TOWARDS A FRAMEWORK FOR DIGITAL TRANSFORMATION SUCCESS IN MANUFACTURING

Research paper

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Abstract

Digital Transformation (DT) affects whole enterprises and is expected to drive a disruptive change in the way people work. Digital technologies leverage changes from simple tasks to the enterprise-wide strategy. Enterprises expect major benefits from investments in DT. However, digital transformation is a complex process and hence difficult to understand. Many different use scenarios exist so that decisions about the adoption of technologies are challenging. Therefore, it is critical to understand which benefits might be achieved with DT. With our research, we contribute to the understanding of digital transformation success. We develop and evaluate a framework that covers the main dimensions of digital transformation success. Literature from IS success and DT research is used to identify these dimensions. To evaluate this framework, we use data gained in a qualitative approach. We combine findings from a literature research with qualitative results to offer deeper insights into peoples' understanding of what shapes the success. The framework is useful to classify benefits achieved by DT and to point out new possibilities of gaining success with DT.

Keywords: Digital transformation, success, benefit, framework.

1 Introduction

Digital transformation (DT) is fundamentally changing the way we live and also the way we work (Brynjolfsson and McAfee 2014). Essential changes in the manufacturing industry are expected (Klötzer and Pflaum 2017). The process of digital transformation is triggered by digital technologies. DT is not about one single technology but the major changes are based on "combinations of information, computing, communication, and connectivity technologies" (Bharadwaj et al. 2013, p.471). The use of internet-based technologies will affect characteristics of products and services and the way how we produce them. Whole value chains are objects of restructuring (Matt et al. 2015; Haverkort and Zimmermann 2017). This change does not only include technological improvements but involves the whole business and therefore the strategy of companies (Kane et al. 2015). New ways of combining products and services (Kagermann et al. 2013) as well as new business models such as digital platforms emerge (Banker et al. 2011; Benlian et al. 2015). Even though DT is gaining more and more attention in research and practice, many firms still struggle to realize possible transformations (Hess et al. 2016). As DT affects people, processes, and products on all levels (Brynjolfsson and McAfee 2011), it implies more than just the application of technology. Enterprises expect major long-term gains in efficiency and productivity by applying DT (Schwab 2017). These gains are linked with high (financial) risks that arise (Matt et al. 2015). Given these opportunities for major business improvements, not all digital initiatives are expected to realize benefits for specific companies (Grover and Kohli 2013). DT is characterized by a high level of uncertainty. The process is gradual and makes the

DT success hard to comprehend. Therefore, it becomes critical for firms to gain the necessary competencies to evaluate alternative digital investments and to understand possible benefits of DT.

In information systems (IS) research the encoding of "what is IS success" plays an important role. If firms plan to invest in new IS or new ways of using IS, it is critical to know the benefits related to the technology use. Various models have been developed in this field (DeLone and McLean 1992, 2003; Gable et al. 2008). Many studies have highlighted different dimensions to describe and measure IS success of certain technologies (Seddon 1997; Herzog et al. 2015). IS success cannot only be expressed by its net value. Social, quality and service gains enable a successful use. This becomes especially important when the whole way of working and organizing changes. New technologies and different usage of existing technologies - as is the case for DT - result in a need for further research on IS success (DeLone and McLean 2016). First approaches investigating success in the context of specific technologies associated with DT can be found. These include big data (e.g., Martens et al. 2016; Günther et al. 2017), internet of things (e.g., Brous and Janssen 2015; Gupta and Gupta 2016), cyber-physical systems (e.g., Barbosa et al. 2017), cloud manufacturing (e.g., Wang et al. 2015) and many others. Due to the broad field of digital transformation, many independent research streams arise. This leads to a gap in understanding the interplay between technology and organization in the context of DT. A holistic view is needed to deepen the understanding of DT as a change in organizational systems. This can also help to decrease uncertainties in practice. To close this gap of understanding the nature of DT success, we develop a framework for digital transformation success. We aim to contribute to the clarification about: *What are relevant dimensions of digital transformation success?* These dimensions enable the understanding of DT success and provide a base to classify benefits achieved by DT. For this study, we chose a holistic view (Devaraj and Kohli 2003; Karimi and Walter 2015) to include different perspectives of staff, management, organization, environment, and technology together.

A two-step research approach is used. First, we studied general IS success literature to identify and suggest dimensions of a success framework in the field of DT. We took a closer look at specific research in the context of DT to enrich the characteristics of the dimensions. Subsequently, we used a qualitative research approach to evaluate the framework. The qualitative view enables in-depth information and is useful when working explorative (Vogelsang et al. 2013; Mayring 2014). While IS success is a widely studied topic, a special holistic view on DT can be regarded as rather new.

We conducted 30 interviews with experts in different manufacturing industries mainly in Germany. The high number of interviewees facilitates to follow different perspectives and leads to a broad view on the topic. Based on the findings from the qualitative analysis, we aim to identify benefits of DT in practice. Thus, we contribute to the research community by extending knowledge on IS success with a focus on DT. We examine the impact of IS use on processes and organizations in the field of DT. Furthermore, we contribute to practice by showing possible benefits realized by transforming business. The framework is useful to classify those benefits and to identify possible new areas where benefits could be achieved.

In the next chapter, we give a theoretical foundation for the paper with a brief review of IS success research. Findings in the context of DT are presented. Afterwards, we present the two-step research approach used for this study. The framework, which is based on the literature search, is presented in chapter 4. The results from this qualitative study are shown and used to evaluate the framework in chapter 5. In the end, our results are discussed, and limitations are shown.

2 Theoretical Foundation

As a basis to understand DT success, we firstly introduce research on IS success in general and the term digital transformation for the manufacturing industry. As success represents one of the most researched areas in IS fields, we will only give a brief overview of the term success. Moreover, two prominent models are introduced. Afterwards, we define DT in manufacturing for our research purpose in chapter 2.2.

2.1 Brief overview of IS success research

The successful use of any information technology (IT) solution is an immanent condition for today's practitioners and remains a top topic for researchers (Urbach et al. 2009; Petter et al. 2012; Schryen 2013). Although the interest on the topic is undisputed, there is a limited consensus about what IS success is. The understanding of the topic has developed over the last decades. While in research at first it was more understood as system use, success was identified as a multidimensional construct later which also includes individual perceptions about IS. In recent research the customer perspective is added and more views are expected to follow. However, the understanding of success in practice differs and is more oriented on company's benefits while lacking an individual view (Schryen 2013). A number of success models were developed in order to propose a definition for IS success including the kind of software and the purpose of use. "Unfortunately, in searching for an I/S success measure, rather than finding none, there are nearly as many measures as there are studies" (DeLone and McLean 1992, p.61). The multiple dimensions make it hard to define the construct. In research IS success is seen as user satisfaction to improve productivity (Bailey and Pearson 1983), individual and organizational impact (Goodhue 1995; DeLone and McLean 2003), net benefits or simply use (DeLone and McLean 2003). Moreover, the labelling of success differs between North American and European researchers (Petter et al. 2012). There is no clear definition of IS success. All attempts are stuck to the focus of the stakeholder (Urbach et al. 2009) and the system type (Seddon et al. 1999). To overcome this problem, Schryen et al. (2013) identified three main research tasks: the synthesis of existing knowledge, the identification of a lack of knowledge and the proposition of paths for closing the knowledge gaps. Many studies on IS success triggering the possible different dimensions were conducted. Theories derived from this research contain on the one hand determinants which are often explained as success factors (in the sense of "those few things that must go well to ensure success for a manager or an organization" (Boyton and Zmud 1984, p.17)). On the other hand, indicators are identified which can be interpreted as the benefits resulting from IS use (Steinhueser et al. 2015). This study aims at indicators of DT success.

Within the field of IS success research, the IS success model by DeLone and McLean (1992) is very dominant. It implies the underlying idea that benefits arise from using the system. The use of the system will be influenced by its quality and the quality of the information provided. This model unifies different aspects of IS success and classifies them by building major categories of mutual influence. The IS success model was successfully tested among practitioners by Rosemann and Vessey (2005) who call for more research to develop specific success models with a clear focus (e.g., on stakeholders). However, the model was also criticized. Researchers comment the interrelationships among the success dimensions (Ballantine et al. 1996; Seddon 1997). Due to the critique of the model, Gable et al. developed the IS-impact measurement model (Gable et al. 2008) to explain IS success. It includes four major dimensions: individual and organizational impact as well as system and information quality. This model offers validated constructs and measures, which rarely overlap. It is a valuable contribution for further research on IS success as it was developed concerning different perspectives on the system success.

2.2 Digital transformation in manufacturing

Digital transformation presents a new way of technology usage which makes the borders of enterprises blur (Lucke et al. 2008). The term is used as a keyword which includes a variety of components; no clear definition exists in research, yet. However, an explicit terminology of digital transformation is critical for research and practice (Morakanyane et al. 2017). In a large study of the MIT Sloan in cooperation with Capgemini DT is defined as "the use of new digital technologies (social media, mobile, analytics or embedded devices) to enable major business improvements (such as enhancing customer experience, streamlining operations or creating new business models)" (Fitzgerald et al. 2014, p.1). However, the technologies itself are not new (Jasperneite 2012). The innovation is about "combinations of information, computing, communication, and connectivity technologies" (Bharadwaj et al. 2013, p.471). This puts the strategy instead of the technology in focus (Kane et al. 2015). Other au-

thors regard digital transformation as a process. Morakanyane et al. analyzed recent research on the topic and concluded that digital transformation is “an evolutionary process that leverages digital capabilities and technologies to enable business models, operational processes and customer experiences to create value” (Morakanyane et al. 2017, p.11). Most definitions include value creation and changes in the way of doing business due to digital technologies. A final and accepted definition cannot be given at this stage. For our research approach, it is helpful to understand the term broadly, so that the view is not limited to single technologies or goals. Therefore, we define digital transformation as a *metamorphosis that is based on the intensive combination of present and future technologies that will change the paradigm of how value-generating processes in and between enterprises as well as with customers take place. DT will affect business models and corporate strategies*.

Basic innovations such as automation and the internet of things (IoT) make up the fundamentals of digital transformation. Especially the manufacturing industry gives room for improvements because of its innovations resulting in cyber-physical production systems (CPPS). IoT and CPPS are the basic tools for an intelligent cross-linking. Based on these technologies and provided with specific data-interfaces, machines or assembly tools are embedded in manufacturing and foster digital transformation. IoT was envisioned as a concept where any object could be tagged with a globally unique code and communicate over the internet characterized by comprehensive interconnection (Haller et al. 2009). It was postulated by Ashton (2009). Exchange of data is achieved by "seamless, ubiquitous sensing, data analytics and information representation with cloud computing as the unifying framework” (Gubbi et al. 2013, p.1647). In the context of digital transformation, CPPS can be understood as whole production plants or logistics components which are connected by the IoT (Roth 2016) with other systems such as ERP. The way of value generation is marked by an in-depth integration of customers and suppliers, due to enhanced digitalization. This forces traditional manufacturing processes to become “smart” or “intelligent”. Due to digital transformation, the modern (and future) production will take place in so-called "smart factories".

The technological realization of digital transformation has many different use scenarios. Therefore, technological solutions are mainly examined in specific context situations. In recent research, many articles from an engineering perspective on context-specific usage scenarios are discussed. However, the digital transformation includes more than technology implications. For example, the widespread use of digital technologies, the corresponding integration of processes and gathering of data leads to new organizational designs or changed business models. However, a technical view on the topic is still dominant. As DT impacts people on different levels, there is a need for research regarding the socio-technical implications and perception of digital transformation. This exploratory focus is beyond specific technologies taking the strategy and the organization of companies into account. This perspective merges the individual and the organizational needs on a higher level (Orlikowski 2000) to support the development of a common corporate strategy.

3 Method

We used multiple steps in our research approach to develop and evaluate a framework for digital transformation success. This included a literature review and a qualitative research design. At first, we developed a framework to explain dimensions of DT success. We deduced the dimensions from the relevant literature. This literature was used to perform a morphological analysis (Zwicky 1969) which is a creative technique to gain relevant characteristics of these dimensions. In the second step, the framework was evaluated following a qualitative research approach by conducting expert interviews. We chose a qualitative approach to work with cases from practice to base our findings on real transformation processes instead of theoretical assumptions. As "fast-changing phenomena are difficult to investigate solely through the use of traditionally privileged methods” (Sarker et al. 2013, p.iii), it seems appropriate to conduct a qualitative research in the context of DT. Though quantitative methods are still prevailing in IS research (Palvia et al. 2004; Sarker et al. 2013), qualitative research is of certain need (Markus and Lee 2000; Hirschheim 2007; Conboy et al. 2012). By choosing a qualitative method, we expect to examine complex interactions in the system of interaction between technologies,

organizations, and individuals involved (Dubé and Paré 2003; Palvia et al. 2004; Walsham 2006). We chose this approach to gain deep insights on a so far quite under-discovered topic. Success is a very complex phenomenon, especially in a dynamic environment such as digital transformation. The material from the interviews was coded twice. The whole research process is illustrated in Figure 1. Moreover, we present the two steps in more depth below.

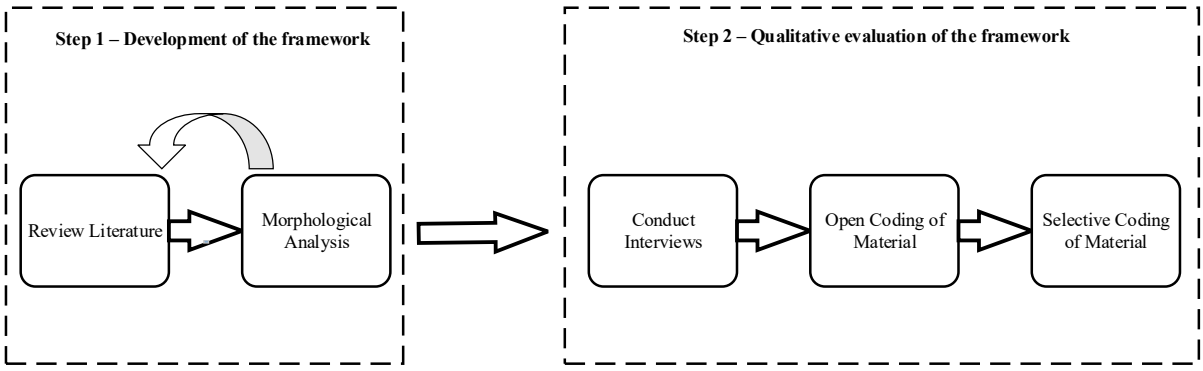

Figure 1. Research Process.

Step 1 – Development of the framework.

By conducting a literature search as the first step, we searched for literature identifying dimensions of DT success and possible characteristics of these dimensions. We searched in several databases (Levy and Ellis 2006) including Scopus, Web of Science, Google Scholar and the leading journals in the field of IS forming the senior scholar`s "basket" of eight. We aimed at articles dealing with IS success which have gained a lot of attention from the research community. The search terms “evaluation”, “success”, “performance”, “business value”, “benefits”, “impact” and “acceptance” have been used independently (with “OR” function). We used forward and backward search to identify more relevant literature. We also combined the above-mentioned terms with “digital transformation” and synonyms like “industrial internet”, “smart factory”, “smart manufacturing” and “Industry 4.0”. Furthermore, we added technology terms related to DT to identify further research streams. These were again all combined with the success associated terms. They are “smart factory”, “internet of things”, “cloud manufacturing” and “cyber-physical system”. After the keyword search a qualitative selection was made. Criteria for the choice of inclusion and exclusion of identified articles can be found in *Table 1*.

Include article if…	**But exclude article if…**
…success is the major topic.	…success is a minor topic.
…a related topic to operationalize success is explored (evaluation, measurement, performance, business value, benefits, impact, acceptance).	…value for operationalizing is missing / too generic and/or strategic level.
…potentially dimensions can be extracted from the article.	…characteristics of the dimensions are unclear.

Table 1. Criteria for qualitative selection of articles.

The findings were analyzed by the authors regarding their value to describe DT success. This was done by examining titles and abstracts. For the development of the framework, we used a morphological analysis. The authors collected the identified dimensions and discussed these jointly. The dimensions should be independent from each other and at the same time together define the success of DT from a holistic point of view. We iteratively worked on the development of the framework until no new ideas aroused during the discussion sessions. Finally, it was presented to another expert on the topic to get feedback before our evaluation took place.

Step 2 – Qualitative evaluation of the framework.

As a next step, the framework, developed on a theoretical basis, was evaluated by practical insights. We conducted 30 semi-structured interviews with experts from manufacturing companies which have already started their digital transformation process and are currently working on the topic. Few of these interviewees are consultants in this area. The interviewees were identified mainly by calls in social network groups dealing with DT. Interested conversation partners contacted us directly and received the project information and questions. So, the potential participants could in the first step evaluate themselves as possible interview partners. Afterwards, we received information about current projects in the companies. If the projects had significant impact on the value creation process of the firm, the interviews were conducted. The interviewees answered in free speech, without being biased by the framework. We asked the interviewees to describe the experienced transformation process in detail to ensure that DT specific changes have been undergone. The data were gathered between December 2016 and July 2017 in 18 companies. We spoke to managers, users of the technologies as well as consultants. We aimed to get a broad picture from different perspectives in different industries. For an overview of the interviewees see *Table 2*, where cases (C), interviewees (I), the position of the interviewee, the industry of the company as well as the focused topics regarding DT are presented. The group of vehicle manufacturers, especially in the automotive industry, was dominant. As these belong to the main driving industries for DT in manufacturing in Germany (Kagermann 2015), we assume to get interesting insights here. Nevertheless, we wanted to have variation by including other industries as the framework is not meant to describe success only in the automotive sector. Other firms from e.g., plastic, steel and glass industry were included. We used a semi-structured guideline to support the conversation with the interviewees (Bryman and Bell 2007). We structured the interviews into three major parts: *(1) introduction of the topic and a short presentation of the interviewee (in order to create a trustful atmosphere), (2) interviewees definition including major characteristics of DT (in order to develop a common understanding), (3) narrative description of DT success (including the major issues: What is DT success for you? How do you make sure that you receive benefits from your investments? What are the success factors for your transformation process?)*.

All interviews were recorded and transcribed. The interviews were conducted in German and afterward translated. The gained qualitative data delivered both: a broad approval of the dimensions and examples of benefits. Our analysis used concepts from the qualitative content analysis by Mayring (2014). To analyze the collected data, we coded the material twice. First, we carried out an open coding process by independently coding the material with the goal to identify statements about benefits due to DT. The results from all coders were used for further analysis and only excluded if this was the result of a common discussion. As a next step, we selectively coded the material for a further classification of the open codes. This technique has been proven as a useful method to receive well-based explanations of a complex phenomenon (Vogelsang et al. 2013). The characteristics of the dimensions from the framework were used as a basis for the coding procedure. The goal was to find appropriate examples for each characteristic if possible. The coding had to be executed in a loop process including: screening the material, independently assigning the characteristics and discussing these in meetings. Some explanations of the benefits are useful for some dimensions (depending on the details given by the interviewee). All authors were involved permanently in the process of data generation and analysis as well as an enduring deduction and discussion of characteristics (Corbin and Strauss 1990). The mixture of open and selective coding was very useful for our purpose to identify the characteristics step by step and to increase objectivity because of many discussions needed.

C	I	Position	Industry	Focus of DT
A	1	Head of R&D	Automotive	self-adaptive and autonomous-driving systems
B	2	Head of Production	Engineering	connection of facility components; hybrid products
	3	Head of Service		
C	4	Head of Production Intelligence	Manufacturing/ Good Industry	vertical integration by using advanced production systems
	5	Dep. Production Intelligence		
D	6	Team Leader Procurement	Automotive	multiple: connection of facility components, big data, digital process chain, CPS, IoT, HCI
	7	Dep. Project Management and Strategy of DT		
	8	Dep. Industrialization of Automation		
E	9	Chief Technical Officer	Manufacturing	horizontal integration
F	10	Dep. Process Optimization and Automation	Plastics Industry	vertical integration
	11	Computer Programmer		
	12	Shift Supervisor Injection Molding		
G	13	Technology & Innovation Center	Agriculture	hybrid products; online platforms
H	14	Head of Production	Manufacturing/ Good Industry	advanced production system
I	15	Chief Executive Officer	Steel Industry	online platform
J	16	Team Leader Electrical Engineering	Automotive	self-adapting systems and robot support
	17	Planning Car Body Construction		
K	18	Chief Executive Officer	Consulting	consultant in DT projects
L	19	CEO Assistant	Agriculture	hybrid products
	20	Chief Executive Officer		
	21	Dep. IT		
M	22	Head of Quality Management & Lean Management	Agriculture	vertical integration; online platform
N	23	Planning Automation	Automotive	multiple: connection of facility components, big data, self-adaptive robot support, CPS, IoT, HCI
	24	Dep. Digitalization		
	25	Head of Shopfloor IT		
	26	Dep. Digitalization		
O	27	Managing Director	Glass Industry	cloud manufacturing
P	28	Business Development Manager	Customer Care	chatbots
Q	29	Chief Executive Officer	Consulting	consultant in DT projects
R	30	Consultant	Consulting	consultant in DT projects

Table 2. Presentation of the Interviewees.

4 Development of the Framework

The framework has the goal to describe different dimensions of the benefits. Moreover, it implies characteristics of the dimensions. So that each benefit can at least be assigned to one characteristic per dimension. In this chapter, we will present the results of the literature review and use them to develop the framework. In chapter 4.1 we present research streams that were identified during the search process. These are all related to DT (as introduced in chapter 2.2) and help to understand success research approaches in this area. They are used as a base for chapter 4.2. There, we will define the levels which we identified as necessary to understand DT success. We try to unify the different aspects of digital transformation and connect them within the framework. The framework is useful to classify the benefits of DT.

4.1 Related research streams

Despite the large examined field of research, we were only able to identify limited contribution to DT success. We detected few articles specializing in single technologies to deepen our understanding of

success dimensions. We could not find articles dealing with DT success using a holistic view. However, we identified different research streams that are loosely connected to DT. In the following, we show some exemplary findings from the literature search.

A larger research field is big data research discussing the value of big data (Günther et al. 2017). Improvements can only be achieved when using fine-grained behavior data compared to traditional structured data (Martens et al. 2016). Successful examples from big data solutions in practice have been described (Tiefenbacher and Olbrich 2015; García-Muñoz and MacGregor 2016). Moreover, success factors for big data implementations have been studied and identified recently (Gao et al. 2015; Cato et al. 2016). Challenges and benefits are under study by various authors (O'Leary 2013; Raguseo 2018). These topics are also investigated for the technologies associated with DT like cloud manufacturing (Wang et al. 2015), internet of things (Brous and Janssen 2015a; Gupta and Gupta 2016) or cyber-physical systems (Barbosa et al. 2017). Moreover, contributions to different sectors can be found which include for example governments (Brous and Janssen 2015b), the health sector (Suraki and Jahanshahi 2013), and higher education (Yetis et al. 2016).

The research field regarding disruption and disruptive changes is close to the holistic view we aim at. Research in this field focusses on new or changed business models (Lucas and Goh 2009) which also leads to a discussion about the strategies that arise with the DT (Matt et al. 2015; Hess et al. 2016; Yeow et al. 2018). In many studies, the resource-based view is used as a lens to study DT (Barua et al. 2004; Zhu and Kraemer 2005; Dong et al. 2009). Building on this, many authors try to link the research field of dynamic capabilities (Karimi and Walter 2015; Yeow et al. 2018) to the field of DT. First approaches for the development of maturity or lifecycle models (Berghaus and Back 2016; Klötzer and Pflaum 2017) come up. They deliver valuable input for our research as they offer a broad view (about organizations, system, and environment) on the field of DT. Aligning digital technologies to enterprises is often linked to the discussions about social implications (Loebbecke and Picot 2015) and team collaboration (Boughzala and De Vreede 2015). Further gains for our research are approaches in the field of technical improvements aiming at use or adoption (Bardaki et al. 2011). Moreover, studies investigating relationships between DT and sustainability as one form of success were identified. Green IS initiatives impact organizational benefits (Loeser et al. 2017). Moreover, the performance level of ecological innovations is influenced by supporting IS (Hanelt et al. 2017).

In summary, we assume the digital transformation is not bound to one type of technology because it is based on a couple of digital improvements. The diversity of research streams reflects the complexity. A successful digital transformation includes more than just the application of one single technology at a certain department. Current research approaches fall short when they examine data structures (Bardaki et al. 2011), technologies and big data applications (Abbasi et al. 2016). A wider focus is needed (Lucas and Goh 2009). This also means that digital transformation cannot be compared to other IT implementations but is impacting the whole company and the environment (Morakanyane et al. 2017). There is recently no approach that covers this array to understand the success of this process.

4.2 DT success framework

The framework shows eight dimensions to represent the essence of where success in the regarded context can be achieved. The dimensions are taken from literature and provide none or just parsimonious overlapping. The framework builds up a triangle of different ways how to achieve success (value, skills, goal, integration and outcome), who is affected by the success (stakeholders) and what the major implications are (strategy, impact). Next, we will present the **dimensions** (bold font) identified with their corresponding *characteristics* (italic font).

Researchers claim that DT influences the digital **strategy** of enterprises (Bharadwaj et al. 2013). During the 21st century, the role of digital strategy shifted from a decentralized hierarchical functional structure to an IT-enabled global network structure (Nolan 2012). Concepts like big data (Constantiou and Kallinikos 2015) and a more competitive environment (Mithas et al. 2013) change the requirements for firms and thus their digital strategies. Moreover, the new role of customers also influences the strategic design (Woodard et al. 2013). Digital business strategies represent a key to make DT

initiatives a success (Bharadwaj et al. 2013). The strategic level needs to be clarified when analyzing benefits. DT is not only affecting one - the *operational* or *functional* - strategy but includes both (Matt et al. 2015). We describe the dimension of strategy with the two major characteristics. For example, products and processes are affected on the operational level and finance and IT on the functional (Venkatraman and Ramanujam 1986; Bharadwaj et al. 2013; Hess et al. 2016).

The **integration** of DT can be successful on a *horizontal* level, on a *vertical* level or for *end-to-end engineering* throughout all phases of a product life cycle (Kagermann et al. 2013; Stock and Seliger 2016). This means DT initiatives can help to improve the intelligent cross-linking between departments in a company and especially beyond company borders across the entire value creation network which is understood as horizontal integration. The cooperation with partners of the value chain network increases by the usage of digital technologies. This leads to an automated exchange of data. Moreover, DT can successfully improve the vertical integration. Vertical integration describes the digitalization of the manufacturing process regarding manufacturing cells, lines and factories.

Adoption research identifies important dimensions which describe “what is the level of analysis” (Seddon et al. 1999, p.5) from a research perspective. The adoption of technologies can be attained on different levels of **impact** and is a central aspect of success. Adoption is "a decision to make full use of an innovation as the best course of action available" (Rogers 2003, p.177). Adoption precedes the successful use (Zhu and Kraemer 2005). Several research streams deal with the processes that occur when new technologies (and innovations) enter the market. The adoption proceeds on different levels. The level of impact is related to *individuals* (Davis 1986)*, organizations* (Gable et al. 2008; DeLone and McLean 2016) and their *environment* (Tornatzky and Fleischer 1990).

We also integrated the **stakeholders** who benefit from DT into the framework. The role of stakeholders for a system's success was widely discussed among researchers (Seddon et al. 2002). Different target groups typically have multiple and sometimes conflicting objectives and priorities. They rarely agree on a set of common aims (Sedera et al. 2004). Different views on IS success from users, IS personnel, *management*, and internal audit exist (Hamilton and Chervany 1981). However, DT implies a broader impact of the technology which means that the stakeholders are not limited to an internal perspective. *Customers* and *suppliers* play a significant role in the success of DT and can therefore also benefit from these initiatives (Baird and Raghu 2015). The interaction with customers is strongly supported and enabled by digital platforms (Banker et al. 2011; Benlian et al. 2015; Ondrus et al. 2015). These platforms enable new chances in communication and business making. Other studies identified *employees* as winners due to improved working conditions (Kagermann et al. 2013; Evans et al. 2015). Benefits often relate to more than one stakeholder because of similar goals. For example, from the perspective of the management, it is also important to consider individual workplace improvements (Grover et al. 1996).

Success always goes hand in hand with **value**. In recent research, the value is considered from two different perspectives: value *creation* and value *appropriation* (Rai and Tang 2014; Hahn et al. 2016). This means DT can be considered as successful when a new value (e.g., for the end-user) is generated but also when existing value is ensured (Pagani 2013). Researchers appreciate further analysis of the role of the digital development regarding the sources of value creation (Bharadwaj et al. 2013). DT leads to the development of more digital products and services which use network-effects for the creation of value. Bharadwaj et al. (2013) define different sources of value creation enabled by the digitalization such as information, multisided business models, and coordinated business models. One example of benefits in the meaning of appropriation is the binding of customers (Teece 2010).

To be able to take advantage of digital transformation, the stakeholders need specific **skills**. As technologies are the basis to realize the transformation, one major aspect is *technology based* skills (Gebhardt et al. 2015; Klötzer and Pflaum 2017). However, communication with customers and about customer needs change. Consumers are getting more integrated into the value creation process (Baird and Raghu 2015; Lang et al. 2015). Therefore, *customer-based* skills need to be adapted. Lastly, products are becoming more complex, and companies produce more variants (Kagermann et al. 2013). It means that also *product based* skills are important for the success of DT.

Dimensions	*Characteristics*				
Strategy What is the major objective where success can be achieved?	Operational			Functional	
Integration What form of integration is supported?	Horizontal		End-to-End Engineering		Vertical
Impact Which adoption level does the benefit impact?	Environment		Organization		Individual
Stakeholder Who benefits?	Supplier	Customer	Management	Employee	others
Value What role does value play?	Creation			Appropriation	
Skills Which skills are needed to take advantage of DT?	Customer-Based		Product Based		Technology-Based
Goals What should be achieved?	Business Value	Performance	Use	Satisfaction	Sustainability
Outcome What is the impact?	Service Improvement		Hybrid		Product Improvement

Table 3. DT Success Framework.

The meaning of the essence of success is of great variance and so are the variables used to explain success (Schubert and Williams 2011). Different terms and perspectives from research exist. This means that success is expressed with different variables in research models (see chapter 2.1). These variables define a specific **goal** that people pursue. Ultimately, firms always want to increase their *business value* (Schryen 2010). Success is also examined as *performance* (Melville et al. 2004) or *use* of the technology (DeLone and McLean 1992, 2003). Moreover, DT can lead to a higher *satisfaction* of employees (Gable et al. 2008) and even be expressed as higher *sustainability* (Hanelt et al. 2017; Loeser et al. 2017).

The impacts of DT initiatives can be observed on different levels. One prominent topic and major **outcome** are *process improvements* which mainly describe an internal view. However, benefits can also occur across company borders because of DT (Schwab 2017). The challenge of DT leverages a rethinking of the existing dynamic capabilities (Karimi and Walter 2015). Technological innovations lead to further development of products. *Product improvements* are often achieved by selling connected devices like connected cars (Schoitsch 2016). Moreover, *service improvements* are becoming more important as these are used as a source of competitive advantage (Gebauer and Fleisch 2007). Decreasing product margins make it difficult to create competitive advantage from products. Thus, services are more and more in focus. These are often directly coupled to the product which leads to *hybrid* products (Frambach et al. 1997).

To sum the identified levels of DT success up, *Table 3* presents the morphological approach. Each dimension can answer questions on the success of digital transformation. The possible benefits can be classified in each dimension to at least one of the characteristics. This means that companies can also identify new areas where to gain a benefit. For example, if up to now the main goal was to improve vertical integration for a higher performance, they can now look for benefits by realizing horizontal integration. This could impact the management on the organizational level to create value. Moreover, customers could benefit and the company would need better customer-based skills to achieve the benefit. Maybe they invest in hybrid products and can thus increase their business value. So, the framework opens up multiple combinations of achieving success in companies. So, practitioners can orient them-

selves by testing at which dimension they already gain success and thus deduce other possibilities from the framework.

5 Qualitative Evaluation of the Framework

To evaluate the identified framework, we used a qualitative approach. This allowed us to get an in-depth view on the meaning of the characteristics. Practical examples can be identified which show where success can be achieved by DT. Based on the examples from our interviews, we found supporting evidence for almost all characteristics. These can all be used to describe and understand success according to DT. As all dimensions are relevant to describe the benefits and categorize these, the presented examples are not bound to one dimension. They could be assigned to each dimension. However, we use the examples to give evidence for the characteristics of the dimensions. We tried to select statements which best explain the confirmed dimension.

Strategy. There are two different ways in which the interviewees realize the strategic effect of DT. On the operational level the business model has to be adapted in order to change and enhance processes and products. "*We have to make strategic decisions, whether we aim on a new business model enabled by the tool. Can we use cloud- and consulting services to generate a new business? […] The market wants digital services; we have to improve our portfolio."* (B-01) On the functional level, the IT-strategy gets more and more in focus, as cloud solutions bridge the borders of the departments. *"Informatics is more dominant in our enterprise than ever."* (N-26) *"The IT department is no longer just administration, but they have to understand the processes and the products."* (K-21)

Impact and Stakeholder. The interviewees confirm benefits on all identified levels. Success can be achieved on a specific adoption level or for a stakeholder. The stakeholder can more or less be assigned to the level of impact. Suppliers and customers represent the most important stakeholders of the environment. Communications with these are radically changing due to DT (Schweer and Sahl 2017). *"By using partner collaborations, we enable the farmer to integrate partners, so that he can make better decisions and collect better data […]."* (G-13) DT leads to a higher integration of consumers in the value creation process (Baird and Raghu 2015). Benefits for employees are almost always on the individual level. The improvement of working conditions was mentioned in every interview. *"I think the system eases the work."* (L-21) *"[…] to enable him [the employee] to be better, faster and more efficient."* (D-07) One other major benefit can be achieved in ergonomics of working places (Maurice et al. 2017). *"The small robot executes the screwing which was performed by the worker before. These are "red" workplaces in the meaning of ergonomics."* (J-16) The stakeholder management can often be put on the same level as organization. For this level, positive structural changes are mentioned. *"One positive effect is that people have the courage to think something new. […] That you really think about the function of the […] enterprise."* (K-18) *"Positive impacts on the whole company culture and structure."* (I-15) Moreover, the managerial goal of cost savings is in focus. *"And this decreases the costs. This is an important driver."* (O-27) Digital transformation opens up possibilities of decentral structures (Stock and Seliger 2016). Due to the use of artificial intelligence, data processing improves and machines are able to self-adapt. *"Manufacturing robots know, aha, this construction part is coming late. That is why I will build this car before the other because it needs different equipment and not the missing part."* (N-26)

Value. The binding of customers and therefore appropriation of value is mentioned a few times in the interviews. *"In the long run it will be about customer binding or we will also be able to draw conclusions on our quality."* (F-10) *"We take action for customer loyalty which impacts the customer lifecycle."* (I-15) The customer loyalty and repurchasing rates can help to measure the customer binding. Furthermore, new value is generated by increasing the production of complex products *"We do this in order to produce complex products and different variants"* (C-04) and new product enhancements like additional services. "*The producer of machine tools, they understood. They aim on a permanent online linkage to our machines, yes, they offer predictive maintenance. However, they sell the machine, they also sell an additional digital use and furthermore the digital service."* (M-22)

Skills. To gain success from DT, a major success factor is skills that need to be developed or sharpened. *"What does digitalization mean for people in the future? How do we need to train our people?"* (D-07) As communication with customers changes, customer-based skills need to be developed further. *"[…] contact with customers. You cannot say it will be easier or it will be more difficult but it will definitely be different."* (P-28) Because the necessary conditions to drive DT forward are technologies, technology-based skills become even more important (Zhu and Kraemer 2005). These are mentioned in all interviews and the need for more education is highlighted. This includes to be able *"[…] to generate other knowledge, more knowledge, connected knowledge, new aspects and so on"* (K-18) and *"to manage software complexity and to manage network complexity."* (N-26) Moreover, DT leads to more complex products or even new products. *"Especially in the car manufacturing industry, the product is getting more complex."* (N-26) This means that also product-based skills need to develop. As additional service will be a consequence of DT, enterprises will need employees with higher skills and knowledge about the products. *"Any downtime is expensive. We offer predictive and preventive maintenance and offer the service even before the customer knows that the machine will stop. The customer will pay for it."* (M-22)

Integration. DT takes place on three levels of integration. First, collaborations regarding the whole value chain are becoming more important. The horizontal integration impacts the cooperation between these partners. *"I would say cooperation. This is where the firm has benefited."* (J-16) The working culture and thinking need to change. *"There is not THE customer, not THE supplier but everything is a big network. And this network needs to get intensified."* (K-18) Besides value chain networks, companies are internally working on a higher vertical integration. This means that production systems are linked with the other IS in use. The gathering of real-time data is enabled. *"Self-adapting, autonomous and rework-free factories of the future"* (N-25) arise. Interviewee O-27 describes a part of an end-to-end integration, starting from the order specification process at the customer, when individual products can be produced on the base of the data gained during the sales negotiations. "*You can even track the lifespan of a machine.*" (l-20) However, none of our interviewees directly described an end-to-end integration which might be due to their progress of DT.

Goals and Outcome. The benefits companies aim to achieve with DT can be classified with two of the identified dimensions. The most often mentioned outcome from DT in the interviews is process improvement. *"[…] understand the processes significantly better and see process errors."* (N-23) *"This would not be possible without the connection: you can report so many error messages from the process back. […] Not only the control process towards the actuator (what do I have to set up) but also the process of reporting back (why is it set up now)."* (J-16) This is consistent with the goal of a higher performance. *"All in all, we have a significantly higher availability of the production plant and the plants do not break down so often."* (J-16) The outcomes are measurable by shorter downtimes (E-09) or for instance less material consumption (H-14). Besides process improvements, the interviewees also mentioned product and service improvements (or hybrids) for their companies. "*We are very good at producing an improved product from the supplier to the service. It is getting better, faster, lighter, more attractive and the quality is better."* (M-22) Especially in the agricultural industry, the machines are improving processes significantly. *"I have harvested potatoes at this place. They are […] thick and five meter forward they are smaller. The [machine] shows that you have to put more fertilizer at this place."* (M-22) Moreover, with new possibilities of data analysis, new business models arise (Lucas and Goh 2009). *"If we sell the product, predictive maintenance and big data analysis can be performed."* (B-03) As one interviewee puts it: *"In the end, it is always about the return on investment that you generate by production and sales of your product."* (D-06) This opinion about the business value in focus is not surprisingly present in all interviews. However, the other three identified goals are less mentioned. Sustainability benefits are mentioned in very few interviews in the automotive and agricultural industries. *"This will have an impact on the environment. For example, the lighting system will only switch on if needed. […] So, I will not need as much power anymore." (*J-17) Besides this, the interviewees from the farming industry see basic advantages. "*It is better for the environment. With the technical possibilities from former times, we would not have the same performance. Precision farming would not be possible."* (G-13) Satisfaction needs to be considered in context with the ergo-

nomics` benefit mentioned before. Thus, only few statements were identified for this characteristic. *"People are more satisfied because they do not have to suffer such hard work."* (J-17) *"Costs, safety and job satisfaction are certainly the most important drivers."* (G-13) Finally, use was also mentioned only a few times although it plays a significant role, for example, in the famous IS success model by DeLone and McLean (1992, 2003). This could be due to the changing focus from a single technology to a network of connecting technologies. Moreover, the technologies are more and more fixed embedded parts of workplaces (Klötzer and Pflaum 2017). This makes the use inevitable and therefore less questionable. During the interviews the focal point was on making the use easier to gain organizational benefits. *"We try to design the technology self-explanatory. [...] So that we can reduce training costs." (*P-28)

6 Conclusion and Limitations

To understand success of digital transformation, we developed a framework and evaluated it by using a qualitative approach. The framework is useful to identify possible areas where benefits can be achieved and cluster these. It can help practitioners to get an overview at where and for whom benefits are attained or could be attained. Moreover, we contribute to IS success literature by broadening the view from single technologies to impacts on the whole organization.

The qualitative research approach enables us to get examples from practice and thus illustrate the framework. We did not aim at a quantitative evaluation but used the qualitative data to gain real-life examples of the characteristics and detect benefits that help to see and rate the success of DT. In total, we identified eight relevant dimensions for DT success. Almost all characteristics of the dimensions could be confirmed by the evaluation. Though, we could not explicitly describe an end-to-end integration based on our data. We assume that this high-end integration is still an exception of actual digital transformation. Most of our interviewees assessed their digital transformation status as still ongoing. The examples show a high linkage between the dimensions although they examine the DT success from different views. DT success will only occur when a digital strategy that follows realistic goals leads to an appropriate integration considering the impact. The success strategy should enclose stakeholder commitments, a reasonable value generation based on skills and upcoming outcomes. It was the aim of this study to show the dimensions of success. The deduction of key performance indicators should consequently follow in further research. This article can only give brief examples based on our data.

Nevertheless, the number of interviews limits the generalizability of our results. Therefore, we call for further research about DT success to better understand the changes which are happening in the industrial sectors. For example, we cannot verify the completeness of dimensions. There might be other important definitions and classifications of DT success which we did not identify during our literature search and morphological analysis. Moreover, most of the data were generated in German companies which limit the view. It could be promising to gain a further international view and test the dimensions. Even though our study shows examples of benefits in the evaluation part, we motivate other researchers to complement these results.

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