Clarification of the Present Understanding of the Assessment of an Organization's gital Readiness in SMEs

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Abstract

The role of digital transformation (DT) in economic development is vital and recurring point of research. It is particularly relevant if we consider the high percent e of digital transformation initiatives that fail to deliver the expected results, particularly in S ll and Medium Enterprises (SMEs). This paper analyzes what is needed to make this transf ation successful from an implementation perspective and, simultaneously, from the standpoin f obtaining the company's expected results. This phenomenon is even more critical to decipher d understand when we look at the small and medium enterprises that face more significant cha nges due to the scarcity of resources and needed skills. This work reviews a large variety of odels through an extensive systematic literature review (SLR) that assess the readiness and maturi of the digital transformation of enterprises, with a focus on SMEs, with its primary objectives be g (1) to review the existing studies and models that assess an organization's maturity and readi ss in the context of digital transformation, focusing on SMEs; (2) to identify if there are gaps considering the importance of the SMEs; and (3) to propose a standardized set of dimensions that should always be considered in a digital transformation assessment. The outcome of this research provides an essential contribution by identifying apparent gaps in the assessment of digital transformation in SMEs and proposing a scalable and standardized set of categories and subcategories that can be used across any future assessment model. These contributions are even more relevant when referencing minimal deep research in the context of SMEs and Digital Transformation.

Keywords:

Readiness Assessment Model;
Maturity Assessment Model;
SMEs;
Digital Transformation;
SLR.

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1- Introduction

The phenomenon of Digital Transformation (DT) has been observed to impact all industries and sectors globally and locally [1, 2]. This occurrence has consistently resulted in a substantial increase in research related to the field of digital transformation [3]. We can view digital transformation as an exercise in continuously improving our organization through digital capabilities that ultimately end up redefining business processes, business models, and how the company interacts within and outside of its borders [4, 7]. Companies that have embraced digital approaches in their products, services, business models, and working methods have shown greater chances of growing and reaching international coverage [8]. DT is seen as the base for the transformation of all the different dimensions of the organization, ultimately delivering more value to the stakeholders through the technology as well as being able to adapt to the change of the surrounding environment more rapidly [9–11]. According to the World Economic Forum (2018) [12], over 80% of CEOs

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indicated that a digital transformation program must be in place. At the same time, by 2030, more than 70% of economic value creation is expected to be based on digital platforms.

These numbers show how fundamental it is for organizations to embrace this journey. This transformation is essential to introducing new businesses and revenue sources, maintaining competitiveness, and preventing companies from becoming obsolete [13]. Nonetheless, the changes that arise from DT also carry risks for organizations [14]. Some research indicates that more than 70% of the initiatives focusing on digital transformation do not reach the expected goals, leading to a significant amount of money wasted and, more importantly, negatively impacting the companies [15]. Therefore, one of the critical aspects of DT is the company's ability to change and transform its proc
organization [16, 17].

The success of SMEs in digital transformation is closely connected to the success of our global economy in the years to come. In this context, Small and Medium Enterprises (SMEs) play an even more vital role within the global economy as (reference), SMEs account for more than 98% of all companies in the European Union and generate more than 100 million jobs. They also secure more than 50% of the global domestic product of Europe [18, 19]. For SMEs to remain (or become) competitive, they must keep up with technological evolution and adjust to it. Development is linked to profitability, growth, market, and performance [20]. From a technology perspective, SMEs behave differently than large organizations, often looking at it to process information rather than gain a competitive advantage [21, 22]. There are clear limitations for SMEs that put them at a disadvantage in evolving their digital strategy, with a couple of factors being the most obvious: Significantly fewer resources and a lack of specialized skills [23]. Lacking those technical skills and resources can be equally damaging compared to not having the technology. The existence of state-of-the-art technology but no qualified workforce to manage it holds no value to the organization [24, 25]. On the other hand, SMEs are characterized by an inherent flexibility that enables them to change faster and adapt to markets more agilely. This behavior is particularly relevant when operating in uncharted waters [26], with the level of commitment of management to DT being directly correlated to positive outcomes [27]. However, a significant portion (66% to 86%) of organizations fail to obtain the expected digital transformation results due to a lack of understanding of new competencies and business models [28].

With the limitations SMEs present and the more significant impact of Digital Transformation across all industries, it is critical to utilize tools that enable the organization to better understand what path to take and what decisions are needed. The most common approach is through maturity models. Maturity models allow the assessment of the company's as-is situation and support the discovery of the areas that need to be improved to move to the next level [29, 30]. When pertaining to digital transformation, the understanding of assessment means two slightly different things: 1) Organizational readiness for DT, which refers to the willingness to change, the "soft" components; and 2) Maturity, to the actual state of implementation [31, 32]. This distinction is critical, as readiness and maturity models are different approaches. Readiness is much more focused on being "ready for starting," and maturity aims to show "how far" [29]. While the maturity models are essential, the relevance of the readiness model may be underestimated, especially when we find research pointing out a significantly high number of initiatives that fail to deliver expected results [15], which may indicate gaps in the "readiness" to achieve the results rather than the maturity levels during the implementation of the planned transformation. Lokuge et al. (2019) [31] define digital organizational readiness as the state of preparedness to deliver or adopt the value of digital tools. The same authors, also supported by Kane et al. (2018) [33], defend that companies must achieve digital transformation due to higher digital organizational readiness. This factor is more relevant if we consider that readiness is associated with being fully ready for it. In this case, it reflects the level of readiness to execute the needed actions to achieve the expected results [34].

Small and medium enterprises are essential to economic development [20]. However, these companies have severe resource limitations [23], creating a possibly even more significant gap with larger enterprises. With the scarcity of resources, maximizing the results of any initiative they may embrace becomes even more critical, with digital transformation at the top of its priorities [29, 30].

1-1- Our Contribution

The limitations SMEs face with their limited resources may be an influential factor in the push towards a lower research investment, as it is more complex to demonstrate or test some of the designed concepts. These challenges impact not only the normal development of the organizations but, at the same time, create a potentially more complex scenario for the researchers to operate in. The scarcity of research focused on SMEs in the context of digital transformation is indeed one of the biggest challenges to executing our research, as it is not simple to benchmark with previous studies, and it is not possible to identify how much may have changed over the past decade. These limitations make our contribution more relevant for the scientific community, as it creates a solid baseline for future research and developments in SMEs and Digital Transformation.

Through the maturity and readiness models, SMEs could have a clearer picture of where to invest their limited resources [15, 31]. With this data showing the possible correlation between readiness and maturity models and more

positive outcomes of DT in SMEs, and with the context of a global economy more and more dependent on organizations embracing their digital transformation and the clear vital role that SMEs play in that economy, this research aims to bring these elements together and better understand how readiness assessment models can be different from maturity models, and more importantly, how those readiness assessment models can support SMEs to maximize the results of their digital transformation.

This work has defined the target to answer the following research questions (RQ):

- ***RQ1)*** What current state-of-the-art models assess an organization's maturity and readiness in their digital transformation?
- ***RQ2)*** Based on the identified models, is there a clearly defined subset designed for Small and Medium Enterprises?
- ***RQ3)*** What models are being assessed using the perspective/inputs from the general employees rather than focusing on the company's management?
- ***RQ4)*** What key influential factors do the authors identify within the identified models as the base for their assessment?
- ***RQ5)*** What is the most appropriate logic to bundle those factors in assessing critical dimensions?

The research is executed through a systematic literature review, focusing on a thorough review of the existing models, aiming to distinguish maturity from readiness, bringing an SME's perspective.

In previous studies, such as the one carried out by Voß & Pawlowski (2019) [35], there was already quite significant research in understanding the role of the assessment models in the success of digital transformation and, at the same time, in identifying probable additional reasons why some of those are not achieving the expected results. In their work, they reviewed a selected list of models, listing the lack of alignment between senior managers and employees as an area that deserves further research. While the research has reviewed quite a significant list of models, it does not distinguish the concept of maturity and readiness, which limits the understanding of whether the gaps are related to one dimension or the other. This clear distinction is the aspect that differentiates our research from previous studies. Primarily, we consider the clear distinction between maturity and readiness, with readiness assessing a state to be ready. Our work will not only contribute to providing a much clearer view of the existing models and how the maturity models distinguish themselves from the readiness models, but equally important; it will deliver an innovative proposal for a complete standardized set of categories and subcategories that will be used in any future development in the field of digital transformation assessment models. This area has been growing immensely over the last years, and the need for standards on what to assess leads to a potential sub-optimal usage of these assessment models and ultimately limits the value they may create for the companies using them.

Ultimately, we aim to create a baseline of data and standards to help accelerate the research in the context of SMEs and Digital Transformation. By thoroughly reviewing the existing readiness and maturity models and putting them in the SMEs, we aim to highlight where the science could be more in-depth. The depth needed to develop further artifacts that can positively impact the outcomes of the SMEs' digital transformation journey. Our proposal regarding what categories and subcategories should be considered in future assessments aligns with our overall goal. It is intended to accelerate the development of models that converge towards similar dimensions.

This document is divided into five chapters, starting with the methodology that explains all the processes we followed to review the existing literature, followed by a chapter that presents the results of our research, the findings of relevance to the scientific community, especially from the lenses of our research questions, and finally a discussion of those findings. We have chapter four, where we present a proposal for a future harmonization of digital transformation readiness and maturity assessment categories and subcategories, and to conclude, we offer our conclusions and opportunities for further research.

2- Research Methodology

We have opted to structure our Systematic Literature Review (SLR) following the recommendations of the procedure designed by Kitchenham (2004) [36].

The process consists of three precise stages (See Figure 1).

Planning: A stage meant not only to plan the review but also to make sure there is some preliminary work to identify if there is a need for a review.

Conducting: The stage is designed for the execution of the review, with a critical focus on identifying the selected articles through inclusion and exclusion (based on an initial search of the defined query string in the selected databases).

Reporting: We will address this phase in Chapter 3 (Results & Discussion). The aim is to report the key findings of our literature review.

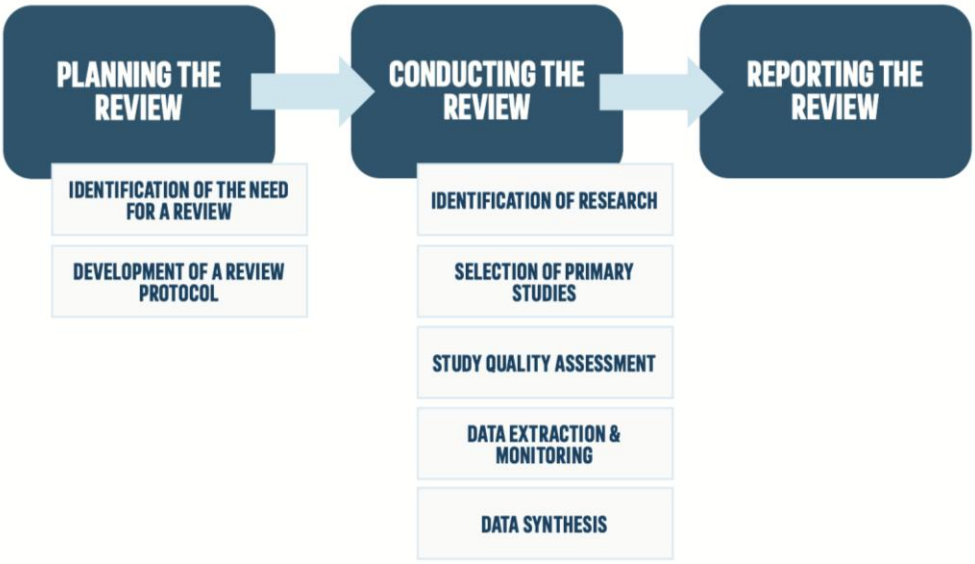


Figure 1. Summary of the review process

2-1- Planning the Review

The first stage is planning, primarily designed to identify the foundational level of information needed to perform the systematic literature review. The key attributes are:

a) *Objectives*

This research work has identified several clear objectives that aim to serve as the foundational drivers of the literature review:

- Understand the state-of-the-art regarding digital transformation in SMEs, focusing on understanding the scientific knowledge in the space of readiness models for companies, especially having the employee (rather than senior management) as the center of those models.
- Understand if and at what level science separates the concept of readiness versus maturity.
- Develop a comprehensive view of the critical factors to deliver a successful digital transformation in an organization, precisely when applied in a small or medium enterprise.
- If it is proven to be possible to separate readiness from maturity, identify key factors that play a critical role in that readiness assessment.

b) *PICOC (Population, Intervention, Comparison, Outcome, Context) (see Table 1)*

Table 1. PICOC (Population, Intervention, Comparison, Outcome, Context)

Population	SMEs
Intervention	Readiness and Maturity for Digital Transformation in SMEs
Comparison	Readiness and maturity models and frameworks
Context	Digital Transformation in SMEs

c) Research Questions

- What current state-of-the-art models assess the organization's maturity or readiness in their digital transformation?
- Based on the identified models, is a clearly defined subset designed for Small and Medium Enterprises?
- What models assess using the perspective/inputs from the general employees rather than focusing on the company's management?
- What key influential factors do the authors identify within the identified models as the base for their assessment?
- What is the most appropriate logic to bundle those factors in assessing critical dimensions?

d) Sources

To support our investigation, we selected three distinct scientific sources to achieve these objectives: SCOPUS, ACM Digital Library, and IEEE. Due to our research being more focused on identifying the scientific knowledge in a specific

domain (in this case, readiness and maturity models for SMEs), we opted to limit our analysis to the artifacts developed within the space of academia.

e) Inclusion & Exclusion Criteria (see Table 2)

Table 2. Inclusion and Exclusion Criteria

Inclusion/Exclusion	Criteria
Inclusion	Include publications that review existing maturity assessment models or frameworks, even of larger enterprises.
	Include publications that distinguish assessment models by their focus on maturity versus preparation.
	Include publications that review success factors to achieve positive outcomes in a digital transformation.
	Include publications that publish Systematic Literature Reviews of digital transformation success factors.
	Include publications that measure the impact of different factors in the outcome of digital transformation.
	Include publications that have publishing dates from 2017 onwards
	Include publications that are final and peer-reviewed.
	Include publications in the English language.
Exclusion	Exclude publications that cannot be accessed.
	Exclude publications that do not address maturity or readiness models.
	Exclude publications that focus on a use case.
	Exclude publications that focus on a specific country.
	Exclude publications that focus on a specific business or sector.

f) Query String

We designed the query string (see Table 3) by extracting the critical aspects of our research question. Our overall research focuses on a) Digital Transformation for SMEs. We selected the keyword "Digital Transformation" and decided to leave SME out of the query string to ensure we could choose a wider group of articles and assess it to provide comparison; b) Readiness and Maturity models to assess digital transformation. Hence, we selected the keywords "Readiness" and "Maturity." c) Our focus is digital transformation assessments of companies; therefore, we added the keyword company and selected a few other keywords often used in literature to refer to a company (Organization, Enterprise, and Business). We have yet to add keywords referring to success factors, which could limit the results. Instead, we extracted the elements from the identified maturity and readiness models.

Table 3. Query String used to identify the relevant articles

Inclusion	("digital transformation" AND (maturity OR readiness) AND (organisation* OR organization* OR enterprise* OR company* OR business*))

g) Quality Assessment Checklist

How will we classify the selected articles considering a well-defined set of criteria that ultimately leads to a final score? According to Kitchenham (2004) [36], a quality assessment checklist is designed to guarantee the minimum quality level of the study. The author also refers to quality as something that "relates to the extent to which the study minimizes bias and maximizes internal and external validity." For our work, we defined the following quality criteria.

a. Does the research compare different models through well-defined criteria?
b. Is the publication looking at it from an SME perspective?
c. Does the publication analyze frameworks/models that assess maturity and readiness for digital transformation?
d. Is the publication clear on the assessment models' perspective (general employee, management, both)?
e. Does the publication identify factors that contribute to the outcomes of digital transformation?
f. Does the publication weigh different perspectives of different authors in terms of what factors play a more significant role in digital transformation?

Each question can be answered with Yes | No | Partially.

The article score will be the sum of the five answers (yes – 1pt, partially – 0.5pt, no – 0 pt). We have defined two or less as the cutoff score for the articles we have not considered within our research.

2-2- Conducting the Review

The conducting stage is when we execute the defined query string and filter out the publications of relevance for our study based on the different inclusion and exclusion criteria. It is divided into three main phases:

i. ***First Search***: Run the query string through the identified sources and select the articles presented. Only a few filters were applied:

- Select publications with publishing dates from 2017 onwards
- Select publications that are final and peer-reviewed.
- Select publications in the English language.

Table 4 shows the summary of the first search with the initial filter

Table 4. Conducting – First Search

Source	Initial Results	First Filtered Results	% Selected
Scopus	772	606	78%
ACM	52	36	70%
IEE	95	93	98%

We have summarized the identified publications by year in Figure 2, showing increased published research year-on-year. This fact is aligned with the literature that indicates a constant increase of research in digital transformation + maturity models + readiness models.

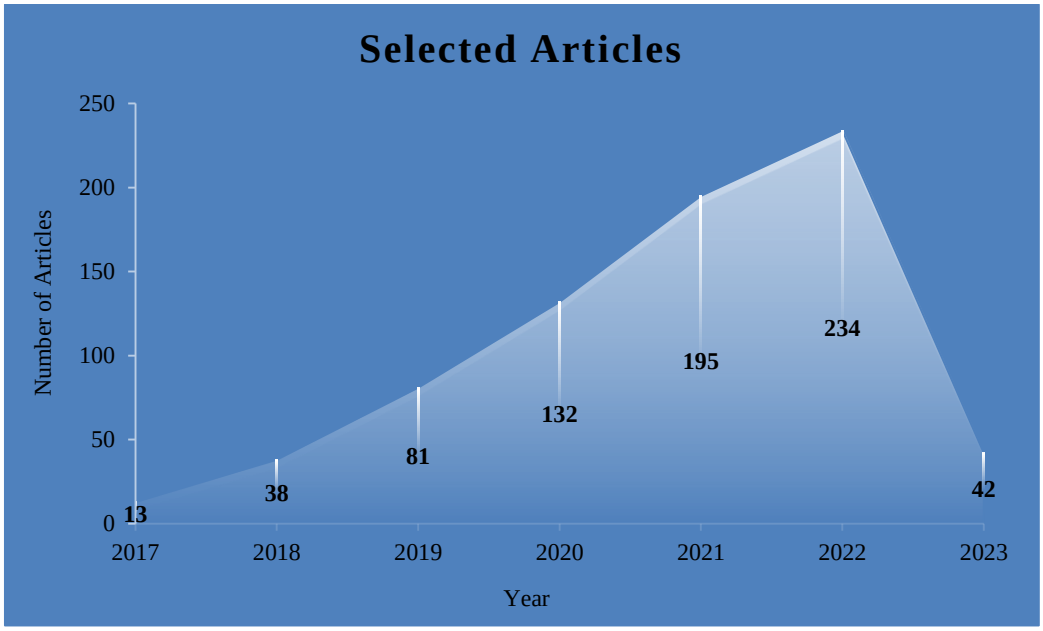


Figure 2. Break down by year

ii. ***Title & Abstract Filter:*** The second step is filtering the 735 articles through the title and abstract and utilizing the exclusion criteria to remove the publications irrelevant to this work.

Table 5. Conducting – Title & Abstract Filtering

Source	First Filtered Results	Duplicated	Title & Abstract Results	% Selected
Scopus	606	59	37	6%
ACM	36	6	2	6%
IEE	93	32	9	10%

Step 2, in the conducting phase, has 48 shortlisted articles that will be the base of our process to identify the suitable models to be reviewed in more detail. We selected roughly 6% of the articles from the original list. Table 5 summarizes the final picture of the definitive list of articles we chose from the different databases and how many were duplicated. Table 6 summarizes the overall breakdown of articles by their status and publishing year.

Table 6. Approved, Rejected & Duplicated by Year

Status	2017	2018	2019	2020	2021	2022	2023	Total
Approved	0	0	4	7	20	13	4	**48**
Rejected	13	29	66	114	145	187	34	**588**
Duplicated	0	9	11	11	30	34	4	**99**

Table 7 summarizes the final mapping of the reviewed articles against the inclusion and exclusion criteria, ultimately leading to the last 48 selected publications.

Table 7. Articles classified by inclusion and exclusion criteria (that were not applied in the first search)

Approved/Rejected	Criteria	# Articles
Approved	Exclude publications that cannot be accessed.	28
	Exclude publications that focus on a use case.	25
	Exclude publications that do not address maturity or readiness models.	446
	Exclude publications that focus on a specific country.	50
	Exclude publications that focus on a specific country.	39
Rejected	Include publications that review existing maturity assessment models or frameworks, even of larger enterprises	22
	Include publications that distinguish assessment models by their focus on maturity versus preparation.	7
	Include publications that review success factors to achieve positive outcomes in a digital transformation	13
	Include publications that publish Systematic Literature Reviews of digital transformation success factors	2
	Include publications that measure the impact of different factors on the outcome of digital transformation	4

iii. Quality Assessment: In step 3, we reviewed the 48 finally selected articles for the research in detail, shortlisting the different maturity and readiness models. We reviewed the entire list through the identified quality assessment checklist, with the final assessment score demonstrated in Table 8.

Table 8. Quality Assessment Score

Score	# articles	%
0-2 (the cutoff for low value/quality)	18	37.5%
2-4 (medium-high quality)	18	37.5%
4-6 (high to very high quality)	12	25%

The data shows that 62% of the articles (30) were marked as a medium to high-quality score, which is an excellent base to proceed and define what we select for our final review models.

iv. Identify the Maturity and Assessment Models: Reviewing the final selected 48 articles, we identified articles focusing on readiness or maturity models and selected thirteen (13) maturity and readiness models from this phase for further detailed review. Through the thorough analysis of the 48 selected articles, we also encountered previous systematic literature reviews that provided cross-referenced models, leading to adding those to our final selection as part of the inclusion criteria. We selected eleven (11) maturity/readiness models through the cross-referenced literature. The final list of all articles reviewed and chosen models is presented in Chapter 3 (see Table 10).

3- Results, Findings & Discussion

This chapter will document the general results identified during our systematic literature review. We have structured this chapter to follow the identified research questions, demonstrating some of the findings in each and the potential research gaps identified during our study.

Table 9. Expected findings in each research question

RQ	Question	Expected Findings (Objective)
1	What current state-of-the-art models assess the organization's maturity or readiness in their digital transformation?	State-of-the-art of Maturity & Assessment Models
2	Based on the identified models, is there a clearly defined subset designed for Small & Medium Enterprises?	Models that apply to small and medium enterprises.
3	What models assess using the perspective/inputs from the general employees rather than focusing on the company's management?	Are the identified models looking into the general employee perspective while assessing digital transformation?
4	What key influential factors do the authors identify within the identified models as the base for their assessment?	What factors should be considered while assessing a digital transformation, and what is the most logical approach to cluster it?
5	What is the most appropriate logic to bundle those factors in assessing critical dimensions?	

3-1- Results

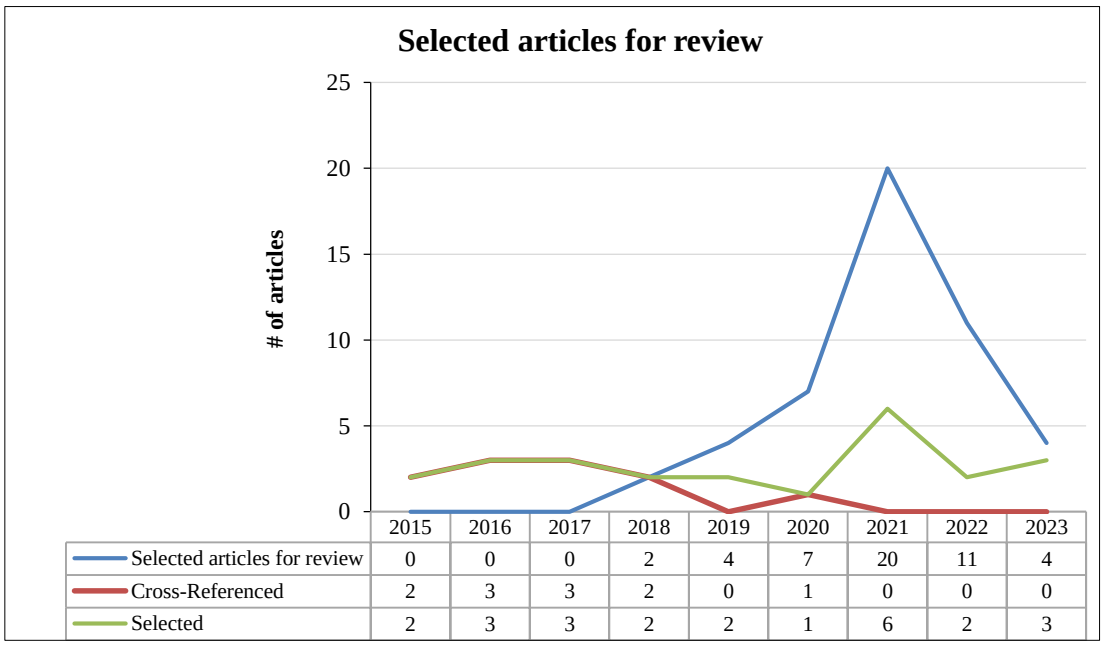
The base of our review identified 48 articles to include in the study. From those 48 articles, we selected 13 maturity and readiness models and cross-referenced an additional 11 models through some of the existing published systematic literature. Table 10 summarizes the 59 articles.

Table 10. List of selected articles of our systematic literature review

	Year	Initial Selection	Cross-Referenced	Shortlisted
Leyh et al. (2015) [37]	2015		X	X
Matt et al. (2015) [38]	2015		X	X
Berghaus & Back (2016) [39]	2016		X	X
Lichtblau et al. (2016) [40]	2016		X	X
Schumacher et al. (2016) [41]	2016		X	X
de Carolis, A et al. (2017) [42]	2017		X	X
Leino et al. (2017) [31]	2017		X	X
Klötzer & Pflaum (2017) [43]	2017		X	X
Canetta et al. (2018) [44]	2018		X	X
Gimpel et al. (2018) [45]	2018		X	X
Hamidi et al. (2018) [46]	2018	X		
Isaev et al. (2018) [47]	2018	X		
Aguiar et al. (2019) [48]	2019	X		X
Colli et al. (2019) [49]	2019	X		X
Teichert (2019) [50]	2019	X		
Voss & Pawlowski (2019) [35]	2019	X		
Chonsawat & Sopadang (2020) [51]	2020	X		
Depaoli et al. (2020) [52]	2020	X		
Kovrigin & Vasiliev (2020) [53]	2020	X		
Machado et al. (2020) [54]	2020	X		
Ndou et al. (2020) [55]	2020	X		
Priyono et al. (2020) [56]	2020	X		
Schuh et al. (2020) [57]	2020	X		X
Stoianova (2020) [58]	2020	X		
Alsufyani & Gill (2021) [59]	2021	X		
Borštnar & Pucihar (2021) [60]	2021	X		
Brozzi et al. (2021) [61]	2021	X		
Bocyte et al. (2021) [62]	2021	X		
Carrijo et al. (2021) [63]	2021	X		
Cordes & Musies (2021) [64]	2021	X		
Cunha & Sousa (2021) [65]	2021	X		X
Denicolai et al. (2021) [66]	2021	X		
Gfrerer et al. (2021) [34]	2021	X		
Gökalp & Martinez (2021) [67]	2021	X		X
González-Varona et al. (2021) [27]	2021	X		
Kokot et al. (2021) [68]	2021	X		
Machado et al. (2021) [69]	2021	X		
Nerima & Ralyté (2021) [13]	2021	X		X
Okfalisa et al. (2021) [70]	2021	X		

Poletaikin et al. (2021) [71]	2021	X		
Saroso et al. (2021) [72]	2021	X		
Sándor & Gubán (2021) [73]	2021	X		X
Sinyuk et al. (2021) [74]	2021	X		
Soares et al. (2021) [75]	2021	X		X
Barry et al. (2022) [76]	2022	X		
Costa et al. (2022) [77]	2022	X		X
Kasperovica et al. (2022) [78]	2022	X		
Kryukov et al. (2022) [79]	2022	X		
Merzlov & Shilova (2022) [80]	2022		X	X
Mutlu et al. (2022) [81]	2022	X		
Pucihar & Borštnar (2022) [82]	2022	X		X
Sándor & Gubán (2022) [83]	2022	X		
Schneider et al. (2022) [84]	2022	X		
Spremic et al. (2022) [85]	2022	X		
Viloria-Nunez et al. (2022) [86]	2022	X		
Ehrensperger et al. (2023) [87]	2023	X		X
Haryanti et al. (2023) [88]	2023	X		X
Hein-Pensel et al. (2023) [89]	2023	X		
Tiss & Orellano (2023) [90]	2023	X		X
		48	**11**	**24**

The number of selected published models versus the initial list of reviewed published models in a particular year ranged from 100% in the years 2015 to 2017 (primarily due to the fact those are 100% cross-referenced articles) to 12.5% in the year 2020 (the lowest selection rate in a particular year of our research). The year 2021 represents the year with more articles in the final list of 59 (34%), with 30% of papers selected for the final models we reviewed in detail. Figure 3 illustrates the overall ratio year by year.

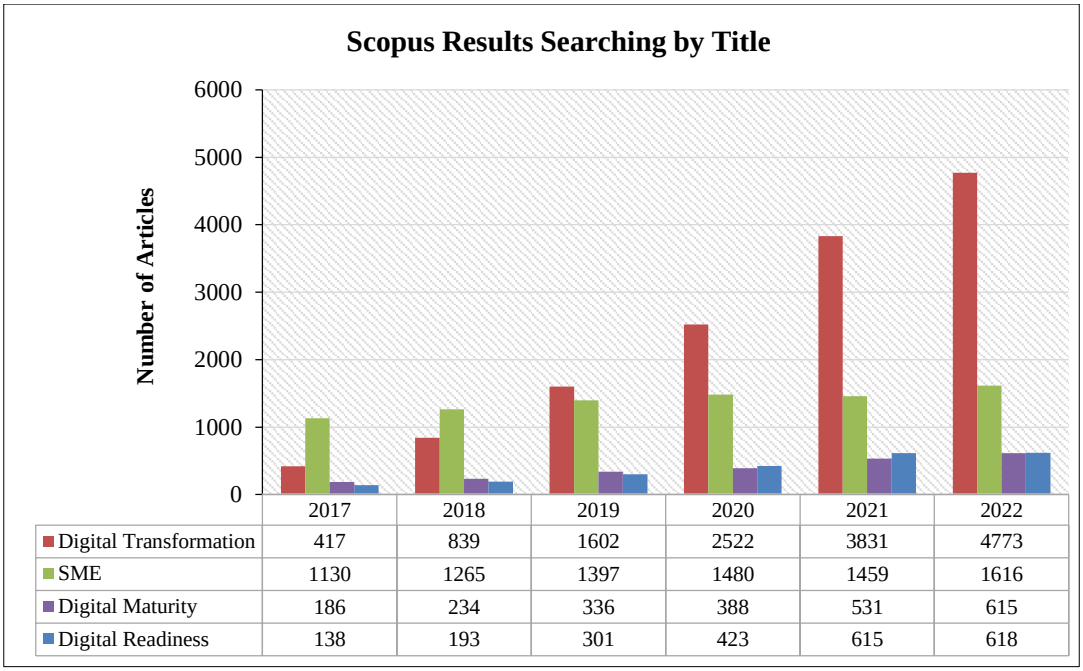


	2015	2016	2017	2018	2019	2020	2021	2022	2023
Selected articles for review	0	0	0	2	4	7	20	11	4
Cross-Referenced	2	3	3	2	0	1	0	0	0
Selected	2	3	3	2	2	1	6	2	3

Figure 3. Selected Models vs. Identified Models

Through our selection, it is possible to identify a growing trend in the number of published articles in readiness and maturity models (within the selected boundaries of our work), with its peak in 2021 and some stabilization (or decline) in 2022 and 2023.

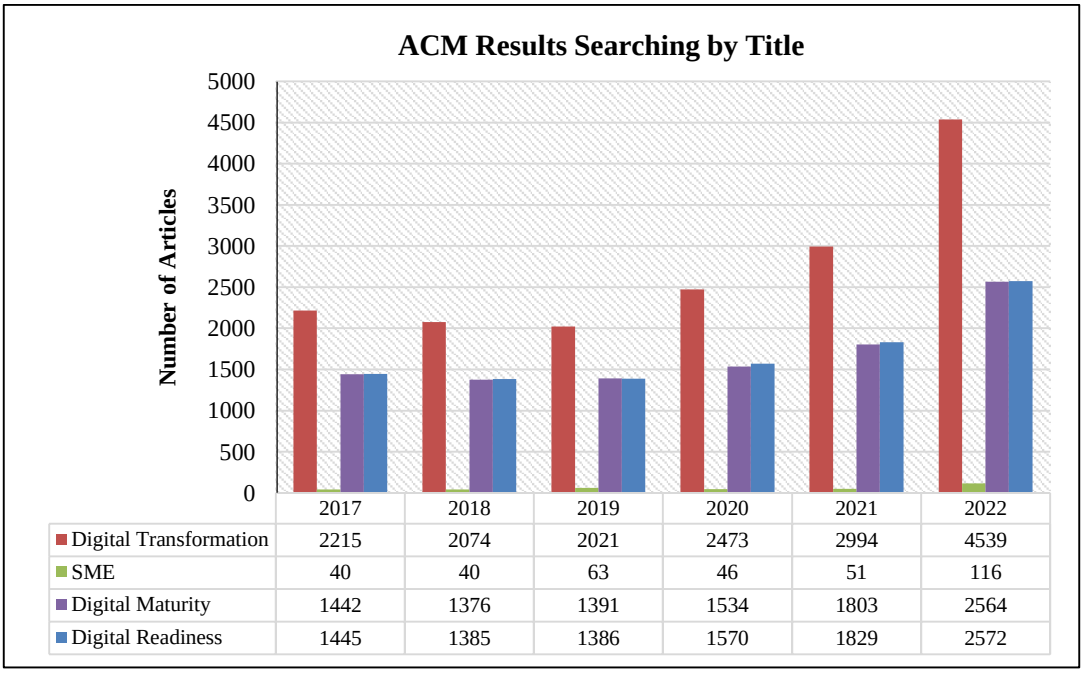
An additional data point came from a further investigation of our three databases, where we looked not only at our selection boundaries but rather an expanded scope, identifying the number of search results using a title-based keyword search so we could better understand the trend of the research happening in the field of our work. We selected four keywords, "Digital Transformation," "SME," "Digital Maturity," and "Digital Readiness," and the period between 2017 and 2022. Figures 4, 5, and 6 show the publications' evolution from 2017 to 2022 with the keywords in the title.



	2017	2018	2019	2020	2021	2022
Digital Transformation	417	839	1602	2522	3831	4773
SME	1130	1265	1397	1480	1459	1616
Digital Maturity	186	234	336	388	531	615
Digital Readiness	138	193	301	423	615	618

Figure 4. Search by keywords in Scopus by year

Figure 4 shows a visible increase in publications in the four keywords, with a steeper increase in "Digital Transformation," especially from 2020 to 2021. One interesting point is the convergence between digital maturity and readiness, especially between 2021 and 2022. This data point may indicate an increased interest in the topics as two different perspectives of digital transformation assessment align with the previous findings [31].



	2017	2018	2019	2020	2021	2022
Digital Transformation	2215	2074	2021	2473	2994	4539
SME	40	40	63	46	51	116
Digital Maturity	1442	1376	1391	1534	1803	2564
Digital Readiness	1445	1385	1386	1570	1829	2572

Figure 5. Search by keywords in ACM by year

The ACM results are consistent with what we found in Scopus, with one main difference (see Figure 5). The hits for "SME" are significantly lower than the other three keywords, which may indicate that research focusing on "SMEs" is not yet a topic of paramount relevance for ACM.

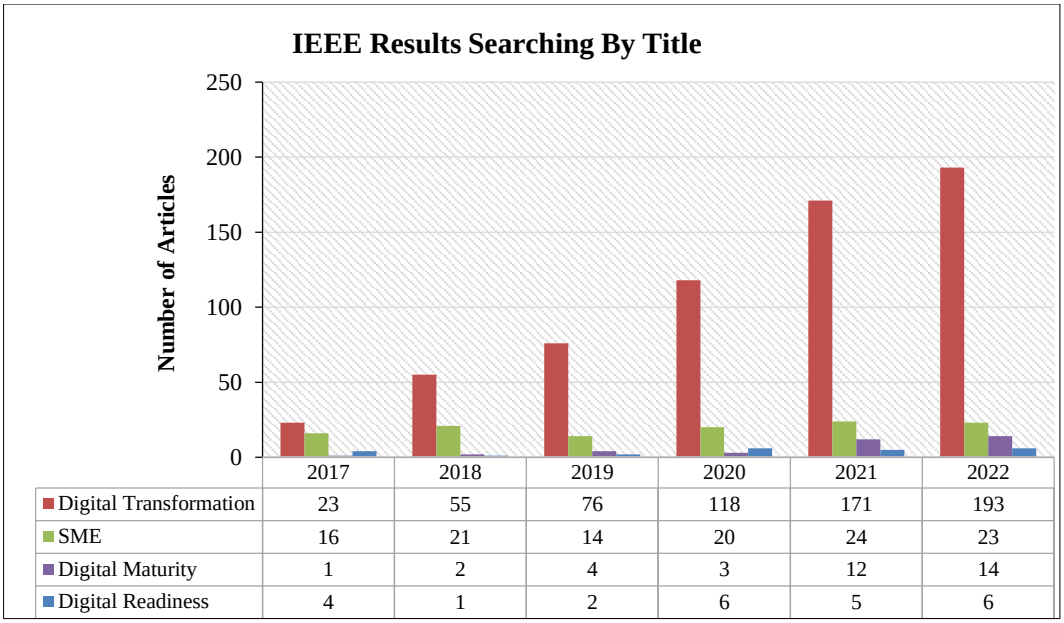


Figure 6. Search by keywords in IEEE by year

When comparing Figures 4, 5, and 6, we can also identify that the topics of digital maturity and digital readiness in the IEEE database have significantly fewer hits than the other two.

To complement the data related to the evolution of the research, in Table 11, we have summarized the list of conferences, journals, and books that published the identified maturity and readiness models. The analysis shows that 46% of the selected articles were published in journals. However, it also indicates that more publications have been published in journals over the past three years (since 2020), while before 2020, conferences were more dominating. Before 2020, 50% of models were published in conferences; post-2020, that number fell to 25%. In the opposite direction, 38% of models were published in conferences before 2019, while post-2020, that number is close to 60%. These figures indicate an increased interest in the subject, leading to more journals accepting those studies.

Table 11. Summary of conferences, journals, and books where models were identified

Title	# articles	Conference	Journal	Book/Other
2018 IEEE International Conference on Engineering, Technology, and Innovation	1	X		
2019 IEEE 23rd International Enterprise Distributed Object Computing Conference	1	X		
2023 27th International Conference on Information Technology	1	X		
Acatech Studie	1			X
Advances in Production Management Systems	1	X		
Annual Reviews in Control	1		X	
Big Data and Cognitive Computing	1		X	
Business & Information Systems Engineering	1		X	
CCSA 2021: Computational Science and Its Applications	1	X		
Computers in Industry	1		X	
Electronics	1		X	
FedCSIS 2016	1	X		
Hawaii International Conference on System Sciences	1	X		
Impuls-Stiftung des VDMA	1			X
International Journal of Systematic Innovation	1		X	
Journal of Information Technology Theory and Application	1		X	
Journal of Universal Computer Science	1		X	
Management and Production Engineering Review	1		X	
MCIS2016	1	X		
Procedia CIRP	1		X	
Procedia Computer Science	1		X	
RCIS 2021: Research Challenges in Information Science	1	X		
Towards a new era in manufacturing	1			X
Trends and Applications in Information Systems and Technologies	1			X
		9	**11**	**4**

The selected 24 maturity-readiness models (see Table 10) have been cited more than 3000 times within the research community, which indicates their relevance in this field. Figure 7 summarizes the aggregation of the citations by the year

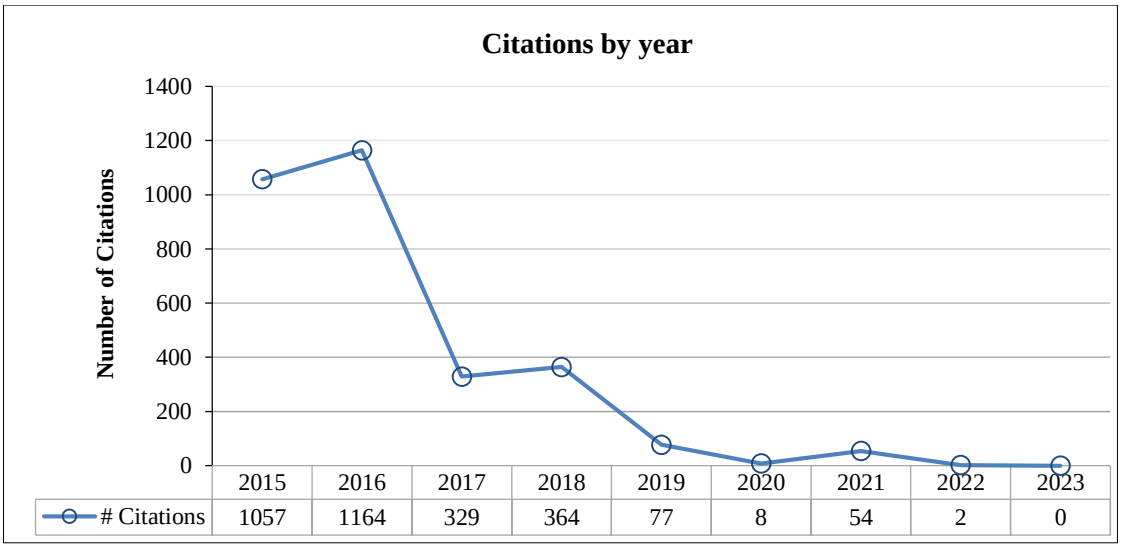


Figure 7. Aggregation of citations by year

With a closer look at the data, we can see that articles published earlier (2015 and 2016) still have the highest citation, which can be expected as those are published in the libraries longer, but especially since 2018, that number has dropped significantly. Especially in a field that is developing so fast and with so much research being done (see Figures 3, 4, and 5), it shows to be conflicting that the most cited models remain (with distance) the ones from 2015 and 2016, counting for more than 73% of the total citations of the selected models. The models that have been cited the most are:

- Matt et al. (2015) [38]: Cited >1000x.
- Schumacher et al. (2016) [41]: Cited > 800x.
- Berghaus & Back (2016) [39]: Cited > 350x.

The three publications account for 70% of the total citations of the models. They are some of the most used reference models in the domain of readiness and maturity for digital transformation.

Lastly, each analyzed model has what dimensions of digital transformation they focused on assessing identified. The different models show many unique names (80 unique names), but not clearly with 80 unique meanings. In other words, it is possible to cluster it to understand better what dimensions are being addressed across all the studies. To simplify the understanding of what factors play a role in the success of digital transformation, we reviewed all 80 dimensions listed in the different models. We normalized them by mapping each unique name found to a more normalized name that could cluster similar ones. Table 12 summarizes the 25 unique nomenclature we developed and their meaning. The following sub-chapter will detail how we mapped the different identified dimensions to the newly normalized names.

Table 12. Identified normalized dimensions and the meaning of each one

	Normalized Dimension	Explanation
1	Process	Process-related dimensions could be process design, mapping, and business process management.
2	Monitoring and Control	Monitoring and control practices, excluding governance (separate dimension)
3	Technology	Technology-related dimensions, including all system IT-related components.
4	Organization	Dimensions addressing organizational structure, organizational setup
5	Strategy	Strategy related dimensions
6	People	Dimensions related to people topics
7	Business Model	Dimensions that analyze how the company operates its business, their digital presence
8	Customers	Dimensions related to customer focus, customer experience, user experience
9	Smart factory	Very industry 4.0 focused, and in this case, dimensions related to the practices described to the smart factory.
10	Culture	Dimensions related to culture management topics
11	Structural Changes	Dimensions related to the processes associated with change and change management

12	Changes in Value Creation	Dimensions related to adjustment to how companies create value for their customers
13	Innovation	Dimensions related to the mechanisms of how companies innovate their products
14	Collaboration	Dimensions related to the way collaboration happens within organizations
15	Transformation	Dimensions associated with the process of managing and executing transformation
16	Vertical Integration	Dimensions related to the strategic approach of vertical integration in some aspects of the business
17	Horizontal Integration	Dimensions related to the strategic approach of horizontal integration in some aspects of the business
18	Products & Services	Dimensions related to the products and services that companies have to offer to their customers
19	Leadership	Dimensions related to the topics associated with leadership
20	Operations	Dimensions related to the topics related to operations management, smart operations
21	Governance	Dimensions related to the governing process around transformation, processes, technology
22	Value Proposition	Dimensions related to the value proposition that companies offer to their customers
23	Market & Marketing	Dimensions related to go-to-market, market network, and marketing
24	Logistics	Dimensions related to the overall logistics management
25	Finance	Dimensions related to the overall finance management

As per the defined normalized dimensions summarized in Table 12, we mapped each unique dimension identified in the 24 assessed models to one normalized dimension name. With this approach, we reduced the view from 80 unique names to 25 unique ones, simplifying the understanding of the factors (dimensions) involved in a digital transformation process. The mapping between the normalized unique names and the different identified names in the 24 analyzed articles is presented in Table 13.

Table 13. Normalized dimensions and mapped reviewed model dimensions

Normalized Dimension	Literature Identified Dimension	Literature Identified Dimension
Process	• Process • Process organization • Digital Process Transformation	
Monitoring and Control	• Monitoring & Control	
Technology	• Technology • Information Technology • Cross-sectional technology criteria • Use of Technologies • Transformation Management • Data • Technical solutions • Hardware • Use of technology	• Complimentary IT System • Connectivity • Information Systems • Knowledge base • Expendability • Transparency • Reusability • Standardization • Software • Role of informatics
Organization	• Organization • Structural organization • Organizational Structure	• Structure • Organizational culture • Orgware
Strategy	• Strategy	• Strategy Development
People	• People • Employees • Workforce Management • Peopleware	• Competencies • Personnel • Resources • Human resources
Business Model	• Business Model • Online Presence	• Digital business model
Customers	• Customer Interface • Customer Experience	• Customers • User Experience
Smart factory	• Smart Factory	
Culture	• Culture	
Structural Changes	• Structural Changes	
Changes in Value Creation	• Changes in Value Creation	• Value Creation
Innovation	• Product Innovation	• Innovation culture
Collaboration	• Collaboration	• Cooperation

Transformation	• Transformation	• Transformation Management
Vertical Integration	• Vertical Integration	
Horizontal Integration	• Horizontal Integration	
Products & Services	• Smart Products • Data-Driven Services • Smart products and services • Product & Service Provision	• Digital Product Development • Products • Product Development
Leadership	• Leadership	• Management
Operations	• Smart Operations	• Operations
Governance	• Governance • IT Governance	• Strategic Governance
Value Proposition	• Offering to the customers	• Value Proposition
Market & Marketing	• Market & Network	• Marketing
Logistics	• Logistics	
Finance	• Financial Aspects • Finance	• Accounting

We looked at the number of times each non-normalized dimension appears in the different models (we call these "hits") to better understand what dimensions have more or less usage across the research work in the selected models. Table 14 summarizes the number of mapped hits each normalized dimension has across all the models (through the original non-normalized dimension names) to provide more insights. A mapped hit is the number of times a specific non-normalized dimension (the original 80 unique names) is selected in different articles. For example, the process has 27 mapped hits, reflecting how many times the non-normalized dimensions (Process, Process organization, Digital Process Transformation) were found across the 24 reviewed models. This indicator is very relevant to understanding the actual prevalence of those dimensions, which may help assess the key focus of the different models.

Table 14. Number of found non-normalized dimensions mapped to normalized dimensions

Normalized Dimension	Number of mapped hits of the non-normalized dimensions in the different models	% of hits vs. Total hits
Process	8	5.8%
Monitoring and Control	1	0.7%
Technology	27	19.4%
Organization	13	9.4%
Strategy	10	7.2%
People	14	10.1%
Business Model	2	1.4%
Customers	7	5%
Smart factory	3	2.2%
Culture	6	4.3%
Structural Changes	1	0.7%
Changes in Value Creation	2	1.4%
Innovation	2	1.4%
Collaboration	2	1.4%
Transformation	5	3.6%
Vertical Integration	2	1.4%
Horizontal Integration	2	1.4%
Products & Services	8	5.8%
Leadership	3	2.2%
Operations	5	3.6%
Governance	7	5%
Value Proposition	2	1.4%
Market & Marketing	4	2.9%
Logistics	1	0.7%
Finance	2	1.4%

In total, we see that we have 139 hits of the different initial non-harmonized dimensions and four main characteristics (accounting for 46%) used in almost all (90%) of the other models: Technology, Organization, Strategy, and People. Looking at the content and target of all the models reviewed, we have not identified any model that uniquely defines the concept of maturity in comparison to the concept of readiness, even in cases where the publication title referred to the "readiness" concept, what ultimately was found in the publication is a mix of concepts that makes it very complicated to comprehend how to isolate the two concepts fully.

When we consider the content of the models, previous systematic literature reviews, such as Voß & Pawlowski (2019) [35], together with the perceived significant increase over the past 7 to 8 years (see Figures 2 to 8). In that case, we can position the topic of readiness assessment as an emergent discussion that has not yet received the same level of attention as the general digital transformation and even less attention when we put it within the SMEs' context. That lack of focus is seen across the number of hits found in the databases, as well as by the lack of models that position readiness as an independent dimension of digital transformation assessment.

3-2- Findings

Through the methodology described in Chapter 2, we shortlisted the 24 models we assessed in more detail, summarized in Table 15.

Table 15. Summary of the different maturity/readiness models reviewed

Publication	Model	Maturity/ Readiness	SME	Sector	Levels	Dimensions to assess
Leyh et al. (2015) [37]	SIMMI 4.0 - System Integration Maturity Model Industry 4.0	Maturity	No	Industry	5	Vertical Integration, Horizontal Integration, Digital product development, Cross-sectional technology criteria
Matt et al. (2015) [38]	Digital Transformation Framework	Maturity	No			Use of Technologies, Structural Changes, Changes in Value Creation, Financial aspects
Berghaus & Back (2016) [39]	Stages in digital business transformation	Maturity	No		5	Customer Experience, Product Innovation, Strategy, Organization, Process Digitization, Collaboration, Information Technology, Culture & Expertise, Transformation Management
Lichtblau et al. (2016) [40]	INDUSTRIE 4.0 READINESS	Maturity & Readiness	Yes	Industry	6	Strategy & Organization, Smart Factory, Smart operations, Smart products, Data-driven services, Employees
Schumacher et al. (2016) [41]	Industry 4.0 Maturity Model	Maturity	No	Industry	5	Strategy, Customers, Leadership, Products, Operations, Culture, People, Governance, Technology
de Carolis et al. (2017) [42]	DREAMY – Digital Readiness Assessment Maturity Model	Maturity	No	Industry	5	Process, Monitoring, and Control, Technology, Organization
Klötzer & Pflaum (2017) [43]	Maturity Model for Digitalization within the Manufacturing Industry's Supply Chain	Maturity	No	Industry	5	Strategy Development, Offering to the customers, Smart factory, Complimentary IT System, Cooperation, Structural organization, Process organization, Competencies, Innovation culture
Leino et al. (2017) [31]	VTT Model of Digimaturity	Maturity	No		4	Strategy, Business Model, Customer Interface, Organization & Processes, People & Culture, Information Technology
Canetta et al. (2018) [44]	Digitalization Maturity Assessment and Impact Analysis	Maturity	No	Industry		Strategy, Processes, Products & Services, Technologies and Personnel
Gimpel et al. (2018) [45]	Framework of Action Fields and its Application at ZEISS	Maturity	No			Customer, Data, Value Proposition, Organization, Operations, Transformation Management
Aguiar et al. (2019) [48]	Digital Transformation Capability Maturity Model Framework	Maturity	No		5	Customer, Data, Value Proposition, Organization, Operations, Transformation Management
Colli et al. (2019) [49]	360DMA	Maturity	No	Industry	5	Governance, Technology, Connectivity, Value creation, Competencies
Schuh et al. (2020) [57]	Acatech	Maturity	No		6	Organizational Structure, Resources, Information Systems, culture
Soares et al. (2021) [75]	SHIFTo4.0	Maturity	No	Industry	5	Strategy & Organization, Employees, Market & network, Smart operations, smart factory, Smart products & services
Borštnar & Pucihar (2021) [60]	Multi-Attribute Assessment of Digital Maturity of SMEs	Maturity	Yes			Organization Capability (Human resources, organizational culture, management), Digital Capability (use of technology, the role of informatics, digital business model, strategy)
Cunha & Sousa (2021) [65]	SMES' Digital Transformation Roadmap	Readiness & Maturity	Yes	Industry	3	Vertical Integration, Horizontal Integration, IT, Product Development, Marketing, People & Processes
Gökalp & Martinez (2021) [67]	DX-CMM	Maturity	No	Industry	6	Strategic Governance, Information Technology, Digital Process Transformation, Workforce Management

Nerima & Ralyté (2021) [13]	Digital Maturity Balance Model for Public Organizations	Maturity	No	Public Sector		Data, IT Governance, Strategy, Organization, Process
Sándor & Gubán (2021) [73]	Digital Maturity Technical Architecture	Maturity	Yes			Peopleware, Online Presence, Technical solutions, Orgware, Software, Hardware
Costa et al. (2022) [77]	Digital maturity of micro and small enterprises	Maturity	Yes		5	Strategy, leadership, products; operations culture, people, governance, and technology
Merzlov & Shilova (2022) [80]	Digital Maturity Model for Organizations	Maturity	No		5	Human Resources, Product & Service Provision, Marketing, Logistics, Finance & Accounting, and Support
Ehrensperger et al. (2023) [87]	Maturity Model for Digital Business Ecosystems	Maturity	No	Digital Business	5	Knowledge base, Expandability, Governance, Transparency, Cybersecurity, Reusability, Standardization
Haryanti et al (2023) [88]	DX-SAMM	Maturity	No		5	Structure & Organization, Technology, Strategy, Customer, Employee, Culture, Transformation Process
Tiss & Orellano (2023) [90]	Maturity Model of Digital Transformation in Supply Chains: A Multi-dimensional Approach	Maturity	No	Supply Chain	5	Technology, User Experience, Organization

One of the first clear findings of our analysis is the visible need for more standardization of models across the academic space. Within the 24 models, we see 80 unique names listed for the dimensions academics selected as the key areas to be assessed in digital transformation. This point highlights the need for more standardization in defining the different dimensions that must be evaluated in the maturity or readiness of a digital transformation. It is even more relevant when considering the timespan between 2015 and 2023, as most (46%) of the models were published between 2021 and 2023, meaning almost half were published very recently. However, we identify a significant gap in normalizing what is being assessed, even though those models could have used previous publications as a clear proposal for a standardized approach. That lack of consistency is likely due to the complexity already indicated around digital transformation and a significant increase in research in this field [3].

While we identify many unique names for the assessed dimensions, we can see synergies in strategy, technology, organization, and people. Those aspects are consistent across most models, though represented through different nomenclature in those areas. However, what is more interesting is the conflicting views of some of the authors. We see authors such as Berghaus & Back (2016) [39] profoundly focused on digital readiness and maturity from a business perspective. On the other hand, we see different models that are fundamentally focused on the technology aspect of the transformation, such as Ehrensperger et al. (2023) [87]. The mentioned conflict exists, as both claim to look at a maturity assessment model and its value to organizations without considering the same baseline to assess. Nevertheless, all models consider the transformation a multi-dimensional process, with conflicts arising mainly from the weight they apply to the different dimensions.

As we described previously, we summarized the 80 different unique names in 25 normalized dimensions of digital transformation assessment (see Table 13). Table 14 provides an essential view of the key focus areas across the different assessment models. It brings to light a transparent understanding that Technology, People, Strategy, and Organization are the most used dimensions across all the models. This pattern tells us that the community is wholly aligned on some key aspects that shall be considered in a digital transformation assessment, which is a relevant confirmation point. However, which is the most critical finding to confirm our statement that we lack a standardized approach, we see that 53% of the hits we identify in the models account for 21 different dimensions (already post-initial normalization). That means it is likely that the extension of the core dimensions (Technology, People, Strategy, and Organization) has yet to achieve the same level of shared understanding, leading to very different and sometimes conflicting views of what is essential to assess.

In the context of our research, especially considering the gap listed before regarding the need for more profound research in the field of readiness instead of maturity, we can also see data supporting it coming from the analysis of the assessment dimensions. For example, Monitoring and Control, which could very well be an essential area to assess when trying to understand how to maximize results, shows a 0.7% usage, being the lowest of all the different dimensions, together with Structural Changes, no less than a dimension related to change management (especially critical when discussing readiness). In addition, marginally higher (1.4%), we see other dimensions that could arguably be very relevant in a state of readiness to adopt a change, such as Collaboration, Business Model, or Value Proposition, but with less focus on the research work we analyzed. One of the possible reasons to justify the enormous gap between the top 4 and the remainder is that those top 4 could be broad enough to include some of the rest, but that would support our finding that this lack of standardized definitions leads to very confusing approaches. By reviewing the most and least used, it is safe to say it supports the statement that research has focused on maturity, as the top dimensions are much more oriented to a measure that indicates "how far it is implemented." In contrast, the least used dimensions are connected to the aspects that are less related to that implementation phase but rather to a state of readiness to embrace that execution. These dimensions often act as enablers to create the willingness to adopt and maximize change [32, 33].

In the context of this research, we also see an ambiguous usage of the terms maturity and readiness, with the two terms frequently being used to describe the same, though they have two very different meanings. For example, de Carolis et al. (2017) [42] refer to their model as "readiness" but describe a maturity assessment throughout their research. In only two clear cases, Lichtblau et al. (2016) [40] and Cunha & Sousa (2021) [65], can we identify a clear separation in understanding between maturity and readiness, though having presented limited clarity on what is the actual difference in the practical execution of the model.

Most of the scientific knowledge present in the domain of maturity and readiness assessments is designed for larger companies. It does not cater to small and medium businesses in the sense of tailoring the whole assessment approach to compensate for the identified gaps in those companies (resources, knowledge, and funds) as, for example, North & Varvakis (2016) [23] identified in their work. However, in more recent models, there is already a more conscious view of SMEs, with three of the models that consider SMEs being published in 2021 and 2022, which accounts for 37,5% of the models published in those years (from our selected subset), in comparison to the interval 2015 to 2020, with only one model accounting for SMEs (7%).

Figure 8 summarizes the number of models (selected for this research) published by year. We cannot identify any pattern contrary to the constant evolution of general publications in the digital transformation space (see Figures 3, 4, and 5). One relevant data point is the spike of published models in 2021, consistent with the significant increase of publications from 2020 to 2021 in Scopus in digital transformation, digital readiness, and digital maturity (see Figure 2). While we have no data to confirm it, one possible hypothesis is that COVID-19 and its ripple effect may have added to increasing the interest in the digital space due to the worldwide spread of lockdowns.

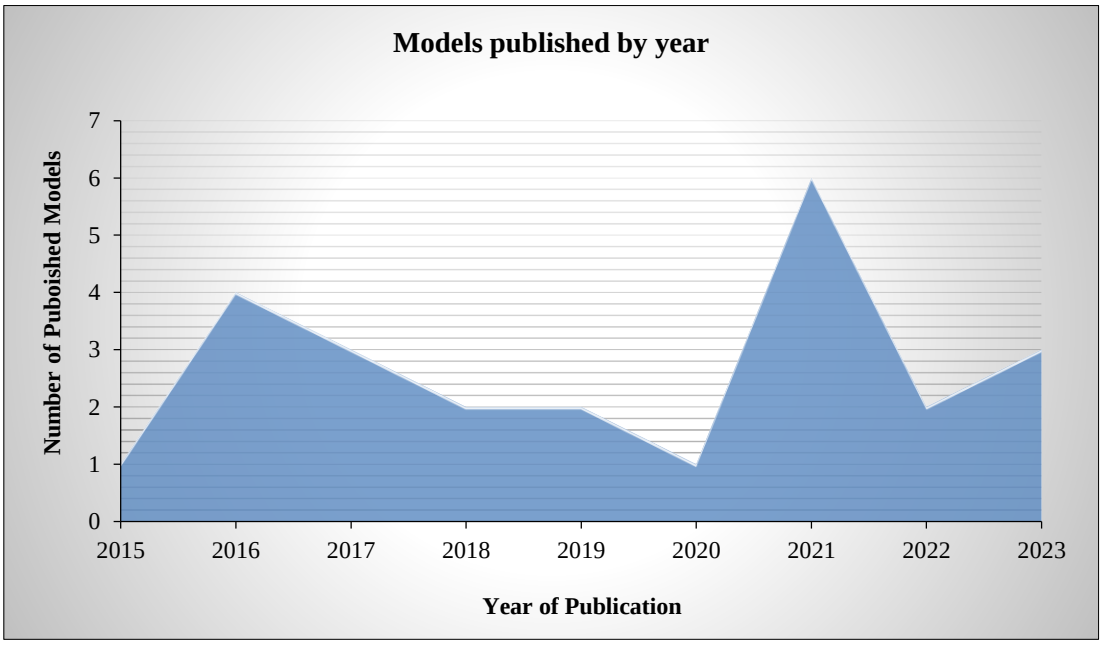


Figure 8. Models published by year

Lastly, Table 16 summarizes some additional critical findings related to the research questions we defined.

Table 16. Other critical findings related to the research questions

RQ	Question	Key Findings
1	What current state-of-the-art models assess the organization's maturity or readiness in their digital transformation?	Reviewing the selected models has provided additional insights for further research. While we searched by maturity and readiness models during our article selection, we can identify that 92% of the selected models are focused on Maturity Assessment, with only the remaining 8% (2) bringing some aspects of readiness, though without a clear separation of what is readiness and what is maturity.
2	Based on the identified models, is there a clearly defined subset designed for Small & Medium Enterprises?	An important finding in our analysis is the significant gap between small and medium enterprises and large enterprises when looking at assessment models. Four of the 24 models approach the SMEs' perspective (16%), a significantly small portion of the overall research in the maturity and readiness models.
3	What models assess using the perspective/inputs from the general employees rather than focusing on the company's management?	Our work has assessed that more than 90% of the models use a self-assessment/questionnaire approach, with minimal segmentation of what profiles will respond to those questionnaires. The majority is focusing either on managers or without categorization at all. None of the models compares general employees and senior management, using that data to understand better what could be a perception gap.

One of the essential findings of our research is the confirmation of the preliminary views shared by Voß & Pawlowski (2019) [35], where the authors have positioned the possibility of the existing research being very biased towards the senior management perspectives, which carries multiple risks. Our research has confirmed that same view and went a few steps deeper by not only identifying that most of the research is indeed not fully considering the employees' perspective but also not distinguishing the concepts of readiness and maturity. While some models refer to that concept, none fully defines the criteria that uniquely identify what is maturity and what is readiness, and often refer to the two terms while presenting very similar criteria. We could not identify systematic literature reviews within readiness and maturity models. Hence, the one published by Voß & Pawlowski (2019) [35] serves as our reference. However, the models of Lichtblau et al. (2016) [40] and Cunha & Sousa (2021) [65] also provide an exciting view of the combined view of readiness and maturity. We could not, though, once more, fully extract the clear separation between maturity and readiness, which makes it complex to assess the validity of our research fully. One of the possible explanations for this lack of investment in the clear separation of the concepts is the reasonably recent phenomenon of digital transformation. We can see in Figures 2 to 8 a steep increase in the research in these fields, but an increase that starts somewhere in 2017 or 2018. While the DT is so widely discussed today, there are still entirely open questions, especially when trying to understand what is behind some of the failures in delivering those transformations and failures to maximize the results. The concept of maturity is more known due to the influence of previous models, such as Capability Maturity Model Integration (CMMI), while the concept of readiness is not so widely used, and the data presented in Figures 2 to 8 help support that understanding. This scenario is even more apparent if we add the SMEs' context. If we consider only from an SME perspective, the gap is even more significant as we have not identified any relevant research isolating readiness within SMEs' environments.

3-3- Discussion

In this chapter, we discuss the findings obtained by reviewing the 59 selected articles and 24 shortlisted maturity and readiness models using the lenses of three of our research questions.

State-Of-The-Art Maturity & Readiness Models:

Reviewing the 59 shortlisted articles has provided relevant insights into the existing line of research. 92% of the reviewed assessment models are purely focused on maturity assessment, and the remainder, 8% not being entirely focused on readiness assessment. On the one hand, the literature demonstrates the relevance of understanding the readiness aspect of the transformation. However, on the other hand, the research of assessment models for that readiness needs to catch up to maturity models. This point is particularly relevant when we revert to the findings of Lokuge et al. (2019) [32] and Kane et al. (2018) [33], which indicate that a lack of organizational readiness is crucial to the failure to achieve digital transformation outcomes. Our analysis is also supported by the data we collected regarding the factors that are more of the focus in the different models. There is a clear focus on the factors (dimensions) that derive from an organization's maturity rather than its readiness to embrace that implementation and obtain the expected results.

In addition, there is minimal alignment across academia on the critical elements to be evaluated in a model of this kind. While there is some alignment in four dimensions (Technology, Strategy, People, and Organization), there is also a very diverse set of directions taken in the remainder of aspects to be evaluated, indicating a gap that needs to be addressed in the current published work.

The data is precise, and there is a significant investment in research in the field of digital transformation, including assessment models. However, our research has demonstrated a substantial gap in the field of readiness assessments, even though the literature unequivocally references this readiness as a critical aspect of the success of any transformation within an organization. We see a clear opportunity to develop an assessment model designed to look at an organization's readiness, potentially as a critical step to address the large number of companies that fail to obtain the results they expect from a digital transformation [28].

Models That Apply to Small & Medium Enterprises:

To set the context, the numbers presented for Europe in 2019 and 2020 demonstrate that SMEs contribute a significant part of the number of companies within the European Union. The relevance of these companies is undisputable, contributing to more than 50% of countries' gross domestic product (GDP) [18, 19]. However, fully supported by the literature, SMEs must keep up with technological advancements, which is critical to their growth and business sustainability [20]. These companies need more human resources and technical skills to face digital evolution [30]. That combination of technology with required skills holds real value for SMEs [24, 25].

However, in the context of our research, we do not find the research work as focused on these companies (from a digital transformation perspective), irrespective of its weight to the global economy. The fact that more than 86% of the assessment models we selected do not refer to SMEs seriously indicates a disproportional investment into models catered

to larger organizations. If we consider the data from the European Commission, more than 90% of companies are SMEs, with that 90 % accounting for 50% of the GDP. However, the assessment models are more than 86% focused on the 10% of the remaining companies. Figure 9 helps visualize the disproportional investment in research focused on larger companies, lagging in a space (SMEs) that is factually, at least, equally relevant to the global economy.

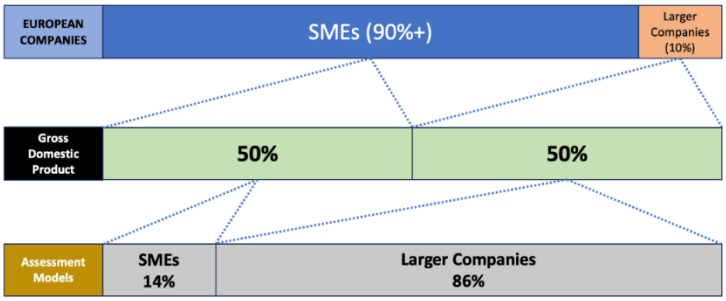


Figure 9. Relationship between the number of companies and assessment models' focus (European Commission Data)

Our research points to a clear gap in assessing SMEs' digital transformation. This point is valid regarding maturity assessments but even more valid when addressing readiness models. Of the 16% of models that somehow consider SMEs, 75% are maturity assessments, and only one of the four considers readiness in combination with maturity without clearly defining the differences.

Are the Models Focusing on Employees?

In 1997, Birkinshaw's [91] work pointed out that perceptions between managers and employees when understanding readiness for change may differ. This data point does not seem to have changed much, and some of the work by Voß & Pawlowski (2019) [35] indicates that same challenge.

While perceptions may vary, managers must realize those perceptions to tackle the gaps and discrepancies to achieve the expected results [34]. Identifying those differences in readiness for change may play a critical role in success and should be considered when addressing readiness assessment models. Our analysis is aligned with the previous findings of Voß & Pawlowski (2019) [35], which pointed to a clear gap in developing readiness models that better understand the employee's perspective rather than so much focused on the managers' view. In their work, Trenerry et al. (2021) [92] bring essential evidence to support the point that digital transformation lags in employee-centric factors, also supporting Birkinshaw (1997) [91] with the view that employees and managers may differ in the perception of what is needed to adopt change and what state of flux the company is in.

Our research, considering the literature view, has evaluated all the models, and no models have yet taken the employees' perspective and the difference of perspective to managers as a critical pillar of the assessment. While some models broach this aspect through questionnaires raised to all employees, they all differ, indicating a significant gap, especially with the gaps identified in readiness models and the lack of focus in SMEs. This data point raises a crucial area that can be significantly further developed in combination with the developments of the other key identified gaps.

4- Proposal for a Standardized Set of Categories and Subcategories to Assess Maturity and Readiness in Digital Transformation

In this chapter, we propose a new baseline set of categories and subcategories that may be used for future standardized assessment models for digital transformation. Our proposal is based on the existing models and all their work to define their assessment dimensions. We followed a three-step approach:

- Normalize the initial 80 unique dimensions found in the assessment models. See Table 13.
- Cluster the normalized dimensions in overarching categories.
- Further aggregate dimensions that have significant proximity.

4-1- Cluster the Normalized Dimensions in Categories

The normalized dimensions give us a better picture of the aspects covered by the selected models. However, we need a more straightforward way to categorize them that could be helpful in future usages of this outcome. The Cambridge Dictionary [93] defines the category as "(in a system for dividing things according to appearance, quality, etc.) a type, or a group of things having some features that are the same." From this definition, we understand that a category is an

approach to different group dimensions, creating an overarching group of categories that fully summarize the identified normalized dimensions.

To support the process of identifying possible categories, we identified in previous research [54, 94-99] that lists three critical blocks of a digital transformation: (1) External Digital Transformation; (2) Strategy; (3) Internal Digital Transformation. Those could be our three categories, but external and internal could need more tangibility, as otherwise too generic. Hence, we have reviewed the different dimensions and defined the following categories with the support of the literature referenced above:

- External Digital Transformation: Summarizes the aspects focus on the outer facing elements of the company such as customers, products, and business models). Hence, we split it into two categories:
  - ***Market****:* What is the company's market to be addressed, what customers are being served, and what products are being sold
  - ***Business Model****:* What business models is a company addressing in the identified market?
- Internal Digital Transformation: Summarizes the aspects that focus on the internal factors a company must address to transform, such as people, culture, organizational structure, or processes. We split this into two categories:
  - ***Processes****:* How is the company managing the operations that are key to the organization
  - ***Organization***: All the aspects related to how companies organize to execute the defined processes.

With this approach, we concluded the following categories: Market, Business Model, Strategy, Organization, and Processes. Those five categories allow us to map every single normalized dimension to it, based on its description and definitions coming from the selected models (using Table 12 description as the base), building a more comprehensive view of what block of digital transformation is influenced through what dimension (See Table 17, summarizing the mapping between categories and normalized dimensions).

4-2- Normalize the Subcategories

In the previous chapter, we identified five possible categories to summarize the normalized dimensions. In Tables 12 to 17, we documented the process that started from 80 unique dimension names towards normalized dimension nomenclature mapped to the identified categories.

As the last step, we have looked into the 25 dimensions. Based on Table 12, we identified further synergies that could simplify the different areas used for future assessment models. To streamline the overall outcome of our research, we assume that category has subcategories, and that subcategory is defined in the Cambridge Dictionary (Cambridge Dictionary, 2023) as "(in a system for dividing things according to appearance, quality, etc.) a category (= a type, or a group of things having some features that are the same) that is part of another category," and that we can map the normalized dimensions as subcategories of the categories summarized in Table 17. Table 18 summarizes the renamed dimensions and the merging of some of those based on its definition (Table 12).

The result of this process led to a proposal that summarizes five categories and twenty subcategories. As in Table 18, in some cases, we propose a name change (e.g., Business Model to Business Structure). In contrast, in another case, we merge different ones under an overarching subcategory that can have one name or a completely different one (e.g., Products & Services = Changes in Value Creation + Products & Services).

Table 17. Normalized dimensions mapped to the five overarching categories

Normalized Dimensions	Business Model	Market	Strategy	Organization	Processes
Process					X
Monitoring and Control					X
Technology			X		
Organization				X	
Strategy			X		
People				X	
Business Model	X				
Customers		X			
Smart factory				X	
Culture				X	
Structural Changes			X		

Changes in Value Creation	X				
Innovation	X				
Collaboration				X	
Transformation			X		
Vertical Integration			X		
Horizontal Integration			X		
Products & Services	X				
Leadership				X	
Operations				X	
Governance					X
Value Proposition		X			
Market & Marketing		X			
Logistics				X	
Finance				X	

Table 18. Mapped normalized dimensions to renamed subcategories and to proposed categories

Category/Subcategory	# of mapped hits of the original non-normalized dimensions	Mapped normalized dimensions	% present in the reviewed models
Business Model			
Business Structure	2	- Business Model	1.4%
Products & Services	10	- Changes in Value Creation - Products & Services	7.2%
Innovation	2	- Innovation	1.4%
Market			
Customers	7	- Customers	5%
Value Proposition	2	- Value Proposition	1.4%
Go To Market	4	- Market & Marketing	2.9%
Strategy			
Strategic Planning	10	- Strategy	7.2%
Change Management	1	- Structural Changes	0.7%
Transformation	5	- Transformation	3.6%
Organizational Strategy	4	- Vertical Integration - Horizontal Integration	2.9%
Technology	27	- Technology	19.4%
Organization			
Organizational Structure	13	- Organization	9.4%
People	14	- People	10.1%
Culture	6	- Culture	4.3%
Collaboration	2	- Collaboration	1.4%
Leadership	3	- Leadership	2.2%
Operations	11	- Operations - Smart Factory - Logistics - Finance	7.9%
Processes			
Process Management	8	- Process	5.8%
Monitoring & Control	1	- Monitoring & Control	0.7%
Governance	7	- Governance	5%

Finally, similarly to the process presented in Table 14, we have also mapped each of the hits of the non-normalized dimension (across the 24 assessment models) with the newly proposed subcategories. The findings are similar to the ones discussed in Chapter 3.

4-3- Map the Selected Articles against the Newly Defined Categories

As a tool to assess the scope of the different models and simultaneously test the defined categories in terms of coverage, we have mapped the selected models against the specified categories. Mapping a category to a specific model indicates that the model at least covers one of the subcategories of that category. Table 19 summarizes the mapping.

Table 19. Selected models mapped against defined categories (cover at least one subcategory)

Publication	Business Model	Market	Strategy	Organization	Processes
de Carolis et al. (2017) [42]			X	X	X
Leino et al. (2017) [31]	X	X	X	X	X
Lichtblau et al. (2016) [40]	X		X	X	
Matt et al. (2015) [38]	X		X		
Berghaus & Back (2016) [39]		X	X	X	X
Leyh et al. (2015) [37]	X		X		
Schumacher et al. (2016) [41]	X	X	X	X	X
Klötzer & Pflaum (2017) [43]		X	X	X	X
Canetta et al. (2018) [44]	X		X	X	X
Gimpel et al. (2018) [45]		X	X	X	
Aguiar et al. (2019) [48]		X	X	X	
Colli et al. (2019) [49]	X		X	X	X
Schuh et al. (2020) [57]			X	X	
Soares et al. (2021) [75]	X	X	X	X	
Gökalp & Martinez (2021) [67]			X	X	X
Nerima & Ralyté (2021) [13]			X	X	X
Cunha & Sousa (2021) [65]		X	X	X	X
Sándor & Gubán (2021) [73]			X	X	
Borštnar & Pucihar (2021) [60]	X		X	X	
Merzlov & Shilova (2022) [80]		X		X	
Costa et al. (2022) [77]		X	X	X	X
Haryanti et al (2023) [88]		X	X	X	
Tiss & Orellano (2023) [90]		X	X	X	
Ehrensperger et al. (2023) [87]			X		X

Based on the mapping summarized in Table 19, it is possible to extract some insights that help to understand the designed models better:

- 38% of the models have at least one category business model category, but 96% have at least one subcategory of strategy, which is vastly explained by the fact that technology-related dimensions are the most used in all the different models.
- Market and Processes are mapped to 50% of the models.
- Only 8% (2) of the models have at least one subcategory in each one of the categories, and there are no models with no category mapped to it.
- In addition, we have about 25% of the models "only" mapped to two categories and 63% to three categories.

These insights help support the fact that the different models follow no single approach. However, the mapped categories distribution supports that all models could leverage one standardized procedure, as the majority (75%) consider at least three categories.

5- Conclusions

Our research has carried out an extensive literature review, attempting to understand better how companies can be more successful in their digital transformation, especially the SMEs that play such a vital role in the global economy.

Through the process, collected data, and findings, we have positively contributed to creating a more vital awareness of what factors play a role in the overall digital transformation and highlighting some research gaps that could significantly support enterprises in their journey. Looking back to our defined research questions (RQ) and how successfully we have answered them through this work:

RQ1) What is the current state-of-the-art in developed models assessing the organization's maturity and readiness in digital transformation?

We have researched several models and documented their approaches, dimensions, and levels. We have also established if those models focus on Maturity or Readiness assessments (See Table 15). We shortlisted 59 articles and assessed in detail 24 models that provide an excellent view of the current line of research in the field of readiness and maturity assessment models.

RQ2) Based on the identified models, is a clearly defined subset designed for Small and medium Enterprises?

Through the review of the selected models, our work has identified a minimal subset of models that assess the maturity assessment of SMEs, with minimal research that focused solely on SMEs. We have presented the data that shows the relevance of SMEs to the global economy and that there is an even level of investment in research in this field, which is possibly detrimental to the future development of the different country economies, as those depend heavily on SMEs, and with their limitations of resources and skills, will need significant support to transition to a more digital-oriented business model successfully. The gap in the research of assessments for SMEs, specifically readiness assessment, is demonstrated in our work and brings to light a tremendous opportunity to develop further.

RQ3) What models are being assessed using the perspective/inputs from the general employees rather than focusing on the company's management?

In line with the findings in SMEs, we have reviewed the models that look at the general employees and their managers and consider their differences in perspective as a critical factor to land a successful transformational change as a digital transformation. Despite the literature demonstrating the significant relevance of this factor, the current published research has not yet addressed it or fully incorporated it in evaluating an organization's readiness or maturity.

RQ4) What key influential factors do the authors identify within the identified models as the base for their assessment?

Our work has identified 80 unique names that define the factors (dimensions) influencing digital transformation within different models and shall be evaluated when assessing. The challenge we identified is the need for more standardization and a common approach. As demonstrated, we could identify common areas in Strategy, Technology, People, and Organization, but at the same, a very conflicting view in other aspects that may even be complementary. Through our approach, we have reviewed all the 80 listed dimensions and defined an aggregated and summarizing view that covers all the different angles from the different models. The results are summarized in Table 12, where it is possible to see a normalized list of 25 dimensions that cover all the various perspectives presented in the different research lines considered in the 24 reviewed models.

RQ5) What is the most appropriate logic to bundle those factors in the critical assessment dimensions?

The last step of our research was to propose a baseline set of categories and subcategories that could be used as a standard approach for any readiness (and maturity) assessment in future developed or enhanced models. We have summarized the review and proposal in Table 19. The final proposal comprises five categories (Business Model, Market, Strategy, Organization, and Processes) and 20 subcategories.

5-1- Contributions

This work has successfully answered the five different research questions and Identified four research gaps of critical relevance to be addressed in future research:

- There is no clear focus in readiness assessment models despite the proven scientific knowledge that readiness for change is critical to maximizing the transition successfully. This gap is particularly relevant when readiness as a success factor has been identified to be so critical [32, 33]. With that being so critical, but at the same not isolated as a dimension to be assessed in the context of the digital transformation, we may lead up to a situation where we are not addressing the core of one of the possible justifications for so many organizations failing to achieve their expected outcomes.

- There is no focus on developing readiness models for Small and Medium Enterprises, despite the significant weight these companies have in the total number of active companies, number of employees, and contribution to countries's gross domestic product. The relevance of the SMEs must be reflected in the research investment to support these organizations. The value of organizational readiness is valid for SMEs as for Large Enterprises, but the characteristics of an SME are different, and therefore, the need to tailor the research of readiness within the SMEs' context may be very much needed.
- There is no focus on considering the difference in perspective between general employees and senior management regarding readiness for change, despite the strong evidence that understanding these differences in perspective and tackling the differences play a vital role in successfully landing change. The literature has made clear [34, 35, 91, 92] the importance of addressing the differences in perception between employees and senior managers, and more importantly, has shown that this gap may lead to higher risks while delivering change. Therefore, this gap requires a stronger focus from the scientific community as we witness failures in delivering that change while simultaneously limiting investment in addressing this issue of differences in perceptions and understandings. There is no standardized set of factors (dimensions) used across the research community when defining what aspects shall be evaluated regarding maturity and readiness in digital transformation. Our research demonstrated that across 24 assessment models, the authors have used 80 unique named dimensions, with many of those meaning the same thing but with a different name. With the increased attention to digital transformation, it becomes more critical to drive some standardization that facilitates the future development of new models or even the enhancement of existing ones. If all authors start from different baselines, we may never be addressing the common problems the organizations are facing.

In addition, and as summarized in Table 19, this research contributes to the scientific community with a proposal of the categories and subcategories that shall be used as a standardized approach to further develop assessment models in digital transformation.

Our research has significantly contributed to the scientific community by not only updating a much-needed review of the assessments in the field of digital transformation but especially by introducing a set of aspects that needed to be consistently considered in previous reviews. Especially:

- It is considered that, as per definition, readiness and maturity are two very different states and, more importantly, that digital transformation is a change. Hence, one must consider what is needed to be ready to adopt that change.
- It is considered that digital transformation is significant to large enterprises, but it is equally essential for SMEs. Hence, those cannot be ignored.
- It is considered that general employees and senior managers have different perceptions; thus, they shall be considered as having different views of the state of readiness.
- It is considered that after so many years of research in digital transformation, it is becoming more imperative that the research community starts to use a more standardized set of factors to assess, as that may simplify the enhancement of the existing models and drive the development of more complete ones.

5-2- Opportunity for Further Research

This research work has unequally identified four significant gaps in the literature that are ultimately an excellent base to develop further to close those gaps. The most significant opportunity in the context of this research is the development of a readiness model that is simple enough for Small and Medium Enterprises and leverages the proposed categories and subcategories (see Table 19) to assess the state of readiness of an organization to maximize the results of their digital transformation. Especially when data shows that a considerable number of companies still fail to obtain those results, it becomes imperative that organizations tackle more of what is preventing that maximization rather than focus on implementing changes. Maturity is essential, but as we demonstrated in this research, readiness is, and must be addressed as a separate assessment profile, and more specifically, must consider the employees and senior managers as two different entities and their gap in perception as a critical variable to measure a possible gap that requires intervention.

6- Declarations

6-1- Author Contributions

Conceptualization, R.S., H.S.M., and V.S.; methodology, H.S.M. and V.S.; software, R.S.; validation, H.S.M. and V.S.; formal analysis, R.S.; resources, R.S.; data curation, R.S.; writing—original draft preparation, R.S.; writing—review and editing, H.S.M.; visualization, V.S.; supervision, H.S.M. and V.S.; project administration, H.S.M. and V.S.; funding acquisition, H.S.M. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

Data sharing is not applicable to this article.

6-3- Funding

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6-4- Institutional Review Board Statement

Not applicable.

6-5- Informed Consent Statement

Not applicable.

6-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

7- References

[1] Shen, K. N., Lindsay, V., & Xu, Y. (Calvin). (2018). Digital entrepreneurship. Information Systems Journal, 28(6), 1125–1128. doi:10.1111/isj.12219.

[2] Galindo-Martín, M. Á., Castaño-Martínez, M. S., & Méndez-Picazo, M. T. (2019). Digital transformation, digital dividends and entrepreneurship: A quantitative analysis. Journal of Business Research, 101, 522–527. doi:10.1016/j.jbusres.2018.12.014.

[3] Reis, J., Amorim, M., Melão, N., & Matos, P. (2018). Digital transformation: A literature review and guidelines for future research. Advances in Intelligent Systems and Computing, 745, 411–421. doi:10.1007/978-3-319-77703-0_41.

[4] Dehning, B., Richardson, V. J., & Zmud, R. W. (2003). The value relevance of announcements of transformational information technology investments. MIS Quarterly: Management Information Systems, 27(4), 637–656. doi:10.2307/30036551.

[5] Lucas, H. C., Agarwal, R., Clemons, E. K., El Sawy, O. A., & Weber, B. (2013). Impactful research on transformational information technology: An opportunity to inform new audiences. MIS Quarterly: Management Information Systems, 37(2), 371–382. doi:10.25300/misq/2013/37.2.03.

[6] Pucihar, A. (2020). The digital transformation journey: Content analysis of Electronic Markets articles and Bled e-Conference proceedings from 2012 to 2019. Electronic Markets, 30(1), 29-37. doi:10.1007/s12525-020-00406-7.

[7] Nadkarni, S., & Prügl, R. (2021). Digital transformation: a review, synthesis and opportunities for future research. Management Review Quarterly, 71, 233-341. doi:10.1007/s11301-020-00185-7.

[8] Hair, N., Wetsch, L. R., Hull, C. E., Perotti, V., & Hung, Y. T. C. (2012). Market orientation in digital entrepreneurship: Advantages and challenges in a web 2.0 networked world. International Journal of Innovation and Technology Management, 9(6), 1250045 1–1250045 18. doi:10.1142/S0219877012500459.

[9] Newman, M. (2017). Digital Maturity Model (DMM): A new tool to navigate the maze of digital transformation. TM Forum White Paper, 1-12. Available online: https://www.tmforum.org/wp-content/uploads/2017/05/DMM-WP-2017-Web.pdf (accessed on November 2023).

[10] Unruh, G., & Kiron, D. (2017). Digital Transformation on Purpose. MIT Sloan Management Review, Massachusetts, United States. Available online: https://sloanreview.mit.edu/article/digital-transformation-on-purpose/ (accessed on November 2023).

[11] Ross, J. W. (2019). Digital Success Requires Breaking Rules. MIT Sloan Management Review: Vol. XVII (Issue 10), Massachusetts, United States. Available online: https://sloanreview.mit.edu/article/digital-success-requires-breaking-rules/ (accessed on November 2023).

[12] World Economic Forum. (2018). Digital Transformation Initiative Maximizing the Return on Digital Investments. World Economic Forum, 1–27. Available online: https://www3.weforum.org/docs/DTI_Maximizing_Return_Digital_WP.pdf (accessed on November 2023).

[13] Nerima, M., & Ralyté, J. (2021). Towards a Digital Maturity Balance Model for Public Organizations. Lecture Notes in Business Information Processing: Volume 415 LNBIP, 295–310. doi:10.1007/978-3-030-75018-3_20.

[14] Kovaitė, K., & Stankevičienė, J. (2019). Risks of digitalization of business models. International Scientific Conference: Contemporary Issues in Business. Management and Economics Engineering, 1-8. doi:10.3846/cibmee.2019.039.

[15] Tabrizi B, Lam E, Girard K, & Irvin V. (2019). Digital Transformation Is Not About Technology. Harvard Business Review, 13, 1–6.

[16] Legner, C., Eymann, T., Hess, T., Matt, C., Böhmann, T., Drews, P., Mädche, A., Urbach, N., & Ahlemann, F. (2017). Digitalization: Opportunity and Challenge for the Business and Information Systems Engineering Community. Business and Information Systems Engineering, 59(4), 301–308. doi:10.1007/s12599-017-0484-2.

[17] Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: How to benefit from digitalization in practice. International Journal of Information Systems and Project Management, 5(1), 63–77. doi:10.12821/ijispm050104.

[18] European Commission (2019). Research and Development and Innovation by SMEs. Annual Report on European SMEs 2018/2019, Publications Office of the European Union. Available online: https://data.europa.eu/doi/10.2826/500457 (accessed on November 2023).

[19] European Commission. (2016). Entrepreneurship and Small and medium-sized enterprises (SMEs). Entrepreneurship and SMEs, Publications Office of the European Union. Available online: https://ec.europa.eu/commission/presscorner/detail/en/fs_20_426 (accessed on November 2023).

[20] Tarutė, A., & Gatautis, R. (2014). ICT Impact on SMEs Performance. Procedia - Social and Behavioral Sciences, 110, 1218–1225. doi:10.1016/j.sbspro.2013.12.968.

[21] Antlová, K. (2009). Motivation and barriers of ICT adoption in small and medium-sized enterprises. Economics and Management 12(2), 140–155.

[22] Ramdani, B., Chevers, D., & Williams, D. A. (2013). SMEs' adoption of enterprise applications: A technology-organisation-environment model. Journal of Small Business and Enterprise Development, 20(4), 735–753. doi:10.1108/JSBED-12-2011-0035.

[23] North, K., & Varvakis, G. (2016). Competitive Strategies for Small and Medium Enterprises. Competitive Strategies for Small and Medium Enterprises, Springer, Cham, Switzerland. doi:10.1007/978-3-319-27303-7.

[24] Ong, J. W., & Ismail, H. Bin. (2008). Sustainable competitive advantage through information technology competence: Resource-based view on small and medium enterprises. Innovation and Knowledge Management in Business Globalization: Theory and Practice - Proceedings of the 10th International Business Information Management Association Conference, 1–2(1), 57–65.

[25] Nagyné, H.Zs., Gubán, M., & Koloszár, L. (2018). IT specialist training in higher education. GIKOF Journal, 11, 40–50.

[26] Williams, T. A., Gruber, D. A., Sutcliffe, K. M., Shepherd, D. A., & Zhao, E. Y. (2017). Organizational response to adversity: Fusing crisis management and resilience research streams. Academy of Management Annals, 11(2), 733–769. doi:10.5465/annals.2015.0134.

[27] González-Varona, J. M., López-Paredes, A., Poza, D., & Acebes, F. (2021). Building and development of an organizational competence for digital transformation in SMEs. Journal of Industrial Engineering and Management, 14(1), 15–24. doi:10.3926/jiem.3279.

[28] Libert, B., Beck, M., & Wind, Y. (2016). 7 Questions to ask before your next digital transformation. Harvard Business Review, 60(12), 11-13.

[29] Mosallaeipour, S., Nazerian, R., & Ghadirinejad, M. (2018). Industrial Engineering in the Industry 4.0 Era. In Industrial Engineering in the Industry 4.0 ERA, 63–81. doi:10.1007/978-3-319-71225-3.

[30] North, K., Aramburu, N., & Lorenzo, O. J. (2020). Promoting digitally enabled growth in SMEs: a framework proposal. Journal of Enterprise Information Management, 33(1), 238–262. doi:10.1108/JEIM-04-2019-0103.

[31] Leino, S. P., Kuusisto, O., Paasi, J., & Tihinen, M. (2017). VTT model of digimaturity. In Towards a new era in manufacturing: final report of VTT's for industry spearhead programme, 41-46. VTT Technical Research Centre of Finland, Espoo, Finland.

[32] Lokuge, S., Sedera, D., Grover, V., & Dongming, X. (2019). Organizational readiness for digital innovation: Development and empirical calibration of a construct. Information and Management, 56(3), 445–461. doi:10.1016/j.im.2018.09.001.

[33] Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., & Buckley, N. (2018). Coming of age digitally. MIT Sloan Management Review, Massachusetts, United States. Available online: https://sloanreview.mit.edu/projects/coming-of-age-digitally/ (accessed on November 2023).

[34] Gfrerer, A., Hutter, K., Füller, J., & Ströhle, T. (2021). Ready or Not: Managers' and Employees' Different Perceptions of Digital Readiness. California Management Review, 63(2), 23–48. doi:10.1177/0008125620977487.

[35] Voß, F. L. V., & Pawlowski, J. M. (2019). Digital readiness frameworks: Current state of the art and research opportunities. Communications in Computer and Information Science, 1027, 503–514. doi:10.1007/978-3-030-21451-7_43.

[36] Barbara Kitchenham. (2014). Procedures for Performing Systematic Reviews. Keele University Technical Report, 33(2004), 1–26.

[37] Leyh, C., Bley, K., Schaffer, T., & Forstenhausler, S. (2016). SIMMI 4.0-a maturity model for classifying the enterprise-wide it and software landscape focusing on Industry 4.0. Proceedings of the 2016 Federated Conference on Computer Science and Information Systems, FedCSIS 2016, 1297–1302. doi:10.15439/2016F478.

[38] Matt, C., Hess, T., & Benlian, A. (2015). Digital Transformation Strategies. Business and Information Systems Engineering, 57(5), 339–343. doi:10.1007/s12599-015-0401-5.

[39] Berghaus, S., & Back, A. (2016). Association for Information Systems AIS Electronic Library (AISeL) Stages in Digital Business Transformation: Results of an Empirical Maturity Study. MCIS 2016 Proceedings, 1-18.

[40] Lichtblau, K., Stich, V., Bertenrath, R., Blum, M., Bleider, M., Millack, A., ... & Schröter, M. (2015). Industrie 4.0 Readiness. Impuls-Stiftung des VDMA, Aachen-Köln, 2015.

[41] Schumacher, A., Erol, S., & Sihn, W. (2016). A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises. Procedia CIRP, 52, 161–166. doi:10.1016/j.procir.2016.07.040.

[42] De Carolis, A., Macchi, M., Negri, E., & Terzi, S. (2017). A maturity model for assessing the digital readiness of manufacturing companies. IFIP Advances in Information and Communication Technology, 513, 13–20. doi:10.1007/978-3-319-66923-6_2.

[43] Klötzer, C., & Pflaum, A. (2017). Toward the development of a maturity model for digitalization within the manufacturing industry's supply chain. Proceedings of the Annual Hawaii International Conference on System Sciences, Volume 2017-January, 4210–4219. doi:10.24251/hicss.2017.509.

[44] Canetta, L., Barni, A., & Montini, E. (2018). Development of a Digitalization Maturity Model for the Manufacturing Sector. 2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 – Proceedings, Stuttgart, Germany. doi:10.1109/ICE.2018.8436292.

[45] Gimpel, H., Hosseini, S., Xaver, R., Huber, R., Probst, L., Röglinger, M., & Faisst, U. (2018). Structuring Digital Transformation: A Framework of Action Fields and its Application at ZEISS. Journal of Information Technology Theory and Application, 19(1), 31–54.

[46] Hamidi, S. R., Aziz, A. A., Shuhidan, S. M., Aziz, A. A., & Mokhsin, M. (2018). SMEs maturity model assessment of IR4.0 digital transformation. Advances in Intelligent Systems and Computing, 739, 721–732. doi:10.1007/978-981-10-8612-0_75.

[47] Isaev, E. A., Korovkina, N. L., & Tabakova, M. S. (2018). Evaluation of the readiness of a company's IT department for digital business transformation. Business Informatics, 2, 55–64. doi:10.17323/1998-0663.2018.2.55.64.

[48] Aguiar, T., Gomes, S. B., Da Cunha, P. R., & Da Silva, M. M. (2019). Digital transformation capability maturity model framework. Proceedings - 2019 IEEE 23rd International Enterprise Distributed Object Computing Conference, EDOC 2019, 51–57. doi:10.1109/EDOC.2019.00016.

[49] Colli, M., Berger, U., Bockholt, M., Madsen, O., Møller, C., & Wæhrens, B. V. (2019). A maturity assessment approach for conceiving context-specific roadmaps in the Industry 4.0 era. Annual Reviews in Control, 48, 165–177. doi:10.1016/j.arcontrol.2019.06.001.

[50] Teichert, R. (2019). Digital transformation maturity: A systematic review of literature. Journal of the Mendelian University of Agriculture and Forestry in Brunnen, 67(6), 1673–1687. doi:10.11118/actaun201967061673.

[51] Chonsawat, N., & Sopadang, A. (2020). Defining SMEs' 4.0 readiness indicators. Applied Sciences (Switzerland), 10(24), 1–30. doi:10.3390/app10248998.

[52] Depaoli, P., Za, S., & Scornavacca, E. (2020). A model for digital development of SMEs: an interaction-based approach. Journal of Small Business and Enterprise Development, 27(7), 1049–1068. doi:10.1108/JSBED-06-2020-0219.

[53] Kovrigin, E. A., & Vasiliev, V. A. (2020). Approaches and problems to assessing readiness for the implementation of modern digital technologies in a quality management system. Proceedings of the 2020 IEEE International Conference "Quality Management, Transport and Information Security, Information Technologies", IT and QM and IS 2020, 336–340. doi:10.1109/ITQMIS51053.2020.9322916.

[54] Machado, C. G., Winroth, M., Almström, P., Ericson Öberg, A., Kurdve, M., & AlMashalah, S. (2021). Digital organisational readiness: experiences from manufacturing companies. Journal of Manufacturing Technology Management, 32(9), 167–182. doi:10.1108/JMTM-05-2019-0188.

[55] Ndou, A. T., Madonsela, N. S., & Twala, B. (2020). The era of digital technology: Analysis of factors contributing to economic growth and sustainability. Proceedings of the International Conference on Industrial Engineering and Operations Management, Volume 59, 1109–1123.

[56] Priyono, A., Moin, A., & Putri, V. N. A. O. (2020). Identifying digital transformation paths in the business model of SMEs during the covid-19 pandemic. Journal of Open Innovation: Technology, Market, and Complexity, 6(4), 1–22. doi:10.3390/joitmc6040104.

[57] Schuh, G., Anderl, R., Dumitrescu, R., Krüger, A., & ten Hompel, M. (2020). Using the Industrie 4.0 Maturity Index in Industry. Current Challenges, Case Studies and Trends. Acatech Cooperation, National Academy of Science and Engineering, Munich, Germany. Available online: https://www.acatech.de/publikation/der-industrie-4-0-maturity-index-in-der-betrieblichen-anwendung/download-pdf/?lang=en (accessed on 9 May 2022).

[58] Stoianova, O. V., Lezina, T. A., & Ivanova, V. V. (2020). The framework for assessing company's digital transformation readiness. Vestnik Sankt-Peterburgskogo Universiteta. Ekonomika, 36(2), 243–265. doi:10.21638/spbu05.2020.204.

[59] Alsufyani, N., & Gill, A. Q. (2021). A Review of Digital Maturity Models from Adaptive Enterprise Architecture Perspective: Digital by Design. Proceedings - 2021 IEEE 23rd Conference on Business Informatics, CBI 2021 - Main Papers, 1, 121–130. doi:10.1109/CBI52690.2021.00023.

[60] Borštnar, M. K., & Pucihar, A. (2021). Multi-attribute assessment of digital maturity of SMEs. Electronics (Switzerland), 10(8), 885. doi:10.3390/electronics10080885.

[61] Brozzi, R., Riedl, M., & Matt, D. (2020). Key Readiness Indicators to Assess the Digital Level of Manufacturing SMEs. Procedia CIRP, 96, 201–206. doi:10.1016/j.procir.2021.01.075.

[62] Bocyte, R., Oomen, J., & Truyen, F. (2021). Self-assessment and Monitoring of CHI Performance in Digital Transformation. Lecture Notes in Computer Science (Including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12866 LNCS, 128–132. doi:10.1007/978-3-030-86324-1_16.

[63] Carrijo, P., Alturas, B., & Pedrosa, I. (2021). Analysis of Digital Transformation Maturity Models. Iberian Conference on Information Systems and Technologies, CISTI, 1–6. doi:10.23919/CISTI52073.2021.9476644.

[64] Cordes, A. K., & Musies, N. (2021). Accelerating the transformation? the impact of COVID-19 on the digital maturity of retail businesses. Proceedings - 2021 IEEE 23rd Conference on Business Informatics, CBI 2021 - Main Papers, 1, 102–110. doi:10.1109/CBI52690.2021.00021.

[65] Cunha, L., & Sousa, C. (2021). A Model for Designing SMES' Digital Transformation Roadmap. In Advances in Intelligent Systems and Computing: Vol. 1366 AISC, 439–448. doi:10.1007/978-3-030-72651-5_42.

[66] Denicolai, S., Zucchella, A., & Magnani, G. (2021). Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths. Technological Forecasting and Social Change, 166, 120650. doi:10.1016/j.techfore.2021.120650.

[67] Gökalp, E., & Martinez, V. (2021). Digital transformation capability maturity model enabling the assessment of industrial manufacturers. Computers in Industry, 132, 103522. doi:10.1016/j.compind.2021.103522.

[68] Kokot, K., Kokotec, I. D., & Calopa, M. K. (2021). Impact of leadership on digital transformation. 2021 IEEE Technology and Engineering Management Conference - Europe, TEMSCON-EUR, 1–6. doi:10.1109/TEMSCON-EUR52034.2021.9488620.

[69] MacHado, C. G., Almstrom, P., Oberg, A. E., Kurdve, M., & Almashalah, S. Y. (2020). Maturity Framework Enabling Organizational Digital Readiness. Advances in Transdisciplinary Engineering, 13, 649–660. doi:10.3233/ATDE200204.

[70] Okfalisa, Anggraini, W., Nawanir, G., Saktioto, & Wong, K. Y. (2021). Measuring the effects of different factors influencing on the readiness of smes towards digitalization: A multiple perspectives design of decision support system. Decision Science Letters, 10(3), 425–442. doi:10.5267/j.dsl.2021.1.002.

[71] Poletaikin, A., Kanev, V., Shevtsova, Y., & Dvurechenskaya, N. (2021). Forming an Indicators System of Digital Maturity an Educational Organization with Attributes of Sufficiency. In Proceedings - 2021 17th International Asian School-Seminar "Optimization Problems of Complex Systems", OPCS 2021, 90–95. doi:10.1109/OPCS53376.2021.9588793.

[72] Saroso, H., Syahchari, D. H., Sudrajat, D., Lasmy, & Herlina, M. G. (2021). Managing digital transformation dilemma with industrial mapping. Proceedings of 2021 International Conference on Information Management and Technology, ICIMTech 2021, 165–170. doi:10.1109/ICIMTech53080.2021.9535025.

[73] Sándor, Á., & Gubán, Á. (2021). A Measuring Tool for the Digital Maturity of Small and Medium-Sized Enterprises. Management and Production Engineering Review, 12(4), 133–143. doi:10.24425/mper.2021.140001.

[74] Sinyuk, T., Panfilova, E., & Pogosyan, R. (2021). Digital transformation of SME business models as a factor of sustainable socio-economic development. E3S Web of Conferences, 295, 1028. doi:10.1051/e3sconf/202129501028.

[75] Soares, N., Monteiro, P., Duarte, F. J., & Machado, R. J. (2021). Extended Maturity Model for Digital Transformation. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12952 LNCS, 183–200). doi:10.1007/978-3-030-86973-1_13.

[76] Barry, A. S., Assoul, S., & Souissi, N. (2022). Benchmarking of digital maturity models according to the dimension component. 2022 2nd International Conference on Innovative Research in Applied Science, Engineering and Technology, IRASET 2022, 1–8. doi:10.1109/IRASET52964.2022.9737781.

[77] Da Costa, L. S., Munhoz, I. P., Pereira, L., & Santos Akkari, A. C. (2022). Assessing the digital maturity of micro and small enterprises: A focus on an emerging market. Procedia Computer Science, 200, 175–184. doi:10.1016/j.procs.2022.01.216.

[78] Kasperovica, L., Lace, N., Ciemleja, G., & Tesarova, M. (2022). Digital maturity and value capture of small and medium sized enterprises. IMCIC 2022 - 13th International Multi-Conference on Complexity, Informatics and Cybernetics, Proceedings, Vol. 2, 159–164. doi:10.54808/IMCIC2022.02.159.

[79] Kryukov, V., Shakhgeldyan, K., Kiykova, E., Kiykova, D., & Saychuk, D. (2022). Assessment of transport enterprise readiness for digital transformation. Transportation Research Procedia, 63, 2710–2718. doi:10.1016/j.trpro.2022.06.313.

[80] Merzlov, I., & Shilova, E. (2022). A Digital Maturity Model for Organizations: An Approach to Assessment and Case Study. International Journal of Systematic Innovation, 7(2), 22–36. doi:10.6977/IJoSI.202206_7(2).0002.

[81] Mutlu, I., Den Hartigh, E., & Ucler, C. (2022). Digital Technology and the Stages of Digital Business Transformation. 2022 IEEE 28th International Conference on Engineering, Technology and Innovation, ICE/ITMC 2022 and 31st International Association for Management of Technology, IAMOT 2022 Joint Conference - Proceedings, 1–8. doi:10.1109/ICE/ITMC-IAMOT55089.2022.10033256.

[82] Pucihar, A., & Borštnar, M. K. (2022). Measurement of Digital Maturity of Enterprises. IDIMT 2022 - Digitalization of Society, Business and Management in a Pandemic: 30th Interdisciplinary Information Management Talks, 43–50. doi:10.35011/IDIMT-2022-43.

[83] Sándor, Á., & Gubán, Á. (2022). A multi-dimensional model to the digital maturity life-cycle for SMEs. International Journal of Information Systems and Project Management, 10(3), 58–81. doi:10.12821/ijispm100303.

[84] Schneider, M., Hellweg, T., & Menzefricke, J. S. (2022). Identification of Human and Organizational Key Design Factors for Digital Maturity - A Fuzzy-Set Qualitative Comparative Analysis. Proceedings of the Design Society, 2, 791–800. doi:10.1017/pds.2022.81.

[85] Spremic, M., Zentner, H., & Zentner, R. (2022). Measuring Digital Business Models Maturity: Theory, Framework, and Empirical Validation. IEEE Transactions on Engineering Management, 1–15. doi:10.1109/TEM.2022.3226864.

[86] Viloria-Nunez, C., Vazquez, F. J., & Fernandez-Marquez, C. M. (2022). A review of the digital transformation maturity models for SMEs in search of a self-assessment. 2022 IEEE ANDESCON: Technology and Innovation for Andean Industry, ANDESCON 2022, 1–6. doi:10.1109/ANDESCON56260.2022.9989889.

[87] Ehrensperger, R., Sauerwein, C., & Breu, R. (2023). A Maturity Model for Digital Business Ecosystems from an IT Perspective. Journal of Universal Computer Science, 29(1), 34–72. doi:10.3897/jucs.79494.

[88] Haryanti, T., Rakhmawati, N. A., & Subriadi, A. P. (2023). The Extended Digital Maturity Model. Big Data and Cognitive Computing, 7(1), 17. doi:10.3390/bdcc7010017.

[89] Hein-Pensel, F., Winkler, H., Brückner, A., Wölke, M., Jabs, I., Mayan, I. J., Kirschenbaum, A., Friedrich, J., & Zinke-Wehlmann, C. (2023). Maturity assessment for Industry 5.0: A review of existing maturity models. Journal of Manufacturing Systems, 66, 200–210. doi:10.1016/j.jmsy.2022.12.009.

[90] Tiss, S., & Orellano, M. (2023). A Maturity Model of Digital Transformation in Supply Chains: A Multi-dimensional Approach. 2023 27th International Conference on Information Technology, IT 2023, 1–7. doi:10.1109/IT57431.2023.10078510.

[91] Birkinshaw, J. (1997). Entrepreneurship in multinational corporations: The characteristics of subsidiary initiatives. Strategic Management Journal, 18(3), 207–229. doi:10.1002/(sici)1097-0266(199703)18:3<207::aid-smj864>3.3.co;2-h.

[92] Trenerry, B., Chng, S., Wang, Y., Suhaila, Z. S., Lim, S. S., Lu, H. Y., & Oh, P. H. (2021). Preparing Workplaces for Digital Transformation: An Integrative Review and Framework of Multi-Level Factors. Frontiers in Psychology, 12, 620766–620766. doi:10.3389/fpsyg.2021.620766.

[93] Cambridge Dictionary (2023). English Dictionary. Available online: https://dictionary.cambridge.org/dictionary/english. (accessed April 2023).

[94] Bughin, J., Catlin, T., Hirt, M., & Willmott, P. (2018). Why digital strategies fail. McKinsey Quarterly 2018(1), 61–75.

[95] Gurbaxani, V., & Dunkle, D. (2019). Gearing up for successful digital transformation. MIS Quarterly Executive, 18(3), 209–220. doi:10.17705/2msqe.00017.

[96] Ulas, D. (2019). Digital transformation process and SMEs. Procedia Computer Science, 158, 662-671. doi:10.1016/j.procs.2019.09.101.

[97] Prezioso, G., Ceci, F., & Za, S. (2020). Employee skills and digital transformation: preliminary insights from a case study. ImpresaProgetto - Electronic Jour, 2(2), 1–23.

[98] Barthel, P. (2021). What is meant by Digital Transformation Success? Investigating the Notion in IS Literature. Lecture Notes in Information Systems and Organisation, 48 LNISO, 167–182. doi:10.1007/978-3-030-86800-0_13.

[99] Zhu, X., Ge, S., & Wang, N. (2021). Digital transformation: A systematic literature review. Computers & Industrial Engineering, 162, 107774. doi:10.1016/j.cie.2021.107774.