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DIGITAL MATURITY VARIABLES AND THEIR IMPACT ON THE ENTERPRISE ARCHITECTURE LAYERS

Abstract

This study examines the variables of digital maturity of companies. The framework for enterprise architectures Archimate 3.0 is used to compare the variables. The variables are assigned to the six layers of architecture: Strategy, Business Environment, Applications, Technology, Physical and Implementation and Migration. On the basis of a literature overview, 15 "digital maturity models" with a total of 147 variables are analyzed. The databases Scopus, EBSCO – Business Source Premier and ProQuest are used for this purpose.

The results of the work will help researchers and managers to identify which digitization variables affect the different layers of the company. This enables researchers or managers to use the right model for a specific purpose or to create a new model from a combination of existing models for the entire company or just one architectural layer.

On the basis of a more precise assessment of the digital maturity of a company, better actions can be derived. This work is important for companies, as the digitization of enterprises and markets changed similarly to the invention of the steam engine did. Websites, sensors, mobile devices, apps, etc. are combined into new digital products and services. The competitors in the market have to adapt. If this is not done, they will increasingly disappear.

Finally, the authors suggests a conclusion about the current situation regarding the measurement of digital maturity in companies and show in which areas further studies could be carried out.

Keywords digitalization, maturity models, enterprise architecture,
digital management

JEL Classification M10, M15

INTRODUCTION

According to a survey by the magazine "MIT Sloan Management Review", 90% of the managers surveyed expect digitalization to play a major or very major role for their company (Kiron, Kane, Palmer, Phillips, & Buckley, 2016). The degree of penetration of the Internet and communication systems plays a major role in the development of national economic growth (Xu, 2014).

Digitization is a crucial part of daily life (Xu, 2014). In the last few years, digitization has led to several dramatic changes (Xu, 2014). The last time technological developments led to similarly enormous changes in the business world was at the time of the first industrial revolution (Westermann, Bonnet, & McAfee, 2014).

In order to react optimally to these changes, companies need leadership and the ability to deal with constant changes (Summa, 2016). In principle, the faster companies are able to adapt, the more likely they

are to achieve advantages over their competitors (Summa, 2016).

For this reason, it is essential to know different digitization factors and to find out to what extent they affect the company or the layers of an enterprise architecture.

According to Berman and Bell (2011), the following questions are suitable for finding out whether the company is ready for digital transformation. This is illustrated by the two perspectives: redesign of the customer promise and the optimization of operations completed. In the area of customer promise, the following questions arise (Berman & Bell, 2011):

1. Will the customer value proposition be redesigned?
2. How is it ensured that the changing needs and expectations of customers in the digital environment are understood?
3. How do mobile and online technologies change the way customers are communicating with the supplier and how the supplier is generating value for the customer?
4. How is the digital transformation being driven by the company in the industry or is the progress in a digital transformation in the industry driven by advanced competitors?

In the area of operational optimization, the following questions are useful (Berman & Bell, 2011):

1. Will the operations part of a company be optimized?
2. How are online and social media touchpoints and customer information used across the enterprise?
3. How is it achieved that the customer is the focus of supply chain planning?
4. How is it achieved that there is an open cooperation within the company, with customers and partners?
5. How will the digital and physical components of the operating model be optimized?

Based on a study conducted by Capgemini Consulting and MIT Sloan Management Review, in which 1,559 executives and managers were interviewed, 63% mentioned that the pace of technological change in their companies is too slow (Xu, 2014). Furthermore, 75% of respondents mentioned the lack of experience with new digital technologies in their company. The poor definition of Key Performance Indicators (KPIs) in the area of digital transformation was also underestimated by 50% (Xu, 2014).

Another study called “The IBM 2010 Global CEO study” found that technology was the second most important driver of digital change after market factors (Berman & Bell, 2011). A distinction in the development of digital transformation is made between three different stages (Berman & Bell, 2011):

- phase 1 (end 1990’s): digital products (e.g. music and entertainment) and infrastructure (e.g. software, information systems);
- phase 2 (approx. 2000): digital sales and web strategy (e.g. e-commerce and online services);
- phase 3 (around 2010): mobile revolution, social media, hyper-digitization, and power of analysis.

In addition, the study reports that decisions today (the year 2010) are made with the help of mobile devices and interactive tools (Berman & Bell, 2011). The ability and convenience to access information anytime, anywhere have dramatically increased expectations in the digital transformation (Berman & Bell, 2011). These mobile devices and interactive tools form the primary force behind the digital transformation across different industries (Berman & Bell, 2011).

Based on these findings, this study aims to use a literature review to identify various digitization factors and assign them to the enterprise architecture layers according to the Archimate architecture framework.

1. LITERATURE REVIEW

1.1. Digitalization

Digitalization, also called digital transformation, is an important topic for companies in all industries. The transformation creates risks for existing companies through disruptive companies in the market. In addition, there are new opportunities for these companies that are willing to take a certain risk and have the skills to use new technologies efficiently and effectively through digitization (Xu, 2014).

A digitized enterprise is characterized by the use of digital technologies and networks to carry out activities. These include the purchase and sale of products and services, interactions with customers and partner companies, as well as the execution of transactions and communication within the company (Xu, 2014).

For Kagermann (2015), it is clear that digitization and its factors will be the driving force for innovation and change in all industries due to the resulting continuous convergence between the real and virtual worlds. The exponentially growing data volumes, as well as the convergence of different, affordable technologies with the accompanying establishment of these technologies additionally, leads to transformations in all areas of the economy (Kagermann, 2015).

In summary, this means that digitization has a disruptive influence on the world of work, markets and social structures. This influence can also be observed in the emergence of new enterprises and the disappearance of established enterprises (Schmidt, Zimmermann, Möhring, Nurcan, Keller, & Bär, 2016).

These facts show that the topic of digitization is one of the most relevant and most discussed topics of

our time (McKinsey & Company, 2014). The significance of this information is based on several studies, which predict enormous advantages through the introduction of digitization programs. In principle, the term digitization describes the collaboration between people and autonomous objects beyond their local context through the use of digital technologies (Zimmermann, Bogner, Jugel, & Schweda, 2016). As a result, the importance of information, data and knowledge as part of the everyday life of human beings is constantly increasing (Zimmermann, Bogner, Jugel, & Schweda, 2016).

More precisely, digitization today means the use of technological innovations in the business context, which have an enormous influence on products, services, business processes, sales channels and supply channels (Urbach & Ahlemann, 2016). The resulting potential benefits include increases in sales or productivity, innovations in value creation and new forms of customer interaction (Urbach & Ahlemann, 2016).

According to Keuper, Hamidian, Verwaayen, Kalinowski, and Kraijo (2013), the concept of digitization has changed dramatically in the last ten years. The focus is no longer on the transmission of analogue information to digital information processing, but rather on transferring people and their living and working environments to a digital level (Keuper, Hamidian, Verwaayen, Kalinowski, & Kraijo, 2013).

Since digitization affects all areas of the company, it is complex to define an optimal digitization strategy. To facilitate this, models for determining the digital maturity level of an enterprise can help. Their use not only provides an overview, but also identifies specific areas with potential for optimization with regard to digitization issues. These maturity models can be very different in terms of their structure, scope and industry focus.

1.2. Archimate

Archimate 3.0 is a standard for modelling enterprise architectures. Basically, Archimate makes it possible to discover or describe any problems in the enterprise architecture. Archimate provides a series of notation forms (elements) for each layer of an enterprise architecture (The Open Group, 2016). Archimate 3.0 differentiates between the core framework and the full framework (The Open Group, 2016). The core framework contains only the three layers: Business, Application and Technology. In addition, the full framework contains the layers: Strategy, Physical and Implementation and Migration.

1.2.1. Strategy layer

The Strategy layer describes resources, capabilities and the focus on defined strategic goals (The Open Group, 2016). Furthermore, the Strategy layer sets the scope for action within the Business layer.

1.2.2. Business layer

The Business layer deals with the business services that the company provides to its customers. This is done by visualizing business actors through business processes (The Open Group, 2016).

1.2.3. Application layer

The Application layer describes application services that support the business. In addition, applications that provide services are also presented here (The Open Group, 2016).

1.2.4. Technology layer

At the Technology layer, systems and software for calculation, storage of data or communication are described, which are required by the applications (The Open Group, 2016).

1.2.5. Physical layer

The Physical layer is based on the technology level and describes physical facilities and objects, distributed systems and networks, as well as materials (The Open Group, 2016).

1.2.6. Implementation and Migration layer

As part of the Implementation and Migration layer, work steps, states and work results of an enterprise architecture modelled using Archimate are described (The Open Group, 2016).

2. RESEARCH QUESTIONS

This work aims to determine maturity models with variables of digitization. These variables are then individually assigned to the different enterprise architecture layers. This makes it transparent which variables can be used to measure digital performance each at company layer. In order to achieve this goal, the following research questions were defined:

FF1: What are the variables of digital maturity and how do they affect the different layers of corporate architecture?

FF2: Which maturity models are available?

FF3: What insights result from the analysis of the respective maturity models?

The research questions can be answered as follows:

Research question FF1:

What are the variables of digital maturity and to what extent do they affect the different layers of corporate architecture?

Answer:

The study has identified a total of 147 variables of digital maturity. These include, for example, the existence of not only a vision to be achieved through digitization and its possibilities, but also a strategy to what extent the company must transform itself in order to exploit possible competitive advantages. Leadership and its ability to define the role of the enterprise in the age of digitization is seen by many maturity models as an important digitization factor. For a complete overview of the determined variables of digital maturity and the analyzed sources, have a look at the detailed tables “Variables of digital maturity” and “Overview of the analyzed literature”.

Basically, the majority of digitization factors affect the corporate architecture Strategy Business and Application layers. In contrast, less attention is paid to the corporate architecture layers of Technology, Physical and Implementation and Migration.

Research question FF2:

Which maturity models are available?

Answer:

15 different maturity models could be determined, which offer the possibility to measure the digital maturity of an enterprise. Some of the models analyzed differ greatly in their areas of application.

Research question FF3:

What insights result from the analysis of the respective maturity models?

Answer:

None of the 15 maturity models considered offers an opportunity to fully evaluate a company's digital maturity. This is because none of the models includes all layers of corporate architecture in the evaluation. Thus, no final statement on digital maturity can be made. The majority of the models focus on the corporate architecture Strategy, Business and Application layers and only partially include the technical layers (Technology, Physical and Implementation and Migration).

The reader learns which digitization variables have an influence on the different layers of corporate architecture. This then allows the selection of an appropriate maturity model for each company to perform a precise analysis for the measurement of digital maturity. This is essential, as digitization changes companies and they have to adapt, otherwise, there is a risk that companies will disappear.

3. METHODS

A transparent, comprehensible literature research approach according to Fink (2014) was developed to determine different variables from digital maturity models.

This approach consists of 7 steps:

- 1) define the research question;
- 2) select scientific databases;
- 3) define search terms;
- 4) select results by title and abstract;
- 5) select remaining results from the full text;
- 6) work up remaining results;
- 7) synthesize text to final results.

When using the literature research method and its qualitative evaluation, the focus is on the term rigorosity (Levy & Ellis, 2006).

For the literature review, the reliability and validity of the search process are important (Levy & Ellis, 2006). As such, the validity indicates the extent to which the literature search produces the sources desired by the creator (Vom Brocke, Simons, Niehaves, Riemer, Plattfaut, & Cleven, 2009). Reliability describes the replicability of the search process to any literature search (Vom Brocke, Simons, Niehaves, Riemer, Plattfaut, & Cleven, 2009). The research process was structured in detail as follows.

After the research questions were defined (section 3), it was decided to use three different databases, namely the databases ProQuest, EBSCOhost and Scopus. The keyword "digital maturity" was used as a search term (see also Table 1). The database queries were carried out on January 15, 2018.

Table 1. Literature search and selection process

Database	Search term	Step 1	Step 2	Step 3	Total
ProQuest	"Digital maturity"	271	-206	-60	5
EBSCOhost	"Digital maturity"	17	-12	-4	1
Scopus	"Digital maturity"	17	-10	-2	5
Total		305	-228	-66	11

To make the search and selection process as comprehensive as possible, no specific search criteria or restrictions were made.

As shown in Table 1 (Step 1), after the basic search of the search term “digital maturity” on the various databases, a total of 305 results were obtained consisting of 271 results from ProQuest, 17 results from EBSCOhost and 17 results from Scopus. The search was carried out on January 15, 2018.

In a second step (see Table 1, Step 2), duplicates and articles based on titles and abstracts that were irrelevant to the subject area were eliminated. Care was taken to ensure that only relevant texts relating to the search term “digital maturity” were considered. The number of results was reduced by 228. Thus, only 77 results (65 results from ProQuest, 5 results from EBSCOhost and 7 results from Scopus) were used as a basis for further processing. A large part of the articles already turned out here as press releases, which dealt with the subject of digitization or digital maturity only very superficially.

For this reason, these articles had no relevance to the present work and were not considered further. Furthermore, several articles were excluded, which dealt in detail with the subject area of digitization, but did not clearly identify digitization factors.

In the third step of the selection process (see Table 1, Step 3), 66 further results could be excluded, as the publications could not be considered relevant for the subject area based on a thorough examination. Based on this procedure, 11 different maturity models with a total of 58 associated digitization factors could be identified.

Based on findings from previously conducted studies, 4 further maturity models for measuring the digital maturity of an enterprise could be determined in a final step. This corresponds to another 22 digitization factors.

Table 2. Mapping of digital maturity models to enterprise architecture layers

Digital maturity models	Enterprise architecture layers (Archimate 3.0)					
	Strategy	Business	Application	Technology	Physical	Implementation and Migration
Digital Maturity Matrix MIT & Capgemini (Westermann, Bonnet, & McAfee, 2014)	X	X	X	–	–	–
Digital Maturity Model Universität St. Gallen (Back & Berghaus, 2016)	X	X	X	X	–	–
Digital Transformation Assessment (Fenwick & Gill, 2014)	X	X	X	X	–	–
Digital Maturity Model Hochschule Reutlingen & Neuland (Land, 2015)	X	X	X	X	–	–
Gartner Taxonomie (Gartner, 2016)	X	X	X	X	–	–
Digital Maturity Model IBM (Berman & Bell, 2011)	X	X	X	X	–	–
Maturity Model PWC (Greif, Kohnis, & Warnking, 2016)	X	X	X	–	–	–
Survival of the Smartest 2.0 (KPMG, 2014)	X	X	X	–	–	v
Digital Capability Framework (O’Hea, 2011)	X	X	X	–	–	–
The Digital Maturity Map (Mueller, Baer, & Weber, 2006)	–	X	X	–	–	–
Aligning the Organization for its Digital Future (Kiron, Kane, Palmer, Phillips, & Buckley, 2016)	X	–	–	–	–	–
Digital Maturity Model for Telecommunications Service Providers (Valdez-de-Leon, 2016)	X	X	X	–	–	–
Digital Maturity Model (TM Forum, 2017)	X	X	X	X	–	–
DREAMY Maturity Model (De Carolis, Machhi, Negri, & Terzi, 2017)	X	X	X	–	–	–
Maturity Scape Model (Schmitz, 2015)	X	X	X	–	–	–

A total of 15 different maturity models with 85 associated digitization factors could thus be identified. In certain models, these digitization factors are divided into more specific variables of digital maturity, so based on an analysis at the lowest level of granularity, another 62 factors of digitization or a total of 147 digitization factors result.

A large number of variables found provide a good picture of which aspects of digitization can be measured at the different layers of the enterprise architecture.

4. GENERALIZATION AND DISCUSSION

As can be seen in Table 2, the literature review has shown that there are a large number of maturity models that can be used to measure the digital maturity of companies. The maturity models analyzed differ enormously in terms of their areas of application.

In principle, the focus of the maturity models is on the business side. There are variables for the technical layers only in six models (see Table 2), namely the Digital Maturity Model of the University of St. Gallen (Back & Berghaus, 2016), the Digital Transformation Assessment (Fenwick & Gill, 2014), the Digital Maturity Model according to Land (Land, 2015), the Gartner Taxonomy (Gartner, 2016), the Digital Maturity Model of IBM (Berman & Bell, 2011) and the Digital Maturity Model according to TM Forum (2017).

In 14 out of 15 models, the strategy level plays a decisive role and is analyzed in detail (see Table 2). The models considered assigning a total of 85 digitization factors to the strategy level. These include topics such as vision for the company in connection with digitization topics: digitization strategy, culture and experience in dealing with digitisation, and the ability to innovate.

The business level is considered by approximately 93% of the determined maturity models and therefore plays an enormous role in measuring the digital maturity of an enterprise, only one maturity model, namely the model of Kiron et al. (2016) called "Aligning the Organization for its Digital

Future", focuses exclusively on the strategic level (see Table 2). Digitization factors such as the IT business relationship, the customer experience or the business models are considered decisive here. In total, 70 variables of digitization have been assigned to this level.

Furthermore, 14 out of 15 maturity models include the application level in determining the maturity level of a company. In total, 61 variables of digitization were assigned to this level. This includes the use of dynamic and efficient processes through digitization, the promotion of collaboration through the use of digital means, aligning processes in different areas with digital structures and, if possible, automating them, and an improved understanding of customers through the use of big data analyses.

The technology level is considered by six maturity models. Only 17 digitization factors have been assigned to this level (see Table 2). These are factors such as the company-wide use of promising technologies, the evaluation of disruptive technologies and trends or the consistent use or provision of data.

The Physical and Implementation and Migration layers are not taken into account by any of the identified maturity models (see Table 2).

From these findings, it can be concluded that the focus of the identified maturity models is clearly on the business side (Strategy, Business and Application layer) and that these only deal with the technical side (Technology, Physical and Implementation and Migration layer) to a limited extent. This approach is questionable, since all digitization projects originate in technology and digitization is additionally driven by developments in the technology sector.

As can be seen in Table 2, none of the maturity models investigated deals with all layers of corporate architecture. The models Digital Maturity Model of the University of St. Gallen (Back & Berghaus, 2016), the Digital Transformation Assessment (Fenwick & Gill, 2014), the Digital Maturity Model according to Land (Land, 2015), the Gartner Taxonomy (Gartner, 2016), the Digital Maturity Model of IBM and the Digital Maturity

Model of the TM Forum (2017) focus on four of the six layers of architecture and thus represent the models that are currently likely to have the highest significance in terms of a company's full maturity assessment.

Different maturity models focus only on the Strategy, Business and Application layers. Therefore, they are not suitable for a complete and

meaningful measurement of a company's digital maturity.

As a result, digital maturity can only be measured at specific corporate architectural layers up to now. Because digitization is driven by technical aspects, it would be useful to be able to measure digital maturity with variables at all layers of a company.

CONCLUSION

The subject of digitization is assigned an enormous role. The influence on the companies and their day-to-day business is enormous and brings with it a wide variety of challenges. In order to be able to react optimally to these, it is important to know the variables of digitization and their influence on the different layers of the company architecture and to use the variables if necessary.

For this reason, the present work has set itself the goal of eliciting different variables of digitization and analysing their influence on the corporate architecture. A total of 15 different maturity models were found and used, which in turn comprise 147 digitization factors.

Since the study is based on a recognized literature research approach, the expected transparency and reproducibility can be guaranteed. The screening of 305 different articles and the procedure in previously defined steps made it possible to eliminate non-relevant articles at an early stage.

Basically, the analysed maturity models focus on the Business, Strategy and Application layers of corporate architecture. The most models only conditionally consider the technical side of an enterprise (Technology, Physical and Implementation and Migration), although digitization is driven and supported by technological developments.

As a result, all maturity models are not suitable for the full evaluation of a company's digital maturity.

Some models are based on fundamental scientific knowledge, while at other maturity models, the importance of the defined digitization factors is difficult to understand.

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APPENDIX. OVERVIEW OF THE RELEVANT/SELECTED LITERATURE

Author (year)	Model name	Published from	Description	Variables
Westerman et al. (2012)	Digital Maturity Matrix MIT & Capgemini	Massachusetts Institute of Technology & Capgemini Consulting	The maturity model Digital Maturity Matrix is a two-dimensional model. A distinction is made here between the dimensions "Digital Intensity", which indicates the intensity of digital initiatives and possibilities, and the dimension "Transformation Management Intensity", which shows the organizational capability with regard to digital transformations. The companies to be investigated are divided into four different categories (beginners, conservatives, fashionistas, digirati) based on the fulfilment of the different digitization variables. The digirati (or digirati) are the elite companies in digitization. The model basically shows which measures a company has to implement in order to make the most efficient use of digital change.	<p>Vision: Leaders should have a clear vision to convey the future ideal image of the company to the employees.</p> <p>Digital Governance: Control of the digital strategy or set of the course by means of clear rules so that the digital activities support the achievement of the set course.</p> <p>Commitment: Employees should be won over to the change project.</p> <p>IT Business Relationships: Create a common understanding between IT and business.</p> <p>Customer Experience: The aim is to increase customer proximity with the help of technological means in order to create a deeper understanding of customers.</p> <p>Operational Processes: More dynamic and efficient processes based on digitization and its possibilities.</p> <p>Business Models: Adapting the business model to drive digital change.</p>
Back and Berghaus (2016)	Digital Maturity Model University St. Gallen	University St. Gallen & Crosswalk AG	The Digital Maturity Model serves as the basis for an annual Digital Maturity Check, with which company can determine the position in the digital world. Based on these survey data, the different levels of maturity are determined and published using a consolidated report.	<p>Customer Experience: The offer and value proposition is consistently adapted to the changing customer behaviour of digital customers, where the boundaries between online and offline interaction with the company are increasingly blurred.</p> <p>Product Innovation: Digital technologies are to be used to generate new services and products in order to create a competitive advantage through the resulting innovative offering.</p> <p>Strategy: A clear objective and vision and the resulting strategy must recognize and optimally use the possibilities that arise from digital technologies.</p> <p>Organization: The organization must be adapted to the new challenges by carrying out cross-departmental digital projects so that digital skills are available within the company.</p> <p>Process Digitization: All processes, internal and external must be simplified, unified and seamlessly integrated to enable agile action. In addition, these processes should be automated if possible.</p> <p>Collaboration: Due to the changed working methods in the age of digitization, technologies are to be used to support and simplify collaboration and communication between employees.</p> <p>Information Technology: The development and operation of IT infrastructure and information systems are flexible and agile, enabling new digital products, services, communication and transactions. The "time to market" factor plays a decisive role here.</p> <p>Culture and Expertise: In order for the digital transformation to be sustainable, the company must pursue a culture of openness with regard to technologies. In addition, there should be a certain willingness to take risks and an open approach to errors.</p> <p>Transformation Management: Digital transformation is a change process that affects the entire company and is, therefore, to be planned, controlled and supported by the top management level.</p>

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Fenwick and Gill (2014)	Digital Transformation Assessment	Forrester Research	<p>The maturity model Digital Transformation Assessment distinguishes between the internal view or Digital Operational Excellence and the external view or the digital customer experience. The companies to be investigated are then assigned to the different categories (Digital Dinosaurs, Digital Employers, Digital Connectors, and Digital Masters).</p>	<p>Improvement of operational capabilities: Digital processes must be defined in a lean and cross-company manner so that digital business models can be implemented outside the company's own core competence area. Fast customer-focused innovations: Customers, suppliers and employees act as dynamic teams. This involvement of customers and suppliers can lead to customer-focused innovations with a higher chance of survival. Digitization for agility over efficiency: Due to the ever faster-changing market conditions, agility is increasingly becoming a key factor for the success of a company. Digital holistic Customer Experience: Analyses of customer journeys are to be used to create positive experiences for the customer at various points of contact. Digital Services and Products: The physical products are to be supplemented with digital services. Trusted Machines: Better customer understanding, as well as improved decision making, should be made possible by means of algorithms and big data.</p>
Land (2015)	Digital Maturity Model University Reutlingen & Neuland	University Reutlingen & Neuland Consulting Company	<p>With the Digital Transformation Index process, the digital maturity level of a company. On the basis of the Digital Transformation Index, fields of action and concrete optimization potentials in individual areas can be identified. This process thus forms the basis for the digital roadmap for the sustainable further development of digital excellence in the company.</p>	<p>Strategy: The digital strategy is documented and communicated so that it can be understood and internalized by managers and employees. All divisions follow this digital strategy, which is reviewed and updated at regular intervals. Leadership: The management level takes over the task of designing and implementing the digital strategy. Employees from different hierarchical levels work together on the same level as the team. The digital strategy creates new task profiles for executives such as a Chief Digital Officer (CDO). People: The digital experts created by the changing act as drivers and networkers. This expertise flows into the development of innovative products and services. The role models, areas of responsibility and job advertisements have an increasingly strong business connection. Culture: The organization is highly transparent and dynamic. Decision making is supported by digital media. The employees who work at the interface to customers have a high degree of independence. The change brought about by digitisation is becoming the core theme of strategic innovation. Products: The business model has been expanded with new digital products and services that create competitive and customer benefits. The innovation dynamics in the company are very high; in addition, digitization encompasses all stages of the value chain. Operations: The exchange with the customer is regarded as a core principle for a high degree of networking with external stakeholder groups. Basically, new organizational units are available for the implementation of the digital strategy. Core processes are increasingly digitalized and external stakeholders such as suppliers are an important component. Technology: Promising technologies are used company-wide. Different approaches such as predictive analytics and real-time metrics are used. Product development is software-based. Governance: The identification of different digital strategies and stakeholders is essential. Established guidelines and steering committees are important for this. An integrated control of the digital activities is carried out.</p>

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Gartner (2016)	Gartner Taxonomy	Gartner Incorporation	The maturity model developed by Gartner Incorporation consists of 5 different levels, which are arranged in a circular logic. It serves to determine the digital maturity.	<p>People: What are the new challenges of digital transformation in the workplace and talent areas? Four different aspects have an impact on the variable people, namely leadership, organization, culture and talent.</p> <p>Customer facing: To what extent does the interaction with the customer have to change? Three different aspects affect the characteristics of variable customer-facing: customer sensing, digital workplace and business model.</p> <p>Operations and Infrastructure: Which processes, architectures and technologies are needed? Three different aspects affect the characteristics of the Variable Operations and Infrastructure: IT Services, Business Services and Supply Chain.</p> <p>Vendors: Which technology and service partners should I work with? The variable vendors are affected by two different aspects: Tech Providers and Service Providers.</p> <p>Emerging Technologies and Trends: Which disruptive technologies and trends need to be evaluated for the company's digital journey? Three different aspects affect the characteristics of the variable emerging technologies and trends, namely technologies, trends and practices.</p>
Berman and Bell (2011)	Digital Maturity Model IBM	IBM Institute for Business Value	The IBM Maturity Model is a two-dimensional model. A distinction is made between two different dimensions: the dimension "Reshaping the customer value proposition" and the dimension "Reshaping the business model". The companies are assigned to different levels of maturity based on a questionnaire.	<p>Business Model Innovation: Design and integration of new business models. The generation of customer benefits across all levels is to be regarded as a core competence to be aimed for.</p> <p>Customer and Community Collaboration: Increasing customer orientation should be driven in all areas of the company. In addition, the interaction with the customer should be redefined by using different social networks.</p> <p>Cross-channel integration: The digital and physical points of contact with customers must be integrated into the company.</p> <p>Insights from Analytics: The available information must be available across all levels and sources (external and internal). In addition, the advantages arising from predictive analytics and advanced analytics are to be used.</p> <p>Digitally enabled supply chain: All elements of the supply chain are to be optimized using digital possibilities and integrated across companies.</p> <p>Networked Workforce: The skills needed to seize business opportunities must be provided.</p>
Greif et al. (2016)	Maturity Model PWC	PricewaterhouseCoopers	The PwC Maturity Model was developed to offer an evaluation scale for Swiss SMEs. It consists of 4 different maturity levels, which are used to evaluate the individual digitization factors.	<p>Process and Infrastructure: Contains changes to processes and structures with the help of digital technologies. Internal processes are increasingly digital, linked and, if possible, automated.</p> <p>Digital Sale: The existing business model or earnings model is increasingly being transformed, initiated by the new possibilities of digitization.</p> <p>Customer Involvement: New interaction points are created for customers, with which they are increasingly integrated digitally into business processes.</p> <p>Employees and Culture: Creating a culture of innovation with the associated recruitment of digital talent is essential for the digital transformation.</p>
KPMG (2014)	Survival of the Smartest 2.0 KPMG	KPMG	This KPMG model is based on a survey conducted with various German companies. The goal was to identify the most essential factors for a successful digitization strategy.	<p>Business Models: The business model must change on different aspects or become more digital in order to open up new business opportunities. The aim is to open up new sales channels and address new target groups.</p> <p>Business Processes: Business processes should be increasingly digitalized and networked.</p> <p>Customer Focus: The digital customer is the focus of the company's actions in order to meet their needs and behaviours.</p> <p>Innovative Capability: A continuous innovation process that increases the speed of innovation and reduces the relevant time to market factor. Therefore, the necessary resources must be provided.</p> <p>Competitive dynamism: The company must be able to react quickly to changes in the markets and to identify and exploit any growth potential and opportunities in order to open up new markets if necessary.</p>

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O’Hea (2011)	Digital Capability Framework	Innovation Value Institute	O’Hea’s model from the Innovation Value Institute consists of five dimensions and five layers of maturity.	<p>Strategy and Planning: New digital transformation possibilities have been identified and are being pursued. Digital channels are becoming an essential part of the strategy. The company must be able to react optimally to competitive dynamics.</p> <p>Business and Leadership: Value generation is tailored to the needs of the customer. The company must also have a clear digital vision.</p> <p>Process Management: The processes should be digital, the resulting gains in effectiveness and efficiency must be used.</p> <p>Technical Capability: The impact of current technologies on the company must be understood. In addition, new technologies must be tested for their benefits and applicability.</p> <p>People and Culture: Collaboration among employees must be supported by digital tools. The customer journey and the customer experience, in general, must be analysed and constantly improved.</p> <p>Data Maturity: Since the digital methods and digital processes are based on data, it is important to guarantee that they are syntactically correct. In addition, the data must be checked for timeliness and relevance.</p> <p>Digital Product Maturity: Comparison between the analysed behaviour of a digital model and the actually required properties of a product. The behaviour of the product is assessed from a functional or product-based perspective.</p> <p>Engineering Process Maturity: The quality of the development process is described, also taking into account the integration of different stakeholders. This is a cornerstone for the success of a product development project.</p>
Mueller et al. (2006)	The Digital Maturity Map	Design Society	This model was developed for the automotive industry to evaluate their early need for automation compared to other industries. Therefore the model is used especially for experts from the automotive industry.	<p>Strategy: The so-called zoom-out/zoom-in approach should be used in order to react optimally to the digital future. With zoom-out, a time horizon of 10 years is considered by making forecasts regarding the market and customer requirements. In contrast, the zoom-in approach looks at the next six to twelve months.</p> <p>Tasks: Complex and slow recruitment procedures can be an obstacle to finding the right talent. New working models have to be created, such as freelance or home office.</p> <p>Culture: The willingness to take risks must be given within the company in order to be successful in the age of digitization.</p> <p>People: Employees must be given the opportunity to acquire new digital skills. The employment of external resources is only intended to bridge short-term periods, as otherwise no digital skills will be built up within the company.</p> <p>Structure: The hierarchical management structures existing in many companies. They were defined in more stable times. In the age of digitization, it is essential to use leaner management structures in order to be able to react quickly to changes.</p> <p>Strategy: The implementation of a digital strategy based on a clear vision, governance, clear planning and management processes.</p> <p>Organization: Make necessary changes in communication, culture, structure, training and knowledge management within the organization to become a digital company.</p> <p>Customer: Increased customer involvement and the creation of new customer experience benefits through the digital transformation of the Customer Journey.</p> <p>Ecosystem: Creating and maintaining common ecosystems as partners form an important basis for the digital business.</p> <p>Operations: The focus should be on the skills that support service delivery. This leads to a more digitized, automated and flexible way of working.</p> <p>Technology: Represents the ability to plan, deploy and integrate the effective use of technologies to support the digital business.</p> <p>Innovation: Focusing on the skills that lead to more flexible and agile ways of working that form the basis of an effective digital business.</p>
Kiron et al. (2016)	Aligning the Organization for its Digital Future	MIT Sloan Management Review	This model was published in the MIT Sloan Management Review magazine and is based on an idea from the 1980s that companies can only be successful if the four basic values of culture, personnel, structure and tasks are coordinated and compatible. This model should make it possible to establish a uniform culture throughout the company and to avoid discrepancies between different parts of the company as far as possible.	<p>Strategy: The so-called zoom-out/zoom-in approach should be used in order to react optimally to the digital future. With zoom-out, a time horizon of 10 years is considered by making forecasts regarding the market and customer requirements. In contrast, the zoom-in approach looks at the next six to twelve months.</p> <p>Tasks: Complex and slow recruitment procedures can be an obstacle to finding the right talent. New working models have to be created, such as freelance or home office.</p> <p>Culture: The willingness to take risks must be given within the company in order to be successful in the age of digitization.</p> <p>People: Employees must be given the opportunity to acquire new digital skills. The employment of external resources is only intended to bridge short-term periods, as otherwise no digital skills will be built up within the company.</p> <p>Structure: The hierarchical management structures existing in many companies. They were defined in more stable times. In the age of digitization, it is essential to use leaner management structures in order to be able to react quickly to changes.</p> <p>Strategy: The implementation of a digital strategy based on a clear vision, governance, clear planning and management processes.</p> <p>Organization: Make necessary changes in communication, culture, structure, training and knowledge management within the organization to become a digital company.</p> <p>Customer: Increased customer involvement and the creation of new customer experience benefits through the digital transformation of the Customer Journey.</p> <p>Ecosystem: Creating and maintaining common ecosystems as partners form an important basis for the digital business.</p> <p>Operations: The focus should be on the skills that support service delivery. This leads to a more digitized, automated and flexible way of working.</p> <p>Technology: Represents the ability to plan, deploy and integrate the effective use of technologies to support the digital business.</p> <p>Innovation: Focusing on the skills that lead to more flexible and agile ways of working that form the basis of an effective digital business.</p>
Valdez-de-Leon (2016)	Digital Maturity Model for Telecommunications Service Providers	Technology Innovation Management Review	This model was developed according to comprehensible scientific standards. It is intended to provide a complete overview of the digital transformation in a company, while at the same time specifically meeting the needs within the intended context, and to enable a standardized comparison with other companies within the telecommunications industry.	<p>Strategy and Planning: New digital transformation possibilities have been identified and are being pursued. Digital channels are becoming an essential part of the strategy. The company must be able to react optimally to competitive dynamics.</p> <p>Business and Leadership: Value generation is tailored to the needs of the customer. The company must also have a clear digital vision.</p> <p>Process Management: The processes should be digital, the resulting gains in effectiveness and efficiency must be used.</p> <p>Technical Capability: The impact of current technologies on the company must be understood. In addition, new technologies must be tested for their benefits and applicability.</p> <p>People and Culture: Collaboration among employees must be supported by digital tools. The customer journey and the customer experience, in general, must be analysed and constantly improved.</p> <p>Data Maturity: Since the digital methods and digital processes are based on data, it is important to guarantee that they are syntactically correct. In addition, the data must be checked for timeliness and relevance.</p> <p>Digital Product Maturity: Comparison between the analysed behaviour of a digital model and the actually required properties of a product. The behaviour of the product is assessed from a functional or product-based perspective.</p> <p>Engineering Process Maturity: The quality of the development process is described, also taking into account the integration of different stakeholders. This is a cornerstone for the success of a product development project.</p> <p>Strategy: The so-called zoom-out/zoom-in approach should be used in order to react optimally to the digital future. With zoom-out, a time horizon of 10 years is considered by making forecasts regarding the market and customer requirements. In contrast, the zoom-in approach looks at the next six to twelve months.</p> <p>Tasks: Complex and slow recruitment procedures can be an obstacle to finding the right talent. New working models have to be created, such as freelance or home office.</p> <p>Culture: The willingness to take risks must be given within the company in order to be successful in the age of digitization.</p> <p>People: Employees must be given the opportunity to acquire new digital skills. The employment of external resources is only intended to bridge short-term periods, as otherwise no digital skills will be built up within the company.</p> <p>Structure: The hierarchical management structures existing in many companies. They were defined in more stable times. In the age of digitization, it is essential to use leaner management structures in order to be able to react quickly to changes.</p> <p>Strategy: The implementation of a digital strategy based on a clear vision, governance, clear planning and management processes.</p> <p>Organization: Make necessary changes in communication, culture, structure, training and knowledge management within the organization to become a digital company.</p> <p>Customer: Increased customer involvement and the creation of new customer experience benefits through the digital transformation of the Customer Journey.</p> <p>Ecosystem: Creating and maintaining common ecosystems as partners form an important basis for the digital business.</p> <p>Operations: The focus should be on the skills that support service delivery. This leads to a more digitized, automated and flexible way of working.</p> <p>Technology: Represents the ability to plan, deploy and integrate the effective use of technologies to support the digital business.</p> <p>Innovation: Focusing on the skills that lead to more flexible and agile ways of working that form the basis of an effective digital business.</p>

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TM Forum (2017)	Digital Maturity Model TM Forum	TM Forum	The Digital Maturity Model was developed over many months by industry leaders to help define a company's digital maturity level. The model is basically divided into five different dimensions.	<p>Customer: An experience should be created for the customers so that they regard the company as their preferred digital partner. The interaction takes place via the desired channels of the customer. This variable also includes the topics of Customer Engagement, Customer Experience, Customer Insights & Behavior and Customer Trust & Perception.</p> <p>Strategy: Deals with the transformation and operational business of the company to leverage competitive advantages through digital initiatives. The digital strategy is an essential part of the corporate strategy. This variable also includes Brand Management, Ecosystem Management, Finance & Investment, Market & Customer, Portfolio, Ideation & Innovation, Stakeholder Management and Strategic Management.</p> <p>Technology: The use, storage, processing, and exchange of data plays an enormous role in the success of a digital strategy. In addition, to meet customer needs and reduce costs. This variable covers the areas of Applications, Connected Things, Data & Analytics, Delivery Governance, Network Security and Technology Architecture.</p> <p>Operations: Increase business efficiency and effectiveness through the use of digital technologies in the execution and development of business processes. This variable includes Agile Change Management, Automated Resource Management, Integrated Service Management, Real-time Insights and Analytics, Smart & Adaptive Process Management, Standards & Governance Automation.</p> <p>Culture, Organization and People: Definition and development of an organisational culture with associated governance and talent processes to support digital transformation in the company and achieve growth and innovation goals. This variable deals with the topics of Culture, Leadership & Governance, Organizational Design & Talent Management and Workforce Enablement.</p>
Carolis et al. (2017)	DREAMY Maturity Model	Springer International Publishing	The aim of this model is to represent a scientifically comprehensible model for production companies. The model is basically divided into five different dimensions.	<p>Design & Engineering: Design of the production process in the areas of quota, concept, requirements & product planning, product design & engineering and plant design & engineering.</p> <p>Production Management: Planning and administration of production include the areas of Production Planning, Production Scheduling, Production Execution and Production Monitoring & Control.</p> <p>Quality Management: Guarantee of quality made possible by Product Testing and Quality Management in Production.</p> <p>Maintenance Management: Concrete and structured maintenance activities made possible by maintenance engineering, maintenance planning, maintenance execution and maintenance monitoring & control.</p> <p>Logistics Management: Includes all logistical activities and is supported by Inbound Logistics, Internal Logistics and Outbound Logistics.</p>
Schmitz (2015)	Maturity Scope Model	International Data Corporation (IDC)	Using this model, the digital maturity level of a company can be determined in order to subsequently derive suitable measures for improving the digital strategy. For each of the five levels of maturity, there are recommendations on how an enterprise can reach the next level of maturity.	<p>Leadership: Leaders must be able to define the role of the company in the age of digitization and decide which level of maturity must be reached in order to achieve the business goals.</p> <p>Information: Finding and determining the correct data to support the company in the digital transformation. The definition of a stable information architecture is indispensable. Knowledge exchange and collaboration must be encouraged.</p> <p>Operating Model: Existing business models are to be transformed or new business models created, based on the integration of digital technologies and the use of the resulting opportunities.</p> <p>Omni-Channel Experience: A new cross-channel customer experience is to be created. Interaction takes place via the channels preferred by the customer and can be digital as well as physical. The focus here is also on the resulting diverse dimensional marketing opportunities.</p> <p>Working World: In order to take advantage of the digital transformation and the resulting opportunities, the company must have employees with digital skills. New requirements are arising in the recruitment area.</p>