-style-type: none"> <li>• New theories emerge through the application and the impact of DMMs as IT artifacts</li> <li>• DMMs, in general, provide a more profound understanding of the ongoing sociotechnical phenomenon of digital transformation by defining relevant dimensions of this process and by assessing and structuring the organization's transformation (e.g. Gill and VanBoskirk 2016; Remane et al. 2017)</li> <li>• Several publications go further and e.g. establish common terms and definitions characterizing digital maturity and related concepts such as digital readiness (e.g. Aslanova and Kulichkina 2020)</li> </ul>	<p>DMMs do not add value to theory as:</p> <ul style="list-style-type: none"> <li>• The models lack academic rigor and validity due their poor theoretical basis and limited empirical evidence (e.g. Chaniias and Hess, 2016b; Remane et al. 2017; Teichert 2019)</li> <li>• They do not extend the theoretical basis of the discipline of IS (Nguyen et al. 2019)</li> </ul>

**Table 3** (continued)

Main controversies	Pro	Contra
3) Empirical evidence on the positive relationship between digital maturity and firm performance	<ul style="list-style-type: none"> <li>• There is limited empirical evidence stemming from both academic and consultancy publications pointing out a direct positive relationship between digital maturity and firm performance</li> <li>• Previous maturity model studies from other fields of IS research underpin a positive relationship based on empirical evidence between DMM dimensions such as process maturity, performance management, management style or leadership and long-term business performance (Pedrimi and Frederico, 2018)</li> <li>• There is a publication proposing theoretically grounded, objective criteria for the scientific validity of existing DMMs (see Thordesen et al. 2020)</li> <li>• IS Researchers have established a directory especially for the development of maturity models in the field of IS in general that can be used to assess DMMs (e.g. Becker et al. 2009; De Bruin et al. 2005; Solli-Sæther and Gottschalk 2010)</li> </ul>	<ul style="list-style-type: none"> <li>• There is no reliable empirical evidence corroborating this often-claimed direct causality (Teichert 2019)</li> <li>• Due to the abstract nature and the multiple understandings of the phenomenon of digital maturity, providing empirical evidence for this relationship is not possible (Teichert 2019)</li> <li>• A higher level of digital maturity does not imply a better business performance (e.g. Hess 2019; Rader, 2019)</li> <li>• The quality and contents of existing DMMs are not comparable, there is no standard or quality criteria (Remane, 2019; Teichert 2019; Gollhardt, 2020)</li> <li>• The heterogeneity of the models renders an objective assessment of the essentiality of DMMs impossible (Gollhardt, 2020)</li> </ul>
4) Differentiation and quality criteria of DMMs		

and disadvantages for a respective organization (Thordsen and Bick 2020; Dobrinić 2020). Furthermore, certain academics claim that DMMs serve as a catalyst on the journey to an organization's digital maturity (Santiago da Costa 2022; Salviotti et al. 2019). Elaborating on this thought, supporters claim that DMMs provide the initial spark igniting the motivation to critically reflect on the digital status quo of the organization. They are convinced that the application of these frameworks triggers productive and structured in-depth discussion among executives caused by an initial facilitation of the digital transformation phenomenon (Teichert 2019; Westerman et al. 2012). This constructive contention then leads to a change of behavior and an increase of the management's commitment for the organizations digital (r) evolution drives the efforts for the organization 's digital transformation forward (Ochoa 2016). En passant, executives are encouraged to take ownership for decisions and future outcomes, thus boosting managerial capabilities. All in all, such a creative period enhances and facilitates organizational learning (Bititci et al. 2015). Apart from the DMMs' function as catalyst, enthusiasts argue that the models also provide a concrete direction for the organization, guiding both its digital strategy and transformation process (Berghaus and Back 2016). In addition, DMMs make first assessments of the organization's digital status quo possible and foster subsequent evaluations (Carvalho et al., 2019; Colli et al. 2018). As a consequence, the review and monitoring of organizational practices become more efficient and thus more frequent (Bititci et al. 2015). A continuous adaption and improvement process is initiated.

Another point of criticism that is often addressed when it comes to the added practical value of DMMs targets the presumably prescriptive character of the models (Menchini 2022). Even though, by definition, DMMs should lay out a predefined path towards digital maturity, only a third of the present publications actually suggests actions or guidelines for such an endeavor (e.g., Catlin et al. 2015; Nguyen et al. 2019; Valdez-De-Leon 2016). A large stake of these works presenting actionable insights comes from consulting backgrounds with questionable theoretical foundations (Lichtblau et al. 2015; Deloitte Switzerland 2017).

Ultimately, both sides of the academic discussion have their justification. DMMs provide some form of guidance and support for the organization's digital journey. However, the phenomenon of digital transformation is most complex and cannot be addressed by one holistic model for all purposes (e.g., Marcos et al. 2019; Tadeau et al. 2019). Therefore, it is imperative to define the DMMs' field of application as specific as possible – e.g., business sector and company profile (Berger et al., 2020; Dobrinić, 2020; Gollhardt et al. 2020). Against the popular opinion of the absence of a predefined path towards digital maturity, significant similarities regarding the nature of the evolutionary stages and their order, different organizations complete on their way to digital maturity can be perceived (Dobrinić, 2020; Ifenthaler and Egloffstein 2020). The idea of Bititci et al. (2015) provides a valuable perspective to conclude on the practical value of DMMs. The researchers believe that it is not imperative, nor realistic for a practical tool to be impeccable and exhaustive. A practical instrument can nevertheless add significant value in a real-world setting.

## 5.2 Claimed contribution of DMMs to theory

Critics furthermore question the theoretical value of the models (e.g., Chaniias and Hess, 2016b; Remane et al. 2017; Teichert 2019). Despite their enduring popularity and relevance, especially the development and application of DMMs is exposed to severe criticism (Nguyen et al. 2019). In this context, scholars address in particular the poor theoretical basis and lack of empirical evidence of DMMs (Thordsen et al. 2020; Williams et al. 2019). As currently, there are merely abstract definitions and multiple understandings of DMM-related terms, the underlying theoretical framework of the models is often not concise (Teichert 2019; Rossmann et al. 2019). This hinders the development of a valid measurement model (Thordsen et al. 2020; Hellweg 2021), leading to the often-criticized lack of academic rigor and validity in current models. An analysis of the empirical basis of the available DMMs shows that the present models are largely tested through real data, however the quality of the approaches and the applied methodology largely differs or cannot be evaluated at all (e.g., Gollhardt et al. 2020; Pavel et al. 2021). Analogous to other IS maturity models, that are exposed to similar points of criticism, this is mostly due to a lack of documentation of the data collection and development procedure (Thordsen et al. 2020).

Two superordinate paradigms characterize the discipline of IS: behavioral science and design science (Hevner et al. 2004). Both paradigms are fundamental to the IS discipline, which is at the intersection of people, organizations, and technology (Laudon and Laudon 2020). The behavioral-science paradigm pursues the goal of developing and verifying theories “that explain or predict human or organizational behavior” (Hevner et al. 2004, p. 76). In contrast, utility is the prime goal of design science research (DSR). Benbasat and Zmud (1999, p. 5) even go as far as to claim that “the relevance of IS is directly related to its applicability in design”. DSR strives for the extension of the borders of human and organizational capabilities by “creating innovative artifacts, such as constructs, models, methods and instantiations” (March and Smith 1995, p. 253). It is often applied based on the need for creative advances in research areas in which existing theory is often insufficient (Hevner et al. 2004). To support the development of such innovative artifacts, Hevner et al. (2004) has established the previously mentioned set of DSR guidelines. They have received considerable attention within the IS community (e.g., Becker et al. 2009; De Bruin et al. 2005; Solli-Sæther and Gottschalk 2010).

DMMs can be understood as being part of the creative advances stimulating critical thinking in the IS community. DMMs are designed to solve the problems of assessing an organization’s status quo of digital maturity while deriving recommendations for improvement (Chaniias and Hess, 2016a). Hevner et al. (2004) argue that new theories emerge through the application and the impact of such IT artifacts. Following this perspective, in general, academic publications in this field strive to provide a more profound understanding of the ongoing sociotechnical phenomenon of digital transformation by defining relevant dimensions of this process and by assessing and structuring the organization’s transformation (e.g., Gill and VanBoskirk 2016; Remane et al. 2017). However, several publications go further in their aim to contribute to research and to extend the theoretical basis of the discipline

of IS. In this context, several works engage e.g., in the identification of drivers for digital transformation (e.g., Jugo et al. 2017), typical evolutionary stages (Mettler and Pinto 2018), initiation factors (Muehlburger et al. 2019), theoretically founded measurement approaches and ultimately relationships between digital maturity and other organizational variables (Santiago da Costa 2022). Furthermore, among others, they aim at establishing common terms and definitions characterizing digital maturity (e.g., Aslanova and Kulichkina 2020) and related concepts such as digital readiness (Nguyen et al. 2019). Pointing out future areas of research can be seen as another theoretical contribution of present papers of this field. Finally, Becker et al. (2010) and Proença and Borbinha (2016) claim that already a deeper understanding, analysis and differentiation of IS maturity models bears a significant theoretical value.

In conclusion it can be said that DMMs initiate the emergence of new theories. Consequently, based on the DSR paradigm, DMMs contribute significantly to the theoretical advancement and relevance of the IS discipline.

### **5.3 Empirical evidence on the positive relationship between digital maturity and firm performance**

Another point of criticism addresses the character of above-mentioned positive effect. Sceptics stress the fact that there is no reliable empirical evidence corroborating this often-claimed direct causality. They claim that to this date, due to the abstract nature and the multiple understandings of the phenomenon of digital maturity, providing empirical evidence for this relationship is not possible (Teichert 2019). The often proclaimed statement “the more digital, the better” is according to these experts nothing more than a presumption (e.g., Hess 2019; Rader, 2019). Following this approach, a higher level of digital maturity does not imply a better business performance. Again, the sheer *raison d’être* of DMMs is put into question.

Despite this point of criticism, authors in this field have made well-argued inferences leading them to believe to that there is truth in the above statement. In general, publications of the literature pool claim that the positive effects of digital maturity on firm performance are realized by seizing the opportunities, and reaping the benefits, while simultaneously reducing the risks of digital transformation (e.g., Carvalho et al., 2019; Westerman et al. 2011). More precisely, academics and practitioners claim that the attractiveness for investments as well as the competitive advantage increases when organizations advance on their path to digital maturity (Arreola González et al. 2016; Korachi and Bounabat 2019; Nikolova-Alexieva, 2019). These previously mentioned positive effects of an organization’s digital transformation on the firm performance are thus indirect. Nevertheless, nine of the analyzed papers in the literature pool claim to provide empirical evidence or references on a direct positive impact of digital maturity on business performance. From these publications, six works come from consultancy backgrounds and present the most extreme and “promising” empirical evidence for the positive relationship between digital maturity and financial performance (revenue generation, profitability, market valuation)

(Westerman et al. 2012) and ultimately the growth of the organization (e.g., Gill and VanBoskirk 2016).

Based on the analysis of the digital maturity level and the industry-adjusted financial performance of 184 publicly traded firms, Westerman et al. (2012) derive that more mature companies outstrip their industry competitors significantly. With regards to revenue per employee and fixed asset turnover, more digitally mature firms outperform their peers by 6–9%. The authors claim that Conservatives and Digirati – level three and four of four predefined digital maturity levels – are “on average 9–26% more profitable than their average industry competitors on a basket of measures including EBIT margin and net profit margin” (Westerman et al. 2012, p. 8). The organizations that have attained the fourth level (Digirati) are according to the authors “on average 26% more profitable than their industry competitors. They generate 9% more revenue through their employees and physical assets. And they create more value, generating 12% higher market valuation ratios” (Westerman et al. 2012, p. 8). Unfortunately, the methodology of the data collection and analysis are not transparent and do not comply with academic standards, which leaves considerable doubt to the scientific credibility of the results.

Another consultancy report by Gill and VanBoskirk (2016, p. 10) suggests “that Differentiators are almost three times more likely to demonstrate double-digit year-over-year revenue growth than Sceptics”. Again, the highest level (Differentiators) and lowest level (Sceptics) of digital maturity according to the underlying DMM of this report are being compared. These results are based on a survey of 1039 marketing decision makers, conducted in eight countries in Europe and North and South America. Again, the methodology remains largely untransparent and can thus not be replicated. Academic publications are much more careful when presenting results supporting the above-mentioned relationship. Previous maturity model studies from other fields of IS research underpin a positive relationship between dimensions such as process maturity, performance management, management style or leadership and long-term business performance (Pedrini and Frederico, 2018). Especially the relationship between process maturity and business performance is well researched (Van Looy et al. 2017). Higher levels of process maturity lead to higher levels of performance (Bititci et al. 2011; Chen and Fong, 2012; Dooley et al. 2001).

Advocates of DMMs suggest a certain contentual overlap between digital maturity and process maturity, performance management, management style and leadership, respectively. Drawing on this assumption, they consider a positive relationship between digital maturity and business performance as highly likely (Eremina et al. 2019). Bordeleau and Felden (2019, p. 8) support this presumption as they identify a relationship between the level of digital maturity and an organization’s efficiency and productivity. On this basis, the authors conclude that often “digitalisation” is equalled to “performance”. However, they note that contextual factors are often neglected in this assumption. The only academic paper presenting concrete empirical evidence on this topic is provided by Santiago da Costa et al. (2022, p.175). Based on the application of a previously tested and peer reviewed DMM to 346 Brazilian micro and small enterprises (MSEs) and the analysis of corresponding financial data, the authors conclude the following: “Digital maturity was shown to be statistically correlated with innovations ( $p=0.000$ ) and business revenue ( $p=0.009$ ).”

In contrast to the previously discussed consultancy reports, the data collection and analysis is transparent and can be replicated. However, due to the geographical and organizational narrow focus of the study, the results cannot be generalized. Furthermore, the absence of a uniform definition of digital maturity, leaves room for interpretation of the presented results.

Concluding, there is indeed a significant lack of empirical studies investigating on the application and impact of DMMs on firm performance. This can be traced back majorly to the jargon jungle and absence of standards. Also, related concepts highly depend on the respective context (e.g., society, company, individual) and thus vary according to the point of view on the subject matter (e.g., human, process, technology). This non-existence of a sound theoretical base leads to a certain ambiguity already when it comes to the central task of DMMs: measuring a company's level of digital maturity (Thordsen et al. 2020). Without a valid measurement procedure for this phenomenon, from a scientific perspective, it is impossible to investigate on the relationship with other concepts such as business performance. Practitioners are however not subject to scientific standards. They solely rely on in-field practical observations, that underline the positive impact of digital maturity on an organization's competitive advantage. As a result, managers clearly perceive a positive relationship between these concepts. This firm belief explains the outstanding popularity of DMMs in practice and their significance in shaping today's digital strategies.

#### 5.4 Differentiation and quality criteria of DMMs

Several scholars claim that the quality and contents of existing DMMs are not comparable – even though they label themselves as DMM (Chanas and Hess, 2016b). As discussed earlier, the large majority of available DMMs does not follow a common, acknowledged academic standard in their design process – such as the above presented guidelines (Remane, 2019; Teichert 2019; Gollhardt, 2020).

This is on one hand due to the practical background of the developers – often consultancies (who are designing the models for a non-academic business context). On the other hand, it is owed to their main target group of users, who do not require academic rigor. Therefore, most developers of DMMs create their individual, often untransparent, design and application for their digital maturity frameworks. According to critics, the different approaches to achieving the common goal of an organization's digital maturity led to significant lack comparability between the models. They thus claim that this heterogeneity renders an objective assessment of the essentiality of DMMs impossible. Sceptics ultimately question the meaningfulness of the models (Gollhardt, 2020).

In response to this significant point of criticism, in the past, researchers have set out to establish a directory especially for the development of maturity models in the field of IS (e.g., Becker et al. 2009; De Bruin et al. 2005; Solli-Sæther and Gottschalk 2010). This directory is based on the design science guidelines of Hevner et al. (2004). It is intended to introduce an academic standard and thus to bolster a more rigorous design process for the new frameworks. Despite this effort, the previously mentioned lack of rigor is still valid for the vast majority of existing

DMMs, especially those coming from a non-academic background (Williams et al. 2019). However, it should be underlined that a number of models from an academic background exist, that comply to the progressive standards proposed by Becker et al. (2009) (e.g., Berger et al., 2020; Berghaus and Back 2016; Lichtblau et al. 2015; Valdez-De-Leon 2016).

Our qualitative content analysis underlines the gravity of this point of criticism as 23 of the DMM publications reflect on the lack of rigor and comparability of the models and offer at least one dimension to compare and differentiate present models. We agree with the skeptical voices that an objective comparison of present models is not realizable. However, another approach can be used to juxtapose and evaluate present DMMs: an assessment the academic rigor and scientific validity of the models. In the past, only a few researchers have set out to critically evaluate the academic rigor of DMMs in general (Thordsen et al. 2020). In this context, the authors of the present paper have established theoretically grounded, objective criteria for the scientific validity of existing DMMs. More precisely, they have investigated on the validity of the measurement process to assess an organizations digital maturity. The measurement process constitutes one of the main components of the research procedure itself. In this context, five requirements for a valid measurement approach based on established literature in this field have been defined: (1) *Observation*, (2) *Generalizability*, (3) *Theory-based Interpretation*, (4) *Exploration*, and (5) *Implications* (Thordsen et al. 2020).

The argument of *Observation* ensures on one hand, that the right indicator for the subject matter is measured and on the other hand, that the measurement is carried out correctly. The requirement of *Generalizability* addresses the possibility of a statistical generalization, which is dependent on the number of objective observations and the degree of standardization of the assessment procedure. *Theory-based Interpretation* emphasizes on the fact that a valid measurement requires a sound theoretical base. *Exploration* becomes relevant when the measured construct is linked with other constructs. The last criterion of *Implications* is raised when decisions are taken based on the measured construct. Here, a thorough chain of arguments needs to be established to back up inferences.

Based on these objective criteria, an perform an in-depth comparison between 17 models developed between 2011 and 2019 could be performed. The result of the analysis makes a differentiation of present DMMs possible. Thus there is a tool for the evaluation of DMMs, supporting both academics and practitioners in identifying the appropriate DMM for their endeavor. It becomes apparent that especially the peer reviewed DMMs can provide a suitable working basis.

Finally, drawing on the results of our analysis, we can agree that DMM does not equal DMM. Again, it becomes apparent that “Digital Maturity Model” is not a protected term. However, objective criteria for the quality assessment of DMMs exist and are applicable. Having shed light and discussed the main areas of dissent regarding the DMMs contribution and rigor, ultimately questioning the sheer reason of existence of the models, we can conclude that DMMs, despite their flaws contribute significantly to practice and to theory. Thus, based on the results of this systematic literature review, the provocative statement “DMMs – Much ado about nothing” can be disproved.



## 6 Research agenda

Through the critical contention with the present controversies in the field of DMMs several research gaps have become obvious. Emerging from these, we have derived several concrete research questions. To visualize and structure the apparent research opportunities and respective questions, we have assembled a first research agenda in the form of the following Table 4.

In the first column we have derived four major fields of interest based on the previously outlined leading questions. These fields of interest and their associated research questions may not be mutually exclusive. As already mentioned, Table 4 serves as mere visualization of present research opportunities in the field of DMMs. Among others e.g., the portrayed fields of interest are interdependent. For instance, DSR principles offer a potential theoretical base for the development of universal standards for DMMs. Coincidentally, the establishment of such standards of its part increases the practical value of DMMs significantly. Analogously, the search for an ideal level of digital maturity bears of course considerable practical value.

## 7 Conclusion

The previously discussed areas of dissent put in question the most central and fundamental aspects of DMMs, ultimately scrutinizing the added value of these models. The provocative nature of some of these assertions is of course obvious. Nevertheless, they could not be left uncommented. We felt the need to shed light on the areas of controversy and to contribute to the further advancement of this research topic. We have thus carefully portrayed the present contentious mindsets of IS scholars. Based on our expertise, we suggest a first draft of a future research agenda for the field of DMMs (Table 4). The research agenda is the natural result of the present discussion of controversies in this research domain.

Hence, we have made both theoretical and practical contributions. From a theoretical point of view, based on a retrospective of eleven years of DMM research, we have sketched a status quo of the present research field. In this context, we have identified, structured, contrasted, and discussed the main areas of dissent within the academic community. Furthermore, we have derived a first synthesis of the general approach, nature, and specific components of existing DMMs through the analysis of a comprehensive collection of detailed information regarding the research area – encompassing extensive DMM literature, academic discussion, and feedback. Moreover, we have carved out directions for future research along with concrete research questions. We have thus established a solid basis and point of reference for the development of a new DMM and ultimately the theoretical advancement of this research field. Finally, we point out solution approaches for a current set of issues within the IS community. Also, from a practical perspective, a synthesis of the current status quo of the topic of DMMs bears considerable added value: generation of transparency, clarification, and guidance and support

**Table 4** Suggested research agenda for the field of DMMs

Fields of interest	Research aim	Potential research questions
1) Contribution to practice	To develop context specific DMMs, e.g. industry, branch, organization type / size	Which design should be applied when developing an industry / organization type / etc. specific DMM? Which central components of DMMs are context-dependent, and which are not? How does the application of DMMs provide added value to the organizations?
2) Contribution to theory	To point out the actual added value of DMMs through their application in along case studies and empirical research To further emphasize on the theoretical foundation of DMMs, we deem particularly the Design Science Research (DSR) as promising paradigm	In which way could practitioners use insights from DMM assessments more effectively? How do DMMs differ from other Maturity Models, e.g. Agile Maturity Models that are based on DSR? How should DSR guidelines be adjusted to fit the requirements of DMMs? Which additional theoretical paradigms could be applied to strengthen the theoretical foundation of DMMs?
3) Impact on performance	To investigate on the relationship between the level of digital maturity and the performance of an organization, e.g. by applying statistical analyses	How does the level of digital maturity relate to an organization's performance? Are there additional factors influencing the relationship between digital maturity and performance?
4) DMM standards	To better understand the discrepancies between existing DMMs To establish standards for DMMs, by considering the requirements of Thordsen et al. (2020)	Which criteria can be used to identify the discrepancies between existing DMMs? What are scientific quality standards for DMMs and how can they be established? How can the effectiveness of a DMM be measured?
	To identify and establish process models for applying and integrating DMMs into existing corporate (strategy) processes	How could a process model for applying and integrating DMMs into existing corporate (strategy) processes be designed?

for the organization's digital journey. First, we have illustrated an outline of the typical evolutionary stages and dimensions of existing DMMs. This provides the practitioner with a deeper understanding and overview of the underlying principles of the maturity models and to differentiate them from e.g., Agile Maturity Models (Schmitt et al. 2019). A deeper understanding empowers managers to assess the quality of the contents of a DMM and to interpret the results of a digital maturity assessment according to their individual needs. Consequently, the practitioner can choose a suitable DMM for a specific area of application from the present selection. Alternatively, Fig. 2, together with the overview of relevant dimensions and provided recommendations, can serve as a blueprint for the development of a new DMM. Ultimately, we bring organizations one step closer to attaining their ubiquitous aim of achieving digital maturity.

We acknowledge the limitations of this paper. As being part of the extremely dynamic phenomenon of digital transformation, the topic of DMM is very fugacious. Both practitioners and researchers engage in the continuous development of new DMMs – differing in content and quality. Therefore, with this systematic literature review, we can only take a snapshot of the current situation. Provided synthesis and recommendations can thus never be complete. Further empirical insights, e.g., expert interviews, group discussion or case studies, could generate additional value. In this context, the present jargon jungle needs to be taken into consideration: a uniform definition of digital maturity would be highly beneficial. Additional directions for future research can be found in Table 4. We are confident that our reflection on eleven years of DMM research, together with the present future-oriented research agenda will further advance the field of DMMs – further increasing the practical and theoretical value of these maturity models.

**Funding** Open Access funding enabled and organized by Projekt DEAL.

**Data availability** All data generated or analysed during this study are included in this published article. The author confirm that all data generated or analysed during this study are included in this article.

## Declarations

**Conflict of interest** The authors certify that there is no actual or potential conflict of interest in relation to this article. The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

**Human or animal participants** This research did not include human participants or animals

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission

directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

- Aguiar, T, Bogea Gomes, S, Rupino da Cunha, P, Mira da Silva, M, (2019): Digital Transformation Capability Maturity Model Framework. In: 2019 IEEE 23rd international enterprise distributed object computing conference (EDOC). 2019 IEEE 23rd international enterprise distributed object computing conference (EDOC), pp. 51–57.
- Arreola González, A, Becker, K, Cheng, C, Döricht, V, Duchon, M, Fehling, M, et al. (2016): Digitale Transformation: Wie Informations-und Kommunikationstechnologie etablierte Branchen grundlegend verändert—Der Reifegrad von Automobilindustrie, Maschinenbau und Logistik im internationalen Vergleich. In *Abschlussbericht des vom Bundesministerium für Wirtschaft und Technologie geförderten Verbundvorhabens „IKT-Wandel“ (Steuerkreis: Grolman von, H, Krcmar, H, Kuhn, K.-J, Picot, A, & Schätz, B.)*.
- Aslanova, Irina V.; Kulichkina, A. I. (2020): Digital Maturity: Definition and Model. In : 2nd International Scientific and Practical Conference “Modern Management Trends and the Digital Economy: from Regional Development to Global Economic Growth”(MTDE 2020): Atlantis Press, pp 443–449.
- Becker J, Knackstedt R, Pöppelbuß J (2009) Developing maturity models for IT management. In *Business Inf Syst Eng* 1(3):213–222
- Becker, J, Niehaves, B, Pöppelbuß, J, Simons, A, (2010): Maturity Models in IS Research. In : 18th European Conference on Information Systems, ECIS2010-0320. Available online at [ecis2010.up.ac.za](http://ecis2010.up.ac.za).
- Benbasat, I, Zmud, RW. (1999): Empirical research in information systems: The practice of relevance. In *MIS quarterly*, pp. 3–16.
- Berger, S, Bitzer, M, Häckel, B, Voit, C, (Eds.) (2020): Approaching Digital Transformation-Development of a Multi-dimensional Maturity Model.
- Berghaus S, Back A (2016): Stages in Digital Business Transformation: Results of an Empirical Maturity Study. In. MCIS 2016. Cyprus, p. 22.
- Berghaus, S, Back, A, Kaltenrieder, B (2016): Digital maturity & transformation report 2016. In *Crosswalk AG*.
- Bititci US, Ackermann F, Ates A, Davies J, Garengo P, Gibb S et al (2011) Managerial processes: business process that sustain performance. *Int J Oper Prod Manag* 31(8):851–891
- Bititci US, Garengo P, Ates A, Nudurupati SS (2015) Value of maturity models in performance measurement. In *Int J Prod Res* 53(10):3062–3085
- Borcan I (2021) The path from digitization to digital transformation: the case of two traditional organizations. *Rev Int Comp Manag* 22(3):376–388
- Bordeleau, F-È, Felden, C (2019): Digitally transforming organisations: A review of change models of Industry 4.0. *SA Journal of Human Resource Management*.
- Braga Tadeu, HF, Castro Moura Duarte, AL, Taurion, C, Jamil, GL (2019): Digital transformation: Digital maturity applied to study Brazilian perspective for industry 4.0. In : *Best Practices in Manufacturing Processes*: Springer, pp. 3–27.
- Bruin, T, Rosemann, M, Freeze, R, Kaulkarni, U (2005): Understanding the main phases of developing a maturity assessment model. In : Australasian Conference on Information Systems (ACIS): Australasian Chapter of the Association for Information Systems, pp. 8–19.
- Büyükoçkan G, Güler M (2020) Analysis of companies’ digital maturity by hesitant fuzzy linguistic MCDM methods. In *J Intell Fuzzy Syst* 38(1):1119–1132
- Caiado RGG, Scavarda LF, Gavião LO, Ivson P, de Mattos Nascimento DL, Garza-Reyes JA (2021) A fuzzy rule-based industry 4.0 maturity model for operations and supply chain management. *Int J Production Econ* 231:107883
- Carvalho, JV, Rocha, ÁWR, Abreu, A (2017): A Maturity model for hospital information systems. In *Journal of Business Research*.
- Catlin, T, Scanlan, J, Willmott, P (2015): Raising your digital quotient. Available online at <https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/raising-your-digital-quotient>.

- Chanias, S, Hess, T (2016b): understanding digital transformation strategy formation: insights from europe's automotive industry. *Pacific Asia Conference on Information Systems (PACIS)*, pp 296.
- Chanias S, Hess T (2016) How digital are we? Maturity models for the assessment of a company's status in the digital transformation. In *Manag Report / Institut Für Wirtschaftsinformatik Und Neue Medien* 2(2):1–14
- Cho W, Fan M, Yoo B, Zhang H (2021) Special issue on digital transformation: challenges and opportunities. *IseB* 19(2):387–388
- Colli M, Madsen O, Berger U, Møller Ch, Wæhrens B, Vejrum; Bockholt, M. (2018) Contextualizing the outcome of a maturity assessment for Industry 4.0. In *Ifac-Papersonline* 51(11):1347–1352
- da Costa LS, Munhoz IP, Pereira L, Akkari ACS (2022) Assessing the digital maturity of micro and small enterprises: a focus on an emerging market. *Procedia Comput Sci* 200:175–184
- David R (2019) Digital maturity – the new competitive goal. In *Strategy & Leadership* 47(5):28–35. <https://doi.org/10.1108/SL-06-2019-0084>
- de Bruin, T, Freeze, R, Kaulkarni, U, Rosemann, M (2005): Understanding the main phases of developing a maturity assessment model. In : *Australasian Conference on Information Systems (ACIS): Australasian Chapter of the Association for Information Systems*. Available online at <https://eprints.qut.edu.au/25152/>.
- de Bruin, T, Freeze, R, Kaulkarni, U, Rosemann, M (2005): Understanding the main phases of developing a maturity assessment model. In : *Australasian Conference on Information Systems (ACIS): Australasian Chapter of the Association for Information Systems*. Available online at <https://eprints.qut.edu.au/25152/>.
- Deloitte Switzerland, ACSC (2017): Digital future readiness-How do companies prepare for the opportunities and challenges of digitalisation.
- Dobrinčić, D (2020): Digital maturity of auditing companies in the Republic of Croatia.
- Dooley K, Subra A, Anderson J (2001) Maturity and its impact on new product development project performance. In *Res Eng Des* 13(1):23–29
- Durek, V, Kadoic, N, Ređep, NB: Assessing the digital maturity level of higher education institutions. In : *41st International Convention*, pp. 671–676.
- Eremina Y, Lace N, Bistrova J (2019) Digital maturity and corporate performance: The case of the Baltic states. *J Open Innov* 5(3):54
- Fath-Allah A, Cheikhi L, Al-Qutaish RE, Idri A (2014) E-government maturity models: A comparative study. *Int J Softw Eng Appl* 5(3):71–91
- Friedrich R, Le Merle M, Grone F, Koster A (2011) Measuring industry digitization: Leaders and laggards in the digital economy. In *Booz & Co., London*
- Gajsek B, Marolt J, Rupnik B, Lerher T, Sternad M (2019) Using maturity model and discrete-event simulation for Industry 4.0 implementation. *Int J Simul Model* 18(3):488–499
- Gill, M, VanBoskirk, S (2016): The digital maturity model 4.0. In *Benchmarks: digital transformation playbook*.
- Gökalp E, Martínez V (2021) Digital transformation capability maturity model enabling the assessment of industrial manufacturers. *Comput Ind* 132:103522
- Gollhardt, Torsten; Halsbenning, Sebastian; Hermann, Andreas; Karsakova, Aleksandra; Becker, Jörg (2020): Development of a Digital Transformation Maturity Model for IT Companies. In : *2020 IEEE 22nd Conference on Business Informatics (CBI): IEEE* (1), pp. 94–103.
- Google Inc. (2021): Google Trends Search "Digital Maturity". Available online at <https://trends.google.de/trends/explore?date=all&q=digital%20maturity>, checked on 3/16/2021.
- Halpern N, Budd T, Suau-Sanchez P, Bråthen S, Mwesiumo D (2021) Conceptualising airport digital maturity and dimensions of technological and organisational transformation. *J Airport Manag* 15(2):182–203
- Hellweg F, Lechtenberg S, Hellingrath B, Thomé AM, Tavares, (2021) Literature review on maturity models for digital supply chains. *Braz J Op Prod Manag* 18(3):1–12
- Hess T (2019) *Digitale Transformation strategisch steuern: Vom Zufallstreffer zum systematischen Vorgehen*. Springer-Verlag
- Hevner AR, March ST, Park J, Ram S (2004) Design science in information systems research. In *MIS Quarterly* 28(1):75–105
- Hizam-Hanafiah M, Soomro M, Ahmed; Abdullah, Nor Liza, (2020) Industry 4.0 readiness models: a systematic literature review of model dimensions. *Information* 11(7):364
- Ifenthaler D, Eglloffstein M (2020) Development and implementation of a maturity model of digital transformation. In *TechTrends* 64(2):302–309

- Ilin I, Iliashenko VM, Dubgorn A, Esser M (2022) Critical Factors and Challenges of Healthcare Digital Transformation. *Digital Transformation and the World Economy*. Springer, Cham, pp 205–220
- Isaev, EA, Korovkina, NL, Tabakova, MS (2018): Evaluation of the readiness of a company's IT department for digital business transformation. In *Бизнес-информатика* (2 (44) eng).
- Jugo, G, Balaban, I, Pezelj, M, Redjep, NB (2017): Development of a model to assess the digitally mature schools in Croatia. In : IFIP World Conference on Computers in Education: Springer, pp. 169–178.
- Kafel, T, Wodecka-hyjek, A, & Kusa, R. (2021). Multidimensional public sector organizations' digital maturity model. *Administration & Public Management Review*, (37)
- Kerpedzhiev GD, König UM, Röglinger M, Rosemann M (2021) An exploration into future business process management capabilities in view of digitalization. *Bus Inf Syst Eng* 63(2):83–96
- Kitchenham, B, Charters, S (2007): Guidelines for performing systematic literature reviews in software engineering.
- Korachi, Z, Bounabat, B (2019): Towards a Maturity Model for Digital Strategy Assessment. In : International Conference on Advanced Intelligent Systems for Sustainable Development: Springer, pp. 456–470.
- Krippendorff, K (2018): Content analysis: An introduction to its methodology: Sage publications.
- Laudon, KC, Laudon, JP (2020): Management Information Systems: Managing the Digital Firm, 16th Edition. 16<sup>th</sup> ed.: Pearson Upper Saddle River.
- Le Chen; Fong, Patrick S. W. (2012) Revealing performance heterogeneity through knowledge management maturity evaluation: a capability-based approach. In *Expert Syst Appl* 39(18):13523–13539
- Lichtblau, K, Stich, Volker; Berthenrath, R, Blum, M, Bleider, M, Millack, A. et al. (2015): Industrie 4.0 Readiness. IMPULS-Stiftung for mechanical engineering, plant engineering, and information technology.
- Mahood Q, van Eerd D, Irvin E (2014) Searching for grey literature for systematic reviews: challenges and benefits. In *Research Synthesis Methods* 5(3):221–234
- March ST, Smith GF (1995) Design and natural science research on information technology. In *Decision Support Syst* 15(4):251–266
- Marcos J, Álvarez; Hernández, Manuel Capelo; Ortiz, José Ignacio Álvarez, (2019) The digital maturity of the Spanish press. A case study. In *Revista Latina De Comunicación Social* 74:499–520
- Matt C, Hess T, Benlian A (2015) Digital transformation strategies. *Business Inf Syst Eng* 57(5):339–343
- Mayring, P (2014): Qualitative content analysis: theoretical foundation, basic procedures and software solution.
- Menchini, F, Russo, PT, Slavov, TNB, Souza, RP (2022): Strategic capabilities for business model digitalization. In *Revista de Gestão* 29 (1).
- Mettler T, Pinto R (2018) Evolutionary paths and influencing factors towards digital maturity: an analysis of the status quo in Swiss hospitals. *Technol Forecasting Soc Change* 133:104–117
- Minh HP, Thanh HPT, Dien HN, Thi NN (2022) Comprehensive review of digital maturity model and proposal for a continuous digital transformation process with digital maturity model integration. *IJCSNS* 22(1):741
- Muehlburger, M, Rueckel, D, Koch, S (2019): A framework of factors enabling digital transformation. In: Twenty-fifth Americas Conference on Information Systems, Cancun, 2019
- Nguyen, DK, Broekhuizen, T, Dong, JQ, Verhoef, P. C. (2019): Digital readiness: construct development and empirical validation.
- Nikolova-Alexieva V, Mihova TB (2019) Measuring the level of digital maturity of Bulgarian industrial enterprises. In *Industry 4.0* 4(5):258–264
- Nolan R, Koot W, William JD (1992) Nolan stages theory today: a framework for senior and IT management to manage information technology. *Holland Manag Rev* 31(1):1–24
- Ochoa OL (2016) MODELOS DE MADUREZ DIGITAL: ¿ EN QUÉ CONSISTEN Y QUÉ PODEMOS APRENDER DE ELLOS?/DIGITAL MATURITY MODELS: WHAT ARE THEY AND WHAT CAN WE LEARN FROM THEM? In *Boletín De Estudios Económicos* 71(219):573
- Ochoa-U, Rafael-Leonardo; Peña, J-I (2020): Digital Maturity Models: a systematic literature review. In : ISPIIM Conference Proceedings: The International Society for Professional Innovation Management (ISPIIM), pp. 1–15.
- Ostmeier E, Strobel M (2022) Building skills in the context of digital transformation: How industry digital maturity drives proactive skill development. *J Bus Res* 139:718–730
- Pauli T, Fiel E, Matzner M (2021) Digital Industrial Platforms. *Business Inf Syst Eng* 63(2):181–190. <https://doi.org/10.1007/s12599-020-00681-w>
- Paulk MC, Curtis B, Chrissis MB, Weber CV (1993) Capability maturity model, version 1.1. *IEEE Softw* 10(4):18–27

- Pavel, E. V, Kudryashova, T. V, Bykova, P. A. (2021): Research on the Digital Maturity of Mechanical Engineering Companies in Russia. In : International Scientific and Practical Conference "Russia 2020-a new reality: economy and society"(ISPCR 2020): Atlantis Press, pp. 408–411.
- Pedrini C, Nailor; Frederico, Guilherme Francisco, (2018) Information technology maturity evaluation in a large Brazilian cosmetics industry. *Int J of Bus Admin* 9(4):15–24
- Pronça D, Borbinha J (2016) Maturity models for information systems-A state of the art. In *Procedia Comput Sci* 100:1042–1049
- Rafael LD, Jaione GE, Cristina L, Ibon SL (2020) An Industry 4.0 maturity model for machine tool companies. *Technol Forecasting Soc Change* 159:120203
- Reddy, R. C, Bhattacharjee, B, Mishra, D, & Mandal, A. (2022). A systematic literature review towards a conceptual framework for enablers and barriers of an enterprise data science strategy. *Information Systems and e-Business Management*, 1–33.
- Remane, G, Hanelt, A, Wiesboeck, F, Kolbe, L (2017): Digital maturity in traditional industries—an exploratory analysis.
- Rossmann, A (2018): Digital maturity: conceptualization and measurement model. In : ICIS. Bridging the Internet of People, Data, and Things: 39th International Conference on Information Systems (ICIS 2018), 13–16 December. vol. 2: Curran Associates Inc, pp. 1633–1641.
- Salume, P. K, BARBOSA, M. W, Pinto, M. R, & Sousa, P. R. (2021). Key dimensions of digital maturity: A study with retail sector companies in Brazil. *RAM. Revista de Administração Mackenzie*, 22.
- Salviotti, G; Gaur, A; Pennarola, F (2019): Strategic Factors Enabling Digital Maturity: An Extended Survey. In : The 13th Mediterranean Conference on Information Systems (MCIS). Munich, pp. 1–13.
- Schallmo, D, Lang, K, Hasler, D, Ehmig-Klassen, K, Williams, CA. (2020): An Approach for a Digital Maturity Model for SMEs based on Their Requirements. In *95233546*.
- Schmitt, A; Theobald, S; Diebold, P (2019): Comparison of agile maturity models. In : International Conference on Product-Focused Software Process Improvement: Springer, pp. 661–671.
- Solli-Sæther H, Gottschalk P (2010) The modeling process for stage models. *J Organiz Comput Electr Commer* 20(3):279–293
- Teichert R (2019) Digital transformation maturity: A systematic review of literature. *Acta Univ Agric Et Silvic Mendelianae Brunensis* 67(6):1673–1687
- Thordsen T, Murawski M, Bick M (2020) How to measure digitalization? a critical evaluation of digital maturity models. *Responsib Des, Implement Use Inf Commun Technol* 12066:358–369
- Thordsen, T; Bick, M (2020): Towards a holistic digital maturity model. In : ICIS 2020. 19th International Conference on Information Systems. India, 13.-16. December 2020.
- Valdez-de-Leon, O (2016): A digital maturity model for telecommunications service providers. In *Technology innovation management review* 6 (8).
- van Looy A, Poels G, Snoeck M (2017) Evaluating business process maturity models. *J Assoc Inf Syst* 18(6):1
- Venkatraman N (1994) IT-enabled business transformation: from automation to business scope redefinition. *Sloan Manag Rev* 35:73–73
- Virkkala P, Saarela M, Hänninen K, Simunaniemi A-M (2020) Business maturity models for small and medium-sized enterprises: a systematic literature review. In *Management* 20:22
- vom Brocke J, Simons A, Niehaves B, Riemer K, Plattfaut R, Cleven A (2009) Reconstructing the giant: On the importance of rigour in documenting the literature search process. *Ecis* 9:2206–2217
- Wagire AA, Joshi R, Rathore APS, Jain R (2021) Development of maturity model for assessing the implementation of Industry 4.0: learning from theory and practice. *Production Planning & Control* 32(8):603–622
- Wernicke B, Stehn L, Sezer AA, Thunberg M (2021) Introduction of a digital maturity assessment framework for construction site operations. *Int J Constr Manag* 23(5):898–908
- Westerman G, Calmèjane C, Bonnet D, Ferraris P, McAfee A (2011) Digital transformation: a roadmap for billion-dollar organizations. In MIT Center for Digital Business and Capgemini Consulting 1:1–68
- Westerman G, Tannou M, Bonnet D, Ferraris P, McAfee A (2012) The digital advantage: How digital leaders outperform their peers in every industry. In MITSloan Manag Capgemini Consulting, MA 2:2–23
- Williams, C, Schallmo, D, Lang, K, Boardman, L (2019): Digital Maturity Models for Small and Medium-sized Enterprises: A Systematic Literature Review. In : ISPIM Conference Proceedings: The International Society for Professional Innovation Management (ISPIM), pp. 1–15.