Model dojrzałości dla czynników stymulujących innowacje

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
CHAIN REACTIONS

WP
D.T1.2.1

Maturity model for the innovation drivers First release

Version 1
14.02.2020

Project information	
Project Index Number:	CE1519
Project Acronym:	CHAIN REACTIONS
Project Title:	Driving smart industrial growth through value chain innovation
Website:	https://www.interreg-central.eu/Content.Node/CHAIN-REACTIONS.html
Start Date of the Project:	01.04.2019
Duration:	36 Months
Document Control page	
Deliverable Title:	DT1.2.1 – Maturity model for the innovation drivers. First release.
Lead Contractor of the Deliverable:	BWCON
Authors:	BWCON
Contractual Delivery Date:	31.10.2019
Actual Delivery Date:	14.02.2020

Table of content

EXECUTIVE SUMMARY

The present deliverable relates to the **analysis** of SMEs and their potential for value chain innovation processes and covers the key step of **assessing the maturity** of SMEs so as to be able to identify innovation potentials.

This deliverable is the first version of the CHAIN REACTIONS maturity models for the innovation drivers considered in the project (digital transformation, service innovation, ley enabling technologies and resource efficiency (circular economy). Considering the strong weight of the digital transformation and digital technologies among the key enabling technologies for the project, this initial version focus on the digital maturity level.

Building on the analysis of relevant models, a CHAIN REACTIONS model has been designed with the aim to be applicable for SMEs and with a clear focus on providing input for the identification of innovation potential.

It can be used in practice in the form of an interview or a self-assessment online questionnaire and adresses six key dimensions:

Dimension 1: Strategy & Leadership

This dimension examines the topic of strategy and business motives. It is linked to the management, as the latter has the decision-making competence in the area.

Dimension 2: Corporate culture and organisation

Staff, cooperation and communication; as mentioned above, these are the keywords for the topic of culture and Digital transformation. The theme is taken up in dimension 2.

Dimension 3: IT infrastructure

To support and use new processes, new business models and new technologies, a suitable IT infrastructure is necessary. Whether this is operated internally or by the service provider is not relevant in this dimension.

Dimension 4: Data maturity level

Providing more information for the changing customer and the evaluation of real-time data is dealt with and examined in this dimension.

Dimension 5: Processes and operations

Dimension 5 deals with the networking of processes, both internal and external. The use of new technologies in operations is also relevant here.

Dimension 6: Product (use phase)

The product dimension takes into account the customer and his changed behaviour. The products and their adaptation to Digital transformation are also to be located here thematically.

The model classifies the companies into three maturity levels with level three as highest level.

The structure of this maturity model, which focuses on the digital transformation, will be adapted to further innovation drivers within the next months. A similar structure along dimensions, capabilities and variables for the operationalisation of the model will be adopted.

1 INTRODUCTION

1.1 The CHAIN REACTIONS transformation process model

The transformation process model for generating value chain innovation processes from the perspective of a support organisation is shown below. It is divided into the following phases:

- Awareness raising and networking
- Transfer of methodological knowledge to practice
  - Analysis
  - Ideation / development
  - Testing
- Implementation or use (which is not implemented in the framework of the project activities)

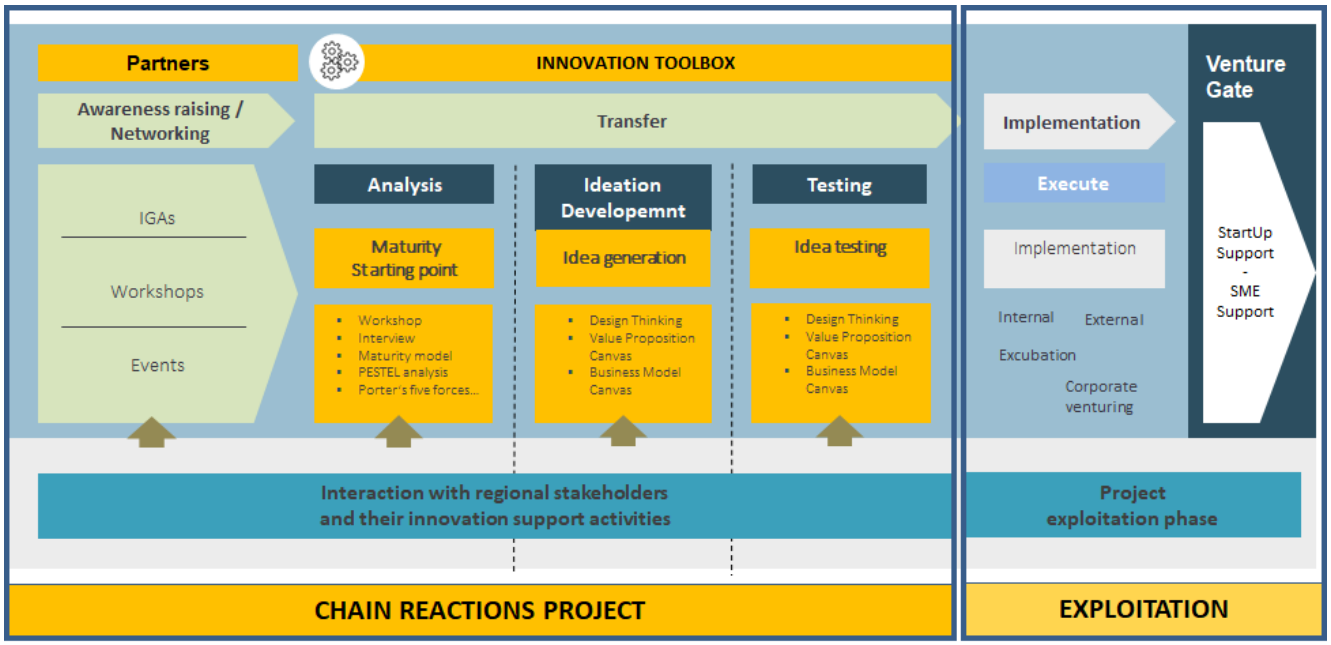

Figure 1: CHAIN REACTIONS innovation journey
Source: own representation

The present deliverable relates to the **analysis** of SMEs and their potential for value chain innovation processes and covers the key step of **assessing the maturity** of SMEs so as to be able to identify innovation potentials.

This deliverable is the first version of the CHAIN REACTIONS maturity models for the innovation drivers considered in the project (digital transformation, service innovation, ley enabling technologies and resource efficiency (circular economy). Considering the strong weight of the digital transformation and digital technologies among the key enabling technologies for the project, this initial version focus on the digital maturity level.

Further iterations addressing the other innovation drivers will follow.

1.2 Maturity level and maturity models in general

Maturity levels exist in different areas. For example, the colour and consistency of a fruit or vegetable is an indication of its maturity. Another example is the maturity of a person, which can be measured, for example, by the school leaving certificate, the university entrance qualification. (see Lindenlauf 2017)

As the previous examples make clear, the degree of maturity describes a state of development. This continues until the next more mature state is reached. Maturity models take up the idea of assigning a maturity level to each state and relate them to each other, they are also called stages: The higher level describes a higher degree of maturity. (see Wagner and Dürr 2008, pp. 13-14)

Prominent examples of maturity models are Phil Crosby's Maturity Grid and the Capability Maturity Model (CMM), which was developed by the Software Engineering Institute (SEI, Carneigie Mellon University) in Pennsylvania. The Maturity Grid measures the degree of maturity of a company with regard to quality (maturity in quality management), while the CMM focuses on the evaluation of software products (maturity in information technology). (see Wagner and Dürr 2008, p. 10)

Classification to a certain degree of maturity is made on the basis of defined criteria (see Wagner and Dürr 2008, p. 11). Based on the identified situation, improvement measures are derived and benchmarking is carried out. **However maturity models are limited to describing maturity levels and stages. There is no procedure for reaching the next higher level. For this reason, a maturity model can only be seen as a starting point for orientation.** (see Khan 2015, p. 23)

1.3 Digital maturity level

The digital maturity level uses the basics of other maturity levels and specifies them in the selected criteria. These relate to digital transformation and its impact on a company. Chapter 2 defines the criteria for the model of the present paper.

The digital maturity level is the actual state of a company, which describes the previous transformation of manual, analogue processes into digital processes. In addition, changed working methods and business models are included as criteria for the degree of maturity and their development is evaluated.

1.4 Benefits and relevance of digital maturity

Within a digital transformation project, the degree of maturity serves as an aid in the analysis phase. The following benefits can be identified:

- A mapping with regard to the digital status becomes possible (cf. Jodlbauer and Schagerl 2016, p. 2). This is also of "strategic importance" for medium-sized companies (Lüerßen 2017, p. 3).
- The further procedure can be planned according to the mapping, taking into account any optimisation potential that is discovered (cf. Azhari et al. 2014, p. 38).
- Furthermore, the digital maturity level serves as a basis for a common understanding: opinions about what determines maturity and how mature a company already is can vary within the company.
- By taking up the important aspects of digital transformation and standardising the calculation, a common understanding of the concept of digital maturity and its influencing factors is made possible. (see Berghaus et al. 2015, p. 6)
- By using the same model for several companies, a comparison between industries and company sizes is also possible (see Berghaus et al. 2015, p. 8).

2 PREPARATION OF THE MATURITY MODEL

2.1 Critical appraisal of related studies

After the goal of the work has been presented and the foundations for thematic understanding have been laid, it is necessary to determine the current state of research with regard to the digital maturity level. The selection of existing studies is presented on the basis of defined criteria. Subsequently, the investigations of the studies and their core content are presented and finally evaluated.

2.1.1 Selection of relevant studies

Before a selection of relevant studies can be made, the goal, perspective, scope, organization and audience of the research on the current state of research must be identified. These aspects of literary research were defined by Harris M. Cooper in "A Taxonomy of Literature Reviews". (see Cooper 1988, pp. 108-112). The following table presents the aspects selected:

Focus	Procedure and result of the measurement of the digital maturity level
Objective	Identification of central aspects for measuring the digital maturity level
Perspective	Neutral presentation of the studies with subsequent critical evaluation
Scope (coverage)	Selective citation, criteria: ▪ Analysis of the digital maturity level with detail of the maturity level model ▪ Statistical analysis ▪ **Timeline: not older than 2015**

The digital maturity level is a prominent topic and is taken up by many management consultancies, among others, as an entry point into projects (see Strategy & Transformation Consulting). However, these analyses are often limited to a minimum as far as information on the derivation and structure of the maturity model is concerned. Such analyses are only of limited relevance for the present study, since the maturity model is to be considered in detail. These analyses will therefore not be discussed further in this chapter.

A study is considered relevant for this work if, in addition to the analysis of the digital maturity level, a derivation and explanation of the tools used is presented. In addition, data collection and its evaluation should be addressed in the study, as this is also an important part of the present work.

A further criterion for the selection of a study is its topicality. The speed of change of the digital transformation is increasing (cf. Lüerßen 2017, p. 3) and thus it is possible that findings on determining the digital maturity level of earlier studies are outdated. For this reason, studies conducted before 2015 are not included here.

2.1.2 Overview of selected studies

The following table shows the selected studies with their key information in chronological order.

authors, year	Motivation of the study	Database - **Sample size** - **Nature of the interview** - **Nature of the survey** - **Industries**
Dr. Karl Light blue et. Al **2015**	Determination of the current location of machine and plant manufacturers in Germany to support them on their way to industry 4.0	n = 232 Online survey Standardized questions Enterprises with 20 or more employees April to July 2015
Sabine Berg- haus, Prof. Dr. Andrea Back, Bramwell Kalten- rieder **2015**	Location of various companies and support in the identification of Management tasks for the digital transformation	n = 196 Online survey from November 2014 to February 2015 Standardized questions
Sabine Berg- haus, Prof. Dr. Andrea Back, Bramwell Kalten- rieder **2016**	Renewed survey of version 2015 with improved questionnaire	n = 417 Online survey from 17.10.2015 to 08.02.2016 Standardized questions
Mario Zillmann, Prof. Dr. Peter Buxmann **2016**	Identification of the orientation towards the digital change in terms of management, strategy and IT processes	n = 103 Online survey Standardized questions Companies from 250 million Euro sales volumes All sectors Switzerland, Germany, Austria and others
Hartmut Lüerßen **2017**	Determining the position of the companies in comparison to the industry	n = 110 online survey Standardized questions Medium-sized companies enterprises

2.1.3 Summary assessment of the selected studies

Objective of the studies

The studies all aim to determine the position of companies with regard to digitisation by examining relevant factors. The factors apply to all companies surveyed. The studies thus serve the companies surveyed, which can assess and evaluate themselves through participation and compare their own level of maturity with other companies. The recommended further steps of the studies should also serve as orientation and guidance for the companies for the further procedure.

Subject of investigation and database

The subject of the studies are companies of different industries, different sizes and from different countries. The samples of the studies are composed differently.

Industries

A sector-specific study is that of the German Engineering Federation (VDMA; cf. Lichtblau et al. 2015). According to the executing company (VDMA), the study is designed purely for companies in the mechanical and plant engineering sector.

The Berghaus et al. (2015) and Berghaus et al. (2016) studies examine companies in all sectors. The survey of participants per sector shows that banks, insurance companies, IT/telecommunications, communications/consultancy and transport & logistics account for more than half of the participants (see Berghaus et al. 2016). The distribution of industries has shifted slightly from 2015 to 2016. In 2016, for example, it is the banks that will make up the largest part and will have overtaken the 2015 largest sector, information and communication.

The study by Zillmann and Buxmann (2016) examines companies in the industry/mechanical and plant engineering, automotive and logistics sectors and transport. The number of participants in the automotive industry is the smallest part.

The study by Lüerßen, which was written in 2017, surveys all industries, but does not provide any information on the distribution of the number of participants per industry.

Company size

The size of the companies does not represent a limiting criterion for participation in the VDMA survey questionnaire. However, most of the participants are the "large companies" (500 or more employees).

In the studies by Berghaus et al (2015, 2016), the number of participants per company size is similarly high. However, it can be observed that in 2016 the distribution will be more balanced. In the 2015 study, companies with 0-100 employees make up the largest share by a clearer margin.

In the study by Zillmann and Buxmann (2016), the focus is on companies with sales volumes ranging from 250 million to over 10 billion. Companies with a sales volume of between 250 million and 1 billion euros represent the largest share of participants.

Lüerßen (2017) does not provide any information on the distribution of participants per company size. However, since the focus here is on small and medium-sized enterprises, this information is not mandatory.

Since the studies indicate the size of the company partly in persons and partly in sales volume, a direct comparison is not possible. The distribution of participation according to company size can presumably be attributed primarily to the company carrying out the survey and its decision to apply for the survey and has no direct significance for the relevance of the topic of digitisation for the respective company size.

Interviewed participants & sample

The VDMA study has a sample size of 232 companies and does not provide any information on the position distribution of the interviewed persons within the company (cf. Lichtblau et al. 2015, p. 15).

The 2015 study by Berghaus et al. shows a sample size of 196 companies and the interviewed persons are business and department managers as well as employees and team leaders. The sample size of Berghaus et al. (2016) is 417 and the participants by position show that the majority come from the area of business and department management. When comparing the two studies by Berghaus et al. it can be observed that the respondents increasingly come from leading positions and that the sample size has increased significantly within a year.

In the study by Zillmann and Buxmann (2016) 103 companies were surveyed. The survey was mainly conducted among IT managers and Chief Information Officers (CIO).

110 companies were surveyed in the study by Lüerßen (2017). No information is given about the position of the persons interviewed.

In summary, it can be said that the interviewees are increasingly in leading positions. What is striking, however, is the focus on the IT area of the study (Mario Zillmann, Prof. Dr. Peter Buxmann, 2016). This can be explained by deriving the word digitization (chapter 2.1.1). First and foremost, digitisation has to do with information technology. The first point of reference on this subject is probably the IT department for this reason.

Method of data analysis

The studies use the methods of descriptive statistics: The mean values of the maturity levels per dimension as well as the mean value of the overall maturity level per defined class (industry, company size, etc.) are calculated.

Lichtblau et al. (2015) and Zillmann and Buxmann (2016) focus primarily on the average levels of maturity per class and compare them with each other.

The studies by Berghaus et al. (2015, 2016) represent the deviation from the mean value per class, from which fields of action are then derived.

In Lüerßen (2017), above all the maturity levels of each corporate division (marketing, sales, etc.) are considered. In addition to the mean value of the degrees of maturity for each corporate division, a gap analysis is also carried out here.

In general, all studies use the average maturity levels for a benchmark approach.

Maturity model applied

The studies presented each use different models to measure the degree of maturity. Above all, the models differ in their defined dimensions, which should measure the digital maturity of a company. In the following sections, the structure of the individual maturity models of the respective studies is explained and the calculation of the maturity level is discussed.

Structure of the maturity models

The study by Lichtblau et al (2015) defines six dimensions and 18 thematic areas. The exact structure is shown in the following picture. The definitions - Smart Factory, Smart Operations, Smart Products, Data-driven Services - result from the definition of Industry 4.0 given in the study. With the additional two, other factors are

also included. The thematic areas describe the dimensions in more detail and are operationalised by means of indicators.

Figure 2: Maturity model VDMA, (Lichtblau et al. 2015)

The studies by Berghaus et al. (2015, 2016) use a model with nine dimensions, which are operationalized by means of indicators. In comparison to the study mentioned above, there are no defined subject areas here. The structure is shown in the picture below.

Figure 3: Maturity model Crosswalk, (Berghaus et al. 2016)

The study by Zillmann and Buxmann (2016) differs in that it does not use a model with superordinate dimensions. The measurement is carried out here by means of questions, which are not assigned to any defined dimension. Based on the headings of the results evaluation of this study, however, it can be speculated that the questions developed cover the following areas:

- Importance of digitisation for businesses
- Business goals
- Digitization strategy
- Drivers of the digitization strategy
- Cooperation between business and IT
- Application of digital technologies
- IT landscape of the companies
- Sourcing strategies
- Investment priorities

The study by Lüerßen (2017) measures the degree of maturity based on department-specific challenges. So the dimensions are equal to the departments and divisions:

- Strategy
- Production
- Warehouse/Purchasing/Logistics
- Administration/Finance
- Distribution/Marketing
- Services
- IT
- Employees/HR

Even if the dimensions or areas that are relevant for digital maturity according to the studies mentioned above are named differently, great similarities can be found in the definitions. This suggests that the indicators for digitisation to be ultimately measured were similarly identified by all the companies. The dimensions that differ most clearly are those of the Stu- der von Lüerßen (2017). The departmental orientation is easy for companies to understand and helps to identify department-specific fields of action. However, a closer look at the indicators within the departments reveals that they do not differ too much from the questions of the other studies. The difference is therefore mainly in the grouping of the indicators.

Maturity levels & point system

The Industry 4.0 Readiness Model of the study by Lichtblau et al (2015), shown in the picture below, describes six maturity levels. These are further divided into three types of companies. For each level, minimum requirements are defined which must be met in order to reach the next higher level. According to this scheme, the surveyed companies can be assigned to the appropriate level. (cf. Lichtblau et al. 2015, p. 21-23)

Figure 4: Maturity levels of the industry 4.0 readiness model, (Lichtblau et al. 2015, p. 23)

The studies by Berghaus et al (2015, 2016) present various analyses and classifications before companies are assigned to an overall maturity level. The first analysis is the difficulty analysis. Here the indicators are divided into levels of difficulty. This is done on the basis of the answers. An indicator that is met by many of the companies surveyed is considered to be more easily achievable than an indicator that is met by a few companies. After the indicators have been assigned to a level of difficulty, they are assigned to the individual levels of maturity in a cluster analysis. Easy to achieve indicators are assigned to a low level of maturity and so on. On this basis, the companies can now be assigned to a cluster maturity level depending on the fulfilled indicators. The easily achievable indicators must be met before the company is assigned to a higher level of maturity. A further degree of maturity is the point maturity level. The indicators are assigned a maximum score based on their difficulty. The degree of fulfilment of the maximum number of points is the basis for the allocation of the companies to a points maturity level. Point and cluster maturity levels result in the overall maturity level, which is calculated from the arithmetic mean of the two.

The study by Zillmann and Buxmann (2016) weights the indicators according to their relevance for digitisation. The arithmetic mean is then calculated. A maximum score of 100 points is set and depending on the degree of fulfilment of the score, the companies are assigned to a maturity level. Table 3 names the maturity levels according to the number of points.

Score	Maturity levels
0-29	non-digitals
30-49	digital beginner
50-69	digital follower
70-79	digital transformer
>80	digital leader

For Lüerßen (2017), the degree of maturity is determined from the number of points achieved. How exactly this score is calculated is not specified. The maturity model has four levels:

- Digital pioneers
- Digital tracker
- Digital stragglers
- Analogue Preservers

The calculation of maturity levels occurs in different ways in different studies, which weakens comparability the comparability. The model of the studies by Berghaus et al. (2015, 2016) is particularly striking. Here the degree of maturity is calculated in the most complex way.

2.1.4 Other studies

Further studies are being considered to establish a new maturity model. These serve primarily to compare and verify the defined dimensions. The indicators which are to determine digitisation in companies are also compared with these studies and thus confirmed. However, since no detailed derivation of the model and/or no survey of companies is available here, these are not used for a closer examination. The following table provides an overview of the defined dimensions in those studies.

Source	Defined dimensions
(Azhari et al. 2014)	• Strategy • Leadership • Products • Operations • Culture • People • Governance • Technology
(Gill and VanBoskirk 2016)	• Culture • Organization • Technology • Insights
(Strategy & Transfor-mation Consulting)	• Corporate Governance • Internal processes • Business • Customer relationship • Technology

(Horváth & Partners)	• Digital influences • Agile business models • Customer-focused sales • smart operations • Steering Business Digitally • Management of digital parameters • Digital Skills/enablers
(BearingPoint GmbH 2015)	• Strategy & Organization • Process & communication • product & technology • customer & competitor • Innovation & Business Models
FPOV	• Leadership Digital Readiness • Systems of Engagement Effectiveness • data maturity • digital workforce assessment • Systems of record effectiveness • Organizational risk and control • Transformative design capabilities • Technology completeness & leverage • Market competitive ranking
The German Digital Maturity Model, source digital transformation report 2014 (Neuland GmbH and WirtschaftsWoche Handelsblatt GmbH)	• Strategy • Leadership • Products • Operations • Culture • People • Governance • Technology
IMP³rove Digital Innovation Quotient https://www.improve-innovation.eu/our-services/assessments/digital-innovation-quotient/	• Strategy • Business model • Processes • Ecosystem and culture • Enablers for digital innovation

Diagnostic 360, Alliance Industry of Future	• Development of the company • Operational Excellence • The Human Ressource • Environmental commitment • Environmental and societal responsability • Modernization of physical resources • The modernization of the digital means
Test Industria 4.0 – Assessment of maturity for manufacturing https://www.testindustria4-0.com/	• Strategy • Business model • Processes • Operations

2.2 Central aspects of digital transformation - Dimensions

The aim of this section is to identify aspects that influence digital transformation and its status within the company. These aspects were mainly determined by the studies examined.

A first central aspect is the corporate strategy. Digital change will sooner or later be relevant to all businesses and it is essential to address it. However, in order to take account of this change, the corporate strategy must be reviewed. Does this still fit into "digital reality" (Berghaus et al. 2015, p. 6)?

However, not only the strategy must be scrutinized, but also the corporate culture is an important aspect that must be ready for the digital change (see Berghaus et al. 2015, p. 6). Employees, cooperation and communication are important keywords here, which influence the digitalization in the company. Particularly noteworthy here is the employee. Even though many articles talk about the fact that people have to adapt their role in the company (cf. Spieß and Fabisch 2017, pp. 16-17), it should not be forgotten that people are also the ones who primarily initiate digital transformation and implement it in the company. If the employees in the company are at odds, digital change cannot be forced. (see Berghaus et al. 2015, p. 65)

In addition, the review of business models is necessary. Airbnb and Uber are just two examples of how companies are using a new business model to compete with the previously 'familiar' model (see Berghaus et al. 2015, p. 8). The model that these two companies use can be described as follows: The company does not own the product (such as a car or a hotel room) but creates a network for people who want to own and share the product. In this way, providers and users can get in touch. With this model, they force other companies to rethink their previous concept. (see Zillmann and Buxmann 2016, p. 5)

The internal networking of processes also holds potential that should be uncovered. Optimized planning and real-time evaluation of data, such as the current availability of resources, are just a few examples. (see Lichtblau et al. 2015, p.10)

Besides internal aspects, external aspects also play a decisive role. The **digitalisation of the value chain** is a central example of this. On the one hand, this concerns the connection to the supplier. Here, advantages arise with regard to just-in-time and just-in-sequence processes. On the other hand, networking with the customer, which gives him new possibilities and, for example, allows him to call up delivery information.

The customer and his changed attitude is another point to be mentioned here. He now has more information and has also changed buying behaviour. This can be seen in the business (B2B) and private customer (B2C)

sectors. (see Berghaus et al. 2015, p. 8) An example for the B2C sector is the decisive influence of online evaluations on purchasing decisions (see Greven Medien 2017).

The high speed of technological change also challenges companies to update and adapt their current status quickly and flexibly. (see Berghaus et al. 2015, p. 8)

From the central aspects discussed, dimensions are derived in the following which can be considered as variables of digital transformation. Six dimensions are defined:

Dimension 1: Strategy & Leadership

This dimension examines the topic of strategy and business motives. It is linked to the management, as the latter has the decision-making competence in the area.

Dimension 2: Corporate culture and organisation

Staff, cooperation and communication; as mentioned above, these are the keywords for the topic of culture and Digital transformation. The theme is taken up in dimension 2.

Dimension 3: IT infrastructure

To support and use new processes, new business models and new technologies, a suitable IT infrastructure is necessary. Whether this is operated internally or by the service provider is not relevant in this dimension.

Dimension 4: Data maturity level

Providing more information for the changing customer and the evaluation of real-time data is dealt with and examined in this dimension.

Dimension 5: Processes and operations

Dimension 5 deals with the networking of processes, both internal and external. The use of new technologies in operations is also relevant here.

Dimension 6: Product (use phase)

The product dimension takes into account the customer and his changed behaviour. The products and their adaptation to Digital transformation are also to be located here thematically.

2.3 Further development of the maturity model

In the following, the operationalisation methodology of the above dimensions so as to make it possible to measure them is explained.

2.3.1 Structure

In order to build up the operationalisation logically, a model is developed which divides the defined dimensions into capabilities. Activities the affect it are assigned to each capability. These activities are then evaluated. (see Khan 2015, p. 23) They are the final items in the questionnaire and serve as indicator variables. The following picture illustrates the structure of the CHAIN REACTIONS digital maturity model.

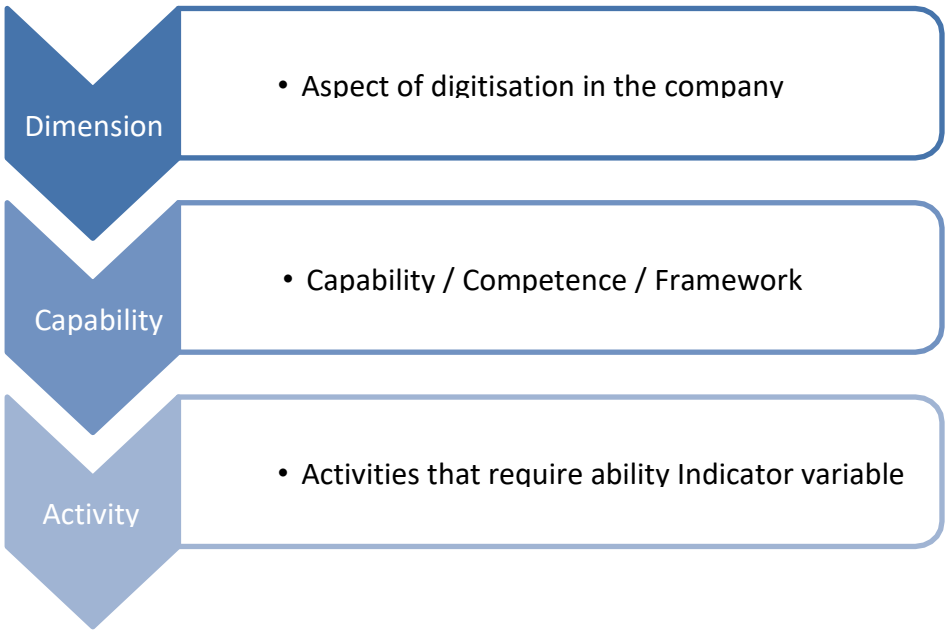

Figure 5: Maturity model structure, based on (Khan 2015, p. 23)

2.3.2 Operationalization of the variables to be measured

Three capabilities are defined for each dimension. These have different numbers of activities. The activities are rated on a five-level Likert scale. The scale ranges from not applicable at all (0) to fully applicable (4).

The variables for dimensions, capabilities and activities are named in the order of the model The first number represents the dimension, the second number is the capability and the third number identifies the indicator variable. The numbers are preceded by a letter to identify the level of the model (example: A1.1.1 is the first activity of the first capability in the first dimension; C2.3 is the third capability in the second dimension).

In the following, the capabilities of the respective dimensions are discussed and items for operationalizing them are presented.

Dimension 1: Strategy and leadership

Capability 1.1: Relevance of the topic identified

Is important for digital change that companies have recognised the relevance of the topic of Digital transformation so that they are prepared to invest resources and thus make change possible (cf. Berghaus et al. 2015, p. 17). Related activities are on the one hand the recognition that digital transformation is relevant and has new potential. On the other hand, the company should consider new business models, as these are often better able to support change (see Lichtblau et al. 2015, p.10; see Lüerßen 2017, p. 3). And as a rule, the company is only prepared to do this if it believes that it is worthwhile, i.e. if the relevance is recognised (cf. Lichtblau et al. 2015, p. 30). The table below shows the formulated items for measuring capability 1.1.

Variable	***Item in the questionnaire***
A1.1.1	Digital transformation is a relevant topic in our company

A1.1.2	Our company is ready (if necessary) to develop and introduce new business models.
A1.1.3	We are ready to invest in digital transformation.

Capability 1.2: Committed management

Changes in strategy, new business models and change are also a topic for the management. This should therefore support and promote the Digital transformation project. (cf. Zillmann and Buxmann 2016, p. 5; cf. Berghaus et al. 2015, p. 64) The following table presents the corresponding items.

Variable	***Item in the questionnaire***
A1.2.1	The management is training/trained on the subject of digital transformation and new technologies.
A1.2.2	The management pushes the topic of digital transformation in the company.

Capability 1.3: Digital strategy implemented

A strategy that takes account of digital transformation in the company is needed to achieve a corresponding level of maturity. However, this should not stand alone, but be in line with the corporate strategy (cf. Zillmann and Buxmann 2016, p. 4). The communication of the strategy is also crucial to inform employees about plans and goals. To keep track of what has been achieved so far, it is necessary to monitor and review the objectives. A key figure system helps in this respect. (cf. Licht- blau et al. 2015, p. 61). The items contained in the following table make these aspects measurable.

Variable	***Item in the questionnaire***
A1.3.1	There is a strategy and the objectives of digital transformation in the company.
A1.3.2	This strategy is integrated in the corporate strategy.
A1.3.3	The digital strategy is clearly communicated within the company.
A1.3.4	The goals of the digital strategy are regularly reviewed using a key indicator system.

Dimension 2: Corporate culture and organisation

Capability 2.1: Pushing forward attitude

Digital transformation must be actively supported within the company. This requires an attitude that promotes digital issues, such as new technologies and new business models. (cf. Lichtblau et al. 2015, p. 9) Openness and acceptance at all levels is a starting point for this. A positive attitude towards the topic is also useful on the employee side. If employees see an opportunity in change, it is most likely that they will support it. (see Berghaus et al. 2015, p. 53) The items for measuring ability 2.1 are presented in the following table.

Variable	***Item in the questionnaire***
A2.1.1	The company culture includes openness to new, digital technologies at all levels.
A2.1.2	The corporate culture includes acceptance of new, digital technologies at all levels.
A2.1.3	The employees see an opportunity in digital transformation.

Capability 2.2: Pushing forward structure and organisation

Not only the attitude and attitude towards the topic of digital transformation is a success factor, but also the appropriate structure and organisation must pave the way. In this context, a clear allocation of responsibilities provides orientation for the company and its employees. (cf. Lichtblau et al. 2015, p. 9 & p. 59; cf. Berghaus et al. 2015, p. 32) In addition, remote working and collaboration platforms support flexibility in everyday working life (cf. Berghaus et al. 2015, p. 48) and knowledge transfer promotes and trains employees among themselves (cf. Berghaus et al. 2015, p. 26). Interdisciplinary teams and cooperation across company boundaries are the beginning of networking and thus advance digital transformation in the company. Furthermore, risks must be prevented in order to be able to act in time. (cf. Berghaus et al. 2015, p. 22; cf. Zillmann and Buxmann 2016, p. 11). The following items make the aspects mentioned measurable.

Variable	***Item in the questionnaire***
A2.2.1	Responsibilities with regard to digital plans are clearly allocated.
A2.2.2	Employees can work remotely.
A2.2.3	Employees can exchange and communicate via collaboration platforms.
A2.2.4	The knowledge acquired by individual employees becomes accessible to everyone via digital channels.
A2.2.5	Employees work together in interdisciplinary teams on projects.

A2.2.6	Cooperation happens across company boundaries.
A2.2.7	Possible risks that digital transformation may entail are prevented (risk management).

Capability 2.3: Competent employees

Employees face new challenges as their role in the company changes. The handling of more automation and the use of new technologies are only part of this change. (cf. Spieß and Fabisch 2017, pp. 35-36) Promoting the skills of employees is important to counteract Digital transformation. (cf. Lichtblau et al. 2015, p. 9; cf. Zillmann and Buxmann 2016, p. 41) Further education is therefore a crucial activity (Lichtblau et al. 2015; Berghaus et al. 2015). The distribution of tasks according to the individual's competencies also enables the company to make full use of the range of competencies available to it. The following table shows the corresponding items.

Variable	***Item in the questionnaire***
A2.3.1	All employees in the company have the opportunity to receive further training with regard to digital transformation.
A2.3.2	The distribution of tasks within the company is based on the competencies of the employees.

Dimension 3: IT infrastructure

Capability 3.1: Requirements-based framework conditions

The IT infrastructure provides the basis for networking and digital transformation in the technical sense. Corresponding framework conditions that do justice to the tasks are necessary. To be able to store and process large amounts of data is one such basic condition. IT security is also an important aspect that should be taken into account as networking increases. Standardized interfaces on systems offer simplified networking. (cf. Lüerßen 2017, p. 20; cf. Berghaus et al. 2015, p. 28) Items were defined for measurement, which are listed in the following table.

Variable	***Item in the questionnaire***
A3.1.1	The IT infrastructure used is capable of storing large amounts of data.
A3.1.2	The IT infrastructure used is capable of processing large amounts of data.
A3.1.3	IT security is constantly monitored and improved by designated responsible persons.
A3.1.4	IT systems have standardised interfaces.

Capability 3.2: End-to-end networking

Continuous networking is an important indicator of digital maturity. (cf. Lichtblau et al. 2015, p. 64) Especially the networking of devices and systems is interesting here, as it can be seen as a driver of change (cf. BMWi 2015, p. 2). Communication via IT systems to external partners is also a step towards process transparency and increased digitalization. (cf. Lichtblau et al. 2015, p. 39) This ability can be measured using the items in the following table.

Variable	***Item in the questionnaire***
A3.2.1	Our IT devices (laptop, beamer, ...) are all networked together.
A3.2.2	Our IT systems (ERP, MES, ...) are all networked and communicate with each other.
A3.2.3	Our IT systems are networked across company boundaries in the sup-ply chain (to the supplier, to the customer (BtoB), ...).

Capability 3.3: implementation of new technologies

Digital change is influenced by technological change. The use of new technologies is therefore the basis for keeping pace with change. (cf. Zillmann and Buxmann 2016, p. 33; cf. Lüerßen 2017, p. 19) Cloud solutions are currently a prominent digital technology. This is about outsourcing infrastructure, information systems or development platforms, which are then accessible as services on the Internet. (cf. Berghaus et al. 2016, p. 56; cf. Zillmann and Buxmann 2016, pp. 42-43) The regular updating and removal of old systems is part of the process of keeping up with technological change. (cf. Zill-mann and Buxmann 2016, p. 49) These aspects can be evaluated using the items defined in the following table.

Variable	***Item in the questionnaire***
A3.3.1	Cloud solutions are used in our company.
A3.3.2	Our systems are regularly updated to the latest digital technologies.
A3.3.3	Legacy systems were eliminated in our company.

Dimension 4: Data maturity level

Capability 4.1: Protected environment

Data and its protection is a sensitive issue and is becoming increasingly relevant with digital transformation (see Zillmann and Buxmann 2016, pp. 17-18; see Lüerßen 2017, p. 22). Data protection should be firmly regulated and internalised among staff. Employees responsible for data protection can be commissioned to monitor and update the data protection decisions. Access to the data should be specific to tasks, but should not be denied, as otherwise the usefulness of the data cannot be fully exploited (see ap-verlag 2016). The corresponding items are listed in the following table.

Variable	***Item in the questionnaire***
A4.1.1	Our company has defined rules that guarantee data protection.

A4.1.2	Employees are trained and instructed in the area of data and its use.
A4.1.3	Data protection officers have been appointed.
A4.1.4	Every employee has access to the data relevant to him/her.

Capability 4.2: Usefulness of data

The meaningful use of the collected data is the real motivation behind the collection itself. They must therefore be evaluated, analyzed and, if possible, visualized. The use of these analyses is helpful in making informed decisions. In addition, data can be used to improve the product and make it more innovative. (see Lichtblau et al. 2015, p. 45; see Zillmann and Buxmann 2016, P. 3) The following table presents the items for this capability.

Variable	***Item in the questionnaire***
A4.2.1	In our company the collected data is analysed and evaluated.
A4.2.2	The collected data are visualized for illustration.
A4.2.3	The analysis and/or the visualization of the data is carried out in order to improve products or make them more innovative.

Capability 4.3: Regular checks

A verification of the data is essential for a corresponding analysis. Therefore, regular checks on the relevance and completeness of the data are essential to avoid a flood of data. (cf. Lüerßen 2017, p. 11) A data strategy can formally describe the storage, collection and use of data (cf. Berghaus et al. 2015, p. 17; cf. Kubrick 2012). Reviewing and, if necessary, adjusting these allows the strategy to be kept up-to-date. These aspects are evaluated using the items in the following table.

Variable	***Item in the questionnaire***
A4.3.1	Collected data is regularly checked for relevance and completeness.
A4.3.2	A data strategy formally defines how data is collected, stored and used.
A4.3.3	The data strategy is regularly reviewed and adjusted if necessary.

Dimension 5: Processes and operations

Capability 5.1: Collecting information via data

Processes and operations run through the company from the product idea to the finished product. In this way there is important information that can be passed on to all the transit points in the form of data.

Collecting data on the product in the manufacturing process and, if necessary, on the machine can provide information for process optimization. Digital images help virtual planning and precise monitoring. (see Lichtblau et al. 2015, p. 13 & p. 45) The formulation of the items in the questionnaire is shown in the following table.

Variable	***Item in the questionnaire***
A5.1.1	In our company data is collected on the product during the manufacturing process.
A5.1.2	In our company data is collected on machines.
A5.1.3	The data is used to create digital images of the product and, if necessary, the machine.

Capability 5.2: Efficient operations

Eliminating manual processes and introducing them autonomously promises to reduce costs and save resources (cf. Zillmann and Buxmann 2016, p. 31). The corresponding items to be evaluated are shown in the following table.

Variable	***Item in the questionnaire***
A5.2.1	Manual operations were eliminated.
A5.2.2	The first autonomous processes were introduced.

Capability 5.3: Future-oriented processes

The processes of the companies should be able to withstand the demands of the future. This means that the processes should be easy to adapt to fluctuations. Support by IT systems helps to ensure that all stations of the process work with the same data. (see Berg- haus et al. 2015, p. 24 & p. 42) Internal and external processes should not show any media breaks (see Berghaus et al. 2015, p.24; see Lüerßen 2017, p.20). These occur when the medium is changed during the information transfer. Here is the danger that information is lost. (cf. Sipermann) Processes should be revised and adapted to new technologies or findings on a regular basis. Since the processes are optimally IT-supported, cooperation with IT in the optimization process is advantageous. (see Zillmann and Buxmann 2016, p. 48) The following table presents the aspects as measurable items.

Variable	***Item in the questionnaire***
A5.3.1	Our processes are agile and can be flexibly adapted to fluctuations.
A5.3.2	Our processes are supported and managed by IT systems (e.g. via an ERP system).
A5.3.3	Internal and external processes merge seamlessly and without so-called media breaks.

A5.3.4	Our processes are regularly revised and adapted.
A5.3.5	Our processes are optimized in cooperation with IT.

Dimension 6: Product (use phase)

Capability 6.1: Physical environment

In order to collect data during the use phase, the products must be equipped with appropriate technology (Lichtblau et al. 2015, p. 45). The following table shows the item for measuring this ability.

Variable	***Item in the questionnaire***
A6.1.1	Our products are equipped with information and communication technology (e.g. sensors) to collect data.

Capability 6.2: Information through data

Similar to processes and operations, data contains information that can be used for innovation and further development. These should be collected and forwarded via the product. Digital services, which offer customer-specific benefits based on data evaluation, are an important aspect of digital transformation. (cf. Licht- blau et al. 2015, p. 45) These aspects are measured via the items from the following table.

Variable	***Item in the questionnaire***
A6.2.1	Data are collected on the product during the use phase.
A6.2.2	Collected data will be forwarded via the product.
A6.2.3	Digital services are offered based on the data.

Capability 6.3: Customer focus

The attitude of the customer changes and the demands on products change as well. Meeting these is a challenge that can be met by interviewing the customers. This is possible quickly and conveniently via digital channels. Customized products and services are required and should be provided to meet customer needs. (cf. Lichtblau et al. 2015, pp. 45-47; cf. Zillmann and Buxmann 2016; cf. Berghaus et al. 2015, p. 8) The following table presents the corresponding items.

Variable	***Item in the questionnaire***
A6.3.1	Customers are questioned about products via digital channels.
A6.3.2	The demand for digitally compatible products on the customer side is growing.
A6.3.3	It is possible for us to offer customer-specific products and services.

2.3.3 Full questionnaire

Dimension		Capabilty		Vari-able	Item in the questionnaire
D1	Strategy and Leadership	C1.1	Relevance of the topic recognized	A1.1.1	Digitization is a relevant topic in our company
				A1.1.2	Our company is ready (if necessary) to develop and introduce new business models.
				A1.1.3	We are ready to invest in digitisation.
		C1.2	Involved manage-ment	A1.2.1	The management is training on the subject of digitization and new technologies.
				A1.2.2	The management pushes the topic of digitization in the company.
		C1.3	Digital strategy implemented	A1.3.1	There is a strategy and the objectives of digital transformation in the company.
				A1.3.2	This strategy is integrated in the corporate strategy.
				A1.3.3	The digital strategy is clearly communicated within the company.
				A1.3.4	The goals of the digital strategy are regularly reviewed using a key indicator system.
D2	Corporate culture and organisation	C2.1	Pushing forward attitude	A2.1.1	The company culture includes openness to new, digital technologies at all levels.
				A2.1.2	The corporate culture includes acceptance of new, digital technologies at all levels.
				A2.1.3	The employees see an opportunity in digitization.
		C2.2	Pushing forward structure and or-ganisation	A2.2.1	Responsibilities with regard to digital plans are clearly allocated.
				A2.2.2	employees are able to work on the move.
				A2.2.3	Employees can exchange and communicate via collaboration platforms.
				A2.2.4	The knowledge acquired by individual employees becomes accessible to everyone via digital channels.
				A2.2.5	Employees work together in interdisciplinary teams on projects.
				A2.2.6	Cooperation happens across company boundaries.
				A2.2.7	Possible risks that digitisation may entail are prevented (risk management).
		C2.3	Competent employees	A2.3.1	All employees in the company have the opportunity to receive further training with regard to digitisation.
				A2.3.2	The distribution of tasks within the company is based on the competencies of the employees.
D3	IT infrastruc-ture	C3.1		A3.1.1	The IT infrastructure used is capable of storing large amounts of data.
				A3.1.2	The IT infrastructure used is capable of processing large amounts of data.

			Requirements-based framework conditions	A3.1.3	IT security is constantly monitored and improved by those responsible.
				A3.1.4	Our systems have standardised interfaces.
		C3.2	End-to-end networking	A3.2.1	Our IT devices (laptop, beamer, ...) are all networked together.
				A3.2.2	Our IT systems (ERP, MES, ...) are all networked and communicate with each other.
				A3.2.3	Our IT systems are networked across company boundaries in the supply chain (to the supplier, to the customer (BtoB))
		C3.3	Use of new technologies	A3.3.1	Cloud solutions are used in our company.
				A3.3.2	Our systems are regularly updated to the latest digital technologies.
				A3.3.3	Legacy systems were eliminated in our company.
D4	Data maturity level	C4.1	Protected environment	A4.1.1	Our company has defined rules that guarantee data protection.
				A4.1.2	Employees are trained and instructed in the area of data and its use.
				A4.1.3	Data protection officers have been appointed.
				A4.1.4	Every employee has access to the data relevant to him/her.
		C4.2	Usefulness of the data	A4.2.1	In our company the collected data is analysed and evaluated.
				A4.2.2	The collected data are visualized for illustration.
				A4.2.3	The analysis and/or the visualization of the data is carried out
		C4.3	Regular checks	A4.3.1	Collected data is regularly checked for relevance and completeness.
				A4.3.2	A data strategy formally defines how data is collected, stored and used.
				A4.3.3	The data strategy is regularly reviewed and adjusted if necessary.
D5	Processes and operations	C5.1	Collecting information via data	A5.1.1	In our company data is collected on the product during the manufacturing process.
				A5.1.2	In our company data is collected on machines.
				A5.1.3	The data is used to create digital images of the product and, if necessary, the machine.
		C5.2	Efficient operations	A5.2.1	Manual operations were eliminated.
				A5.2.2	The first autonomous processes were introduced.
		C5.3	Future-oriented processes	A5.3.1	Our processes are agile and can be flexibly adapted to fluctuations.
				A5.3.2	Our processes are supported and managed by IT systems (e.g. via an ERP system).
				A5.3.3	Internal and external processes merge seamlessly and without so-called media breaks.

				A5.3.4	Our processes are regularly revised and adapted.
				A5.3.5	Our processes are optimized in cooperation with IT.
D6	Product (use phase)	C6.1	Physical environ-ment	A6.1.1	Our products are equipped with information and communication technology (e.g. sensors) to collect data.
		C6.2	Information through data	A6.2.1	Data are collected on the product during the use phase.
				A6.2.2	Collected data will be forwarded via the product.
				A6.2.3	Digital services are offered based on the data.
		C6.3	Customer focus	A6.3.1	Customers are questioned about products via digital channels.
				A6.3.2	The demand for digitally compatible products on the customer side is growing.
				A6.3.3	It is possible for us to offer customer-specific products and services.

2.3.4 Calculation of the degree of maturity

The calculation of the degree of maturity is similar to that of Zillmann and Buxmann (2016). The dimensions are weighted according to relevance and then the arithmetic mean $\bar{x}$ is calculated as follows:

$$\bar{x} := \frac{1}{n} \sum_{j-1}^{k} x_j \, n_j$$

2.3.5 Weighting

Weighting of the dimensions

In a survey to check the comprehensibility of the questionnaire, the two most important dimensions were asked, among others. The dimensions of corporate culture and organization as well as strategy and learning were considered most relevant. Although IT infrastructure is considered relevant, it does not appear to be one of the two most relevant dimensions. This statement was compared with the studies examined as well as with our own findings and assessments. The following results for weighting the dimensions result after the determination:

Dimension	Weighting
D1 Strategy and Leadership	30%
D2 Corporate culture and organization	30%
D3 IT infrastructure	20%
D4 Data maturity level	6,67%
D5 Processes and operations	6,67%
D6 Product (use phase)	6,67%

Weighting of skills

The key question for determining the skill weights is: What skill does an advanced level of the dimension convey? For example, in the dimension product (use phase) data collection is a capability. The use of data is another skill and builds on the data collection. Thus, the use of data represents the advanced level here. Accordingly, the rating here is more important. The results of the determination for weighting the skills are presented below.

	Capability	Weighting
D1	C1.1 Relevance of the topic recognized	16,67%
	C1.2 Involved management	33,33%
	C1.3 Digital strategy implemented	50%
D2	C2.1 Propelling attitude	16,67%
	C2.2 Driving structure and organization	66,67%
	C2.3 Competent employees	16,67%
D3	C3.1 Requirements-based framework conditions	16,67%
	C3.2 Continuous networking	50,00%
	C3.3 Use of new technologies	33,33%
D4	C4.1 Protected environment	16,67%
	C4.2 Usefulness of the data	66,67%
	C4.3 Periodic check	16,67%
D5	C5.1 Obtaining information about data	16,67%
	C5.2 Efficient operations	16,67%
	C5.3 Future-oriented processes	66,67%
D6	C6.1 Physical boundary condition	16,67%
	C6.2 Information through data	16,67%
	C6.3 Customer focus	66,67%

2.3.6 Calculation of the degree of maturity and presentation

The five-level Likert Scale used makes it possible to evaluate the activities quantitatively. Thus, if the answer is "yes", the score is 4 points, if the answer is "no" the score is 0 points. The distributed number of points per capability is multiplied by the corresponding weighting, then the arithmetic mean is calculated.

According to the maturity model, interim results are obtained for each capability and dimension until the overall maturity level is calculated. The dimensional results are the interesting point of the evaluation, as they can be used to identify further steps.

A network diagram is used for clarity and identification of fields of action. The following picutre shows this with exemplary data.

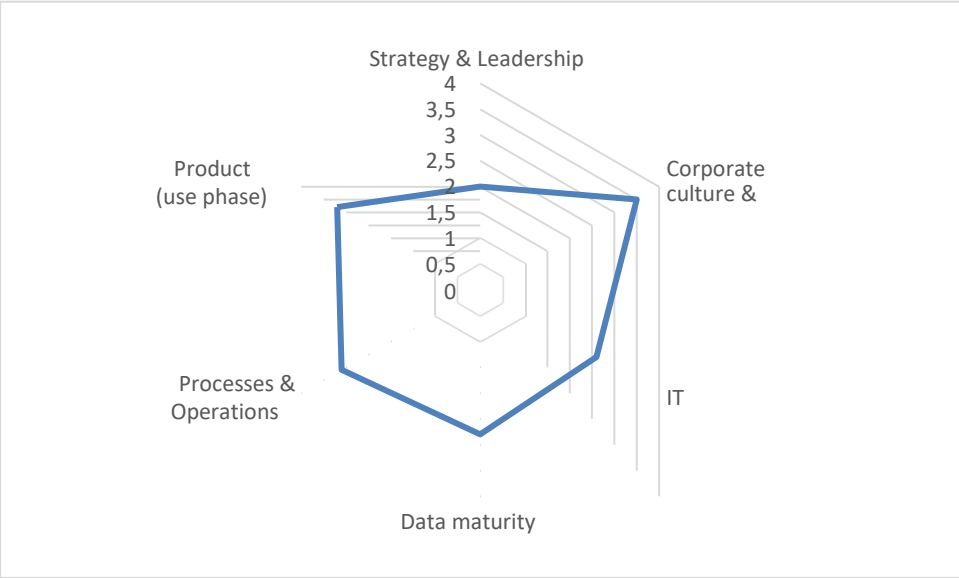

Figure 6: Representation of the digital maturity

This representation is useful, because it is possible to identify at a glance for which dimension there is a need for action. Here, for example, that would be strategy and leadership. On this basis, the capability results of the dimension can be used to identify the cause of the low value.

The overall degree of maturity allows the classification into different levels of maturity, which are based on the number of points achieved. The five generic levels of maturity (cf. Khan 2015, p. 23) are taken up and defined accordingly for digital maturity.

Due to the used Likert scale the maximum score is 4 points, the minimum score is 0 points. In the case of 5 levels, this means that 1 point would stand for a maturity level. The number of maturity levels is reduced in our model to three because of the quick change to the next one. The higher the level, the more advanced the digital transformation in the company. The following table shows the levels.

maturity level	*Description*	*Necessary score*
Level 1	First digital transformation measures introduced, but no fully developed procedural measure defined yet. Effects on companies and processes still small.	> 0 points

Level 2	Digital transformation measures are formally described and implemented.	> 2 points
Level 3	Quantitative targets and monitoring are established. Reflection and adaptation of Digital transformation measures.	> 3 points

If a company has a maturity level of 0, it is not assigned to any maturity level. It has not yet reached digital maturity.

3 USE IN CHAIN REACTIONS

Digital transformation is evolving fast and new maturity models will emerge. The one proposed by CHAIN REACTIONS has been designed with the aim to be applicable for SMEs and with a clear focus on providing input for the identification of innovation potential.

It can be used in practice in the form of an interview or a self-assessment online questionnaire.

Simplified version

The following simplified version of the questionnaire might be used in the case the maturity model is only used for the purpose of identified fields for improvement.

Dimension		Variable	Item in the questionnaire
D1	Strategy and Leadership	A1.1.1	Digitization is a relevant topic in our company
		A1.1.3	We are ready to invest in digitisation.
		A1.2.2	The management pushes the topic of digitization in the company.
		A1.3.1	In our company, there is a strategy that describes procedures and the objectives of digitisation in the company.
D2	Corporate culture and organisation	A2.1.1	The company culture includes openness to new, digital technologies at all levels.
		A2.2.2	Employees can work remotely.
		A2.3.1	All employees in the company have the opportunity to receive further training with regard to digitisation.
D3	IT infrastructure	A3.1.2	The IT infrastructure used is capable of processing large amounts of data.
		A3.1.3	IT security is constantly monitored and improved by those responsible.
		A3.2.2	Our IT systems (ERP, MES, ...) are all networked and communicate with each other.
		A3.2.3	Our IT systems are networked across company boundaries in the supply chain (to the supplier, to the customer (BtoB))
		A3.3.1	Cloud solutions are used in our company.

		A3.3.2	Our systems are regularly updated to the latest digital technologies.
D4	Data maturity level	A4.1.2	Employees are trained and instructed in the area of data and its use.
		A4.1.3	Data protection officers have been appointed.
		A4.2.1	In our company the collected data is analysed and evaluated.
		A4.3.2	A data strategy formally defines how data is collected, stored and used.
D5	Processes and operations	A5.1.1	In our company data is collected on the product during the manufacturing process.
		A5.2.2	The first autonomous processes were introduced.
		A5.3.1	Our processes are agile and can be flexibly adapted to fluctuations.
		A5.3.2	Our processes are supported and managed by IT systems (e.g. via an ERP system).
		A5.3.4	Our processes are regularly revised and adapted.
D6	Product (use phase)	A6.1.1	Our products are equipped with information and communication technology (e.g. sensors) to collect data.
		A6.3.1	Customers are questioned about products via digital channels.
		A6.3.3	It is possible for us to offer customer-specific products and services.

Adaptation to further innovation drivers

The structure of this maturity model, which focuses on the digital transformation, will be adapted to further innovation drivers within the next months. A similar structure along dimensions, capabilities and variables for the operationalisation of the model will be adopted.

BIBLIOGRAPHY

ap-verlag (2016): Data governance is needed to exploit the full added value of Business Intelligence. Available online at http://ap-ver- lag.de/es-braucht-data-governance-um-den-voll- Mehrwert-von-business-intelligence-auszuschoepfen/27490/, last reviewed on 11.09.2017

Azhari, Peyman; Faraby, Nilufar; Rossmann, Alexander; Steimel, Bernhard; Wichmann, Kai S. (2014): Digital Transformation Report 2014, published by neu- land GmbH & Co KG. Available online at http://www.wiwo.de/down- loads/10773004/1/dta_report_neu.pdf, last checked on 27.06.2017

Bach, Rafael (2017): Review of the questionnaire, 01.07.2017. E-mail to Franziska Blatz.

Bannick, Sonja (2011): Digital communication - which channels are currently available? Available online at http://on-operations.com/2011/02/06/digi- tale-kommunikation-welche-kanale-givethis-time/, last checked on 20.09.2017

BearingPoint GmbH (2015): Digital Maturity Assessment. Ed. v. Bearing- Point GmbH. Online available athttp://toolbox.bearing- point.com/ecomaXL/files/DI-15010_BEDE15_0993_FC_EN_Digital_Matu- rity_final-1.pdf?download=1, last checked on 27.06.2017.

Bendel, Oliver: Digital transformation. Available online at http://wirtschaftslexikon.gabler.de/Definition/Digital transformation.html, last checked 19.07.2017.

Bengsch, Danielle (2011): Welt.de. Ed. by welt.de. Available online at https://www.welt.de/print/die_welt/wissen/article12506319/2002-begann- das-Digitalzeitalter.html, last checked 19.07.2017.

Berghaus, Sabine; Back, Andrea; Kaltenrieder, Bramwell (2015): Digital Transformation Report 2015, ed. by /Crosswalk/ St. University of Gallen. On-line available at https://www.google.de/url?sa=tct=j=src=source=webd=1ad=rja&uact=8&ved=0ahUKEwibmeXNrd7UAh-VSI1AKHclGBSMQFgglMAA&url=https%3A%2F%2Fww.post.ch%2Fbos w%2F-%2Fmedia%2Fpost%2Fbosw%2Fdocuments%2F20150430_dtre- port2015.pdf%3Fla%3Dde&usg=AFQjCNGPyI-boy_o5DU4S5WaLHW4eOD_3Hw, last checked 27.06.2017.

Berghaus, Sabine; Back, Andrea; Kaltenrieder, Bramwell (2016): Digital Maturity & Transformation Report 2016, ed. by /Crosswalk/ St. University of Gallen. Available online at https://www.google.de/url?sa=tct=j=src=source=webd=1ed

=0ahUKEwidjoK7rN7UAhVMJ1AKHcCFBygQFggp- MAA&url=https%3A%2F%2Fwww.post.ch%2Fbosw%2F-%2Fme- dia%2Fpost%2Fbosw%2Fdocuments%2Fdigital-maturity-transformation-report-2016.pdf%3Fla%3Dde&usg=AFQjCNEO1tXicUe3X4K8DYQy- Nemd3Iry8w&cad=rja, last checked 27.06.2017.

Beyrau, Michael (17.05.2016): Convincing industry 4.0. Inter- view with Horst Maywald. online.

BMWi (2015): Intelligent Networking Strategy. Federal Ministry of Economics and Energy (BMWi). Available online at http://www.bmwi.de/Redaktion/DE/Publikationen/Digitale-Welt/Intelligente- Networking/Strategy Intelligent Networking.pdf? blob=publication- File&v=3, last checked on 2017-09-11.

Bulander, Rebecca (2008): Customer relationship management systems using mobile devices. Karlsruhe, University, Diss, 2008. Karlsruhe: University Press.

Bulander, Rebecca (2014): Lecture Statistics 1: Descriptive Statistics. Pforzheim University.

Bulander, Rebecca (2017): Data evaluation possible change in the survey, 13.09.2017. Telephone call to Franziska Blatz.

Cooper, Harris M. (1988): Organizing Knowledge Syntheses: A Texonomy of Literature Reviews.

Shaping the Digital Change. Available online at https://www.bmwi.de/Redaktion/DE/Dossier/digitalisierung.html, last checked on 19.07.2017.

Digital. Available online at http://www.itwissen.info/Digital-digital.html, last checked on 19.07.2017.

Duden: digital. Available online at http://www.duden.de/rechtschrei- bung/digital, last checked on 19.07.2017.

efficiency, effectiveness (2017). Available online at http://www.wirtschafts- lexikon24.com/d/effizienz-effektivitaet/effizienz-effektivitaet.htm, last checked on 20.07.2017.

Fehling, Christoph: Cloud computing. Available online at http://wirt- schaftslexikon.gabler.de/Definition/cloud-computing.html, last reviewed on 20.09.2017.

FPOV: The FPOV Digital Maturity Assessment. Ed. by FPOV. Available online at http://www.fpov.com/digitalmaturity/, last checked on 26.07.2017

Gill, Martin; VanBoskirk, Shar (2016): The Digital Maturity Model 4.0. Benchmarks: Digital Business Transformation Playbook. Unter Mitarbeit von Patti Freeman Evans, James Nail, Alexander Causey, Laura Glazer.

Edited by Forrester Research. Available online at https://forrester.nitro-di- gital.com/pdf/Forrester-s%20Digital%20Maturity%20Model%204.0.pdf, last checked on 27.06.2017.

Greven Medien (2017): Current study: Customer ratings are decisive for purchase decisions. Available online at http://www.pressepor- tal.de/pm/59864/3555972, last checked on 11.09.2017.

Hemmerich, W. A. (2015a-2017): Cronbach's Alpha: Evaluation and reporting. Available online at https://statistikguru.de/spss/reliabilitaetsana- lyse/auswerten-und-berichten-2.html, last reviewed on 11.09.2017

Hemmerich, W. A. (2015b-2017): Cronbach's Alpha: An Introduction. Available online at https://statistikguru.de/spss/reliabilitaetsanalyse/einleitung- 5.html, last checked on 11.09.2017.

Hess, Thomas(2016): Digital transformation. Available online at http://www.enzyklopaedie-der-wirtschaftsinformatik.de/lexikon/technolo- gien-methoden/Informatik- Grundlagen/digitalisation, last updated on 23.11.2016, last checked on 19.07.2017.

Horváth & Partners: Determine your digitalization maturity with the help of the Di- gital Maturity Assessment. Edited by Horváth & Partners. Available online under- ter https://www.horvath-partners.com/fileadmin/horvath-partners.com/as-sets/00_Allgemein/PDFs/english/160407_Digital_Maturity_Assess- ment_web_g.pdf, last checked on 27.06.2017.

ITML (2016): White paper. Internet of Things / Industry 4.0 in medium-sized businesses. Available online at http://es-wird-einfach.de/wp-content/uplo- ads/2016/08/Whitepaper_IoT.pdf, last checked on 09.09.2017.

itwissen.info (2012): Legacy system. Available online at http://www.it- wissen.info/Legacy-System-legacy-system.html, last checked on 20.09.2017

Jodlbauer, Herbert; Schagerl, Michael (2016): Maturity model industry

4.0 A process model for identifying industry 4.0 scenarios. ed.

v. Heinrich C. Mayr., Martin Pinzger: Informatik 2016, LNI, Gesellschaft für Informatik, Bonn 2016. available online at https://subs.emis.de/LNI/Pro- ceedings/Proceedings259/1473.pdf, last reviewed on 27.06.2017.

Kamps, Udo: Scale. Available online at http://wirtschaftslexikon.gab- ler.de/Definition/skala.html, last checked on 11.09.2017.

Khan, Alexander (2015): Innovation management in the energy industry. Dissertation. With the collaboration of Martin G. Möhrle (Research).

Klett, Jürgen: In four steps to the "Smart Factory". In: Digital Manufacturing 2016 (2/16), pp. 10-11. Available online at http://www.digital-manufac- turing-magazin.de/sites/default/files/magazine-pdf/dm_2016-02_archiv_re- duziert.pdf

Klodt, Henning: middle class. Available online at http://wirtschaftslexi- kon.gabler.de/Definition/mittelstand.html, last checked on 26.07.2017.

Köhler, Klaus (2017): IDS 1987: Start of Digital transformation Available online at https://media.zwp-online.info/archiv/pub/sim/dd/2017/dd0117/Edito- rial_3.pdf, last checked on 19.07.2017

Kropp, Rene (2014): The normal distribution assumption in the t-test. Available online at https://www.psystudents.org/die-normalverteilungsan- nahme-beim-t-test/, last checked on 13.09.2017.

Kubrick, Kelly (2012): Digital Maturity: the Data Strategy Dimension. Available online at http://www.onlineauthority.com/blog/data-strategy-dimen- sion/, last checked on 23.05.2017

Lackes, Richard: Internet of things. Available online at http://wirt-schaftslexikon.gabler.de/Definition/internet-der-dinge.html, last reviewed on 21.07.2017.

Leyendecker, Bert (30.05.2015): Digital transformation. Opportunity and challenge for medium-sized businesses. University of Koblenz.

Lichtblau, Karl; Stich, Volker; Bertenrath, Roman; Blum, Matthias; Bleider, Martin; Millack, Agnes et al. (2015): Industry 4.0 Readiness. Published by the Impulse Foundation of the VDMA. Aachen, cologne. Available online at http://www.im- puls-stiftung.de/studien, last reviewed on 27.06.2017

Lindenlauf, Frank (2017): Maturity origin, 25.04.2017. E-mail to Fran- ziska Blatz.

Ludwig-Mayerhofer, Wolfgang: Analysis of crosstabs. University of Sie- gen.

Luebbert, Dorthe (1999): 4. the limit value rates. 4.1 Main theorem of theoretical statistics: The central limit theorem. Available online at http://www.luebbert.net/statistik-tutorial/allgemeine-theorien/4.html, last checked on 13.09.2017

Lüerßen, Hartmut (2017): Digital Maturity in Medium-Sized Businesses 2017, published by Lünendonk & Hossenfelder GmbH, TÜV Rheinland. Available online at https://www.digitalisierung-gestalten.de/wp-content/uplo- ads/2017/06/T%C3%9CVRC_Reifegrad-Mittelstand.pdf, last checked on 26.07.2017.

Maier, Günter W.: Test quality criteria. Available online at http://wirt-schaftslexikon.gabler.de/Definition/testguetekriterien.html, last reviewed on 11.09.2017.

medistat (2016): rank correlation coefficient according to Spearman. Available online at https://www.medistat.de/glossar/korrelation-assoziation/rang- korrelationskoefficient-nach-spearman/, last reviewed on 19.09.2017

Moshagen, Morten (2017): Evaluation methods. 5. Missing data. University of Ulm.

Niklas, Cornelia (2002): More security in decisions with the benefit value analysis. Available online at http://community.easymind.info/page- 76.htm#3.%20Weighting factors%20Determine, last checked on 02.08.2017.

Peterson, Rober A. (1994): A Meta-analysis of Cronbach's Coefficient Al- pha. Online verfügbar unter https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjjq-iS7ZzWAhUBvhQKHV0oDqIQFg- guMAA&url=https%3A%2F%2Fwww.researchgate.net%2Ffile.PostFileLo-wire.html%3Fid%3D551a3a72cf57d7583b8b45f3%26asset-Key%3DAS%253A273747691409421%25401442277943673&usg=AFQjC

NGGfIYQOX37f4I7-cHf00x6iSXAJw, last inspection on 11.09.2017.

Radic, Marija; Maicher, Lutz; Dijk, Sandra; Große, Caroline; Ziessnitz, Maik; Behrendt, Erich et al. (2016): Zukunftschance Digitalisierung. A way- wise man. Edited by the Federal Ministry of Economics and Energy (BMWi). Available online under http://www.mittelstand-digital.de/MD/Redak- tion/DE/PDF/brochure-future-Digital transformation,property=pdf,be- reich=md,sprache=de,rwb=true.pdf, last checked on 07.07.2017.

Reiboth, Christian (2016): Grundlagen der Statisitk: Was sind Zusammen- konhan- tungsmaßße - und warum ist Korrelation nicht gleich Kausalit? available online at http://wissenschafts-thurm.de/grundlagen-der-statistik-korrela- tion-ist-nicht-kausalitaet/, last checked on 09.09.2017.

Saam, Marianne; Viete, Steffen; Schiel, Stefan (2016): Digital transformation in medium-sized businesses: Status quo, current developments and challenges. Research project on behalf of the KfW Banking Group. With the collaboration of Armando Häring, Jette Kellerhoff, Jörg Ohnemus, Lukas Trottner. Ed. by KfWZEW. Mannheim. Available online at https://www.kfw.de/PDF/Download-Center/Konzernthemen/Rese- arch/PDF-Documents-Studies-and-Materials/Digital transformation-in-Resource-stand.pdf, last reviewed on 19/07/2017.

Schweikl, Tobias (2017): Digitalisation: Data is the fuel of industry 4.0. Available online at http://www.logistra.de/news-nachrich- ten/nfz-fleet-lagerlogistik-intralogistik/8467/maerkte-amp-trends/digita- lisation-data-is-the-fuel-of-, last checked on 13.09.2017

Sipermann, Markus: Media break. Available online at http://wirtschafts-lexikon.gabler.de/Definition/medienbruch.html, last checked on 14.08.2017.

Sopra Steria Consulting (2016): Data as the fuel of Digital transformation. Banks in the area of conflict between cost pressure and the desire for individual Customer service. Available online at https://www.soprasteria.de/news- room/news/data-as-fuel-of-digitalization-banks-in-tension-field-of-cost-pressure-and-desires-of-individual-customer-consultation, last checked on 13.09.2017.

Spieß, Brigitte; Fabisch, Nicole (eds.) (2017): CSR and new working environments. Change of perspective in times of sustainability, Digital transformation and industry 4.0. Berlin, Heidelberg: Springer Gabler (Management Series Corporate Social Responsibility).

Statista (2017): Number of small and medium-sized enterprises* in Germany from 2004 to 2016 (in millions). Available online at https://de.sta- tista.com/statistics/data/study/321958/survey/number-of-small- and medium-sized enterprises-in-germany/, last reviewed on 28.08.2017.

Strategy & Transformation Consulting: Digital Maturity Assessment (DMA). Published by Strategy & Transformation Consulting. Available online at http://www.strategy-transformation.com/digital-maturity-assessment/, last checked on 27.06.2017.

Strobel, Christopher (2016): Totally networked. The Internet of things in the smart home. Available online at https://christopherstrobel.de/2016/03/29/das- internet-der-dinge-im-smart-home/, last checked on 09.09.2017

Wagner, Karl W.; Dürr, Walter (2008): Determining the degree of maturity according to ISO/IEC 15504 (SPiCE) /Karl W. Wagner; Walter Dürr. 1st ed. s.l. : Carl Hanser Fachbuchverlag.

What does digital mean? Definition, meaning. Available online at http://www.fremdwort.de/suchen/bedeutung/digital, last checked on 19.07.2017.

Wittpahl, Volker (ed.) (2017): Digital transformation. Education / Technology / Innovation. Berlin, Heidelberg: Springer Vieweg (iit-themed volume).

Zillmann, Mario; Buxmann, Peter (2016): Are you already digitizing? A benchmark for the digital agenda. Edited by Lünendonk GmbH, Lufthansa In- dustry Solutions. Online available at http://luenendonk-shop.de/out/pic- tures/0/lnendonk_studie_2016_digitaler_reifegrad_f160216_fl.pdf, last checked on 27.06.2017.