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Why Context Matters: Explaining the Digital Transformation of the Manufacturing Industry and the Role of the Industry's Characteristics in It

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Abstract

Background: *The digital transformation is an increasingly popular research topic. Unfortunately, it lacks a common and sustainable theoretical fundament. Further, it is unclear which role the characteristics of the affected industries, firms and markets play regarding the impact that the digital transformation has on them.*

Method: *Taking up these two challenges in a combined fashion for one of the economically most important, but also most specialized and physical global industries, we systematically review the latest literature on the digital transformation within the manufacturing context.*

Results: *This work is the first one that provides a valid theoretical basis on the digital transformation of the manufacturing industry. Thereby, it becomes clear that this basis is severely depending on its context. In particular, we show that the manufacturing industry is special in several dimensions, mainly due to its high physicality. Many of the connected technological concepts and domains are solely applicable within that particular environment. Also, our results indicate that a notable share of manufacturing firms did not experience any or at least not big impacts by the digital transformation on the business model level but indeed heavy impacts on the process level until now. However, for our initial suspicion that the structural differences between the manufacturing industry and other more hardware-independent industries are so far reaching as that they would even lead to definitional differences, no evidence was found.*

Conclusions: *This study contributes to the ongoing line of activities trying to streamline the extensive research around the digital transformation and thereby especially emphasizes the importance of context in that area of research.*

Keywords: Digital Transformation, Digitalization, Digitization, Manufacturing, Literature Review.

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Introduction

Research on the digital transformation has become very popular in recent years, leading to the emerging of numerous independent literature streams and a five-digit number of publications across almost all academic disciplines (Hausberg et al., 2019).

Unfortunately, this extensive and still growing body of literature lacks a common theoretical fundament, especially regarding the definition and differentiation of the three terms that are interchangeably used to address the same phenomenon, i.e. “digital transformation”, “digitalization” and “digitization” as well as the context they are supposed to cover. Such a situation bears various dangers for the scientific community as such and the information systems (IS) community in special, whose very own task should actually be to lead and objectify that discussion (Mertens et al., 2017). This unfortunate situation has therefore led to an extensive discussion among various highly rewarded members of that community within the last four years (Demlehner & Laumer, 2019; Legner et al., 2017; Mertens et al., 2017; Mertens & Wiener, 2018; Riedl et al., 2017; Vial, 2019). As we are firm supporters of the assumption that a strong theoretical fundament should stand right in the middle of every scientific undertaking, including at least reliable and specific definitions for its core terms as well as a clear contentual scope (Sparrowe & Mayer, 2011), we are fully convinced of the necessity and the value of that discussion.

Nevertheless, we do not per se agree with the generality implied in it at several points, as we believe that the digital transformation touches every societal entity and economic sector in a different way – sometimes more, sometimes less different. More precisely spoken, the digital transformation undoubtedly has the potential to substantially reshape several quite fast-moving and hardware-independent industries together with the respective firms’ business models, as already seen e.g. in the music industry through streaming (Trefzger et al., 2015) or the banking industry through FinTechs (Eickhoff et al., 2017). But we strongly doubt whether the same can be said for almost purely “physical” companies and markets, i.e. the manufacturing sector (Müller et al., 2018).

This suspicion is backed up by previous studies (Arnold et al., 2016; Müller et al., 2018; Veit et al., 2014), one of which perfectly exemplifies the peculiarity of that sector. Within one of the interviews Müller et al. (2018) conducted with managers of manufacturing companies, they were confronted with the cost-benefit calculation of the firm at hand. Thereby, the interviewed manager stated that digitalizing his company’s 180 machines would account for hardware costs of around 360,000€, after already having invested an enormous amount of money for purchasing them in the first place. This investment would then solely technically enable the firm to monitor its machines in real-time, while for the data analysis itself further running costs would accrue. For him, it seems questionable if that feature would allow the company to raise its prices at all. Undoubtedly, however, is that their “customers’ willingness to pay does not proportionally increase”, which is why such things in that environment in the best case are regarded as “costly in the short-term, whereas its expected benefits require time to unfold” (Müller et al., 2018, p. 5).

This is not a special situation at one particular firm but instead founded in the structure of the manufacturing industry overall. According to the latest International Standard Industrial Classification of All Economic Activities (ISIC), the manufacturing industry “includes the physical or chemical transformation of materials, substances, or components into new products [...]. The materials, substances, or components transformed are raw materials [...]. Units engaged in manufacturing are often described as plants, factories or mills and characteristically use power-driven machines and materials-handling equipment.” (United Nations, 2008, p. 85). As already indicated by the last sentence, the marketable value created by firms in that environment strongly depends on their highly advanced heavy machinery and production facilities, i.e. very expensive and long-lasting assets (Schmitz et al., 2019). The

resulting very high share of fixed costs leaves manufacturing companies little alternative but to scale their production to the maximum to make the most out of their equipment, resulting in the mass production of per se exclusively physical products (Fiedler, 2012). Also, due to the long-lasting nature of these main assets and their long amortization times, business models in that industry tend to be of very long-lasting nature, too, leaving little financial room for adaptations after once the required hardware is set up (Demlehner & Laumer, 2020). Regardless of the fact that in recent years many firms from that industry have sought to get more independent from their machinery's utilization rates by offering additional services (Lerch & Gotsch, 2015), this hardware-focused market characteristics still play a very dominant role in that business, unlike as in many other industries (Veit et al., 2014).

Therefore, logically speaking, questions arise whether the results and insights from studies that are either without focus on a specific industry (and consequently oversee or underweight such decisive peculiarities) or located in an industry with significantly different characteristics can be transferred to the manufacturing sector without further ado. In addition, although the manufacturing sector contributes the largest part of the value added in most of the developed countries across the world (OECD, 2015), it is so far clearly underrepresented within the research on the digital transformation, as the citation network analysis of Hausberg et al. (2019) shows.

In consequence, within this study we limit ourselves exclusively to the manufacturing industry and seek to provide a thorough theoretical fundament on the digital transformation of exactly that industrial sector with all its aforementioned features and peculiarities. Therewith, we contribute to the ongoing discussion within the IS community¹, but due to the deep vertical dive performed with a very different approach than in the past. We do so along the following three research questions:

R1: How are the terms “digital transformation”, “digitalization” and “digitization” defined in the existing literature on the digital transformation in the manufacturing sector? And how should they be defined in the future to prevent further fragmentation of the respective research landscape?

R2: What technological concepts and domains are subsumed under those terms in the manufacturing context?

R3: What impact does the digital transformation have on the business models of companies in the manufacturing industry?

Looking at the five-digit number of existing digital transformation-related publications (Hausberg et al., 2019), we are convinced that already enough primary data exists within those to thoroughly answer these questions. We therefore regard a systematic literature review as the ideal methodological approach. After outlining the necessary theoretical elements for our endeavor in Section 2, we explain this reviewing approach in further detail in Section 3. After that, each research question is dedicated a different section, before we move over to a combined discussion of our results in Section 7 and some concluding remarks in Section 8.

¹ A prior version of this paper as been presented at and published in the proceedings of the 25th Americas Conference on Information Systems (AMCIS) 2019.

Theoretical Background

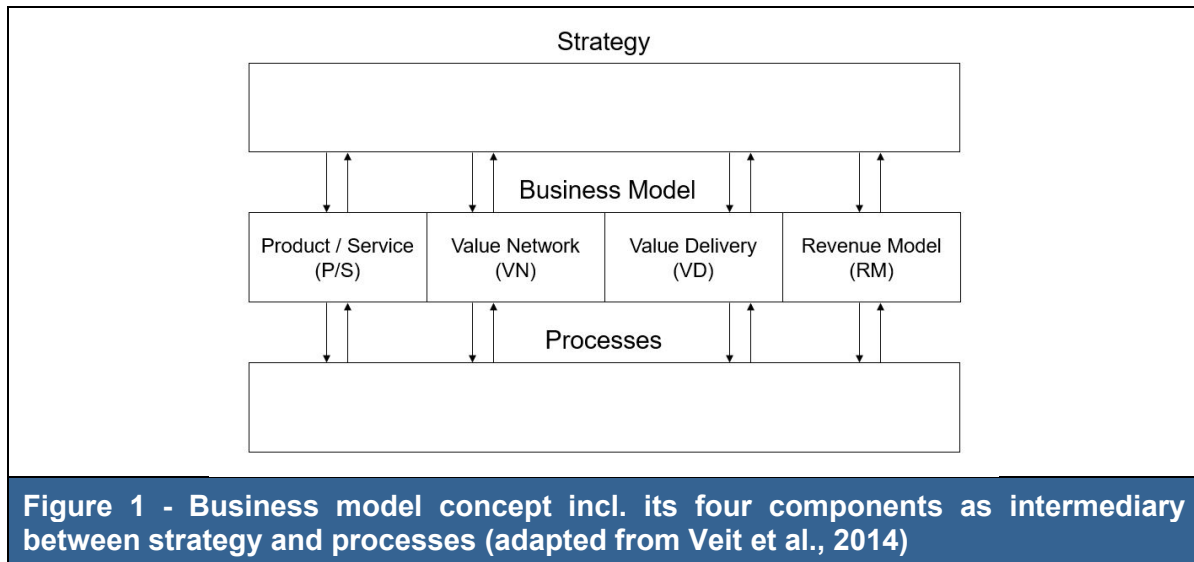
Unlike as in most studies, the theoretical background of the phenomenon that stands at the core of interest (here: the digital transformation) does not impose a necessary prerequisite for understanding the remainder of the paper (Maier et al., 2020; Stetten et al., 2008). Instead, such a common understanding is the explicit aim of our study. In consequence, we consciously refrain from presenting any theoretical background on the digital transformation going beyond what we already have mentioned in the introduction, but instead would like to refer the readers of this paper to later sections for this. Nevertheless, as we intend to answer our third research question by relying on the business model concept, we do see the necessity to provide theoretical background on that particular concept.

Its use is, on the one side, in line with previous works with similar goals (Arnold et al., 2016; Müller et al., 2018; Veit et al., 2014) and, on the other side, well justified by the wording that science and practice have chosen in their publications in the past. Within those, it is not uncommon to declare the digital transformation as a paradigm shift in the way how business is conducted, including fundamental changes of existing and the creation of completely new business models (Mertens et al., 2017; Mocker & Fonstad, 2017). Reminding oneself of the huge impact that various digital innovations had in one's personal life in the last years, it is not surprising that a lot of companies or market sectors are significantly reshaped. The radical change of the music industry through streaming (Trefzger et al., 2015), for instance, is just one example. Nevertheless, questions arise whether the same can be said for almost purely "physical" companies and markets, i.e. firms from the manufacturing sector. The peculiarities of that industry, as elaborated within the introduction, set the threshold for significant business model changes quite high (Bilgeri & Wortmann, 2017; Müller et al., 2018; Piccinini et al., 2015), which leads to the assumption that most digital transformation-induced impacts might come to effect rather on a process level than on a business model level. Recent review works in the field of business model research support this assumption as they stress the importance of physicality in that field (Veit et al., 2014).

Overall, business model research is gaining land within the IS research community (Hedman & Kalling, 2003; Ojala, 2016; Veit et al., 2014) as well as in adjacent research areas (Arnold et al., 2016; Massa et al., 2017; Müller et al., 2018) in recent years. Plainly speaking, one can refer to business models as "stories that explain how enterprises work" (Margretta, 2002). As this proposition tends to be too little to base research on it, many different interpretations exist addressing the questions on how to exactly define or graphically represent the business model concept. There has already been done a lot of work on those questions (Osterwalder et al., 2005; Veit et al., 2014), including various extensive reviews (Massa et al., 2017; Zott, Amit, & Massa, 2011). This is why we want to leave the details of that debate aside and conclude that, by now, a sustainable fundament of research and consensus is available, on which one can base his or her argumentation (Massa et al., 2017; Ojala, 2016; Veit et al., 2014).

When it comes to defining the business model concept, Ojala (2016) reduces the rather extensive frameworks published by Osterwalder and Pigneur (2010) to four main components, which incorporate the perfect basis to build our research on: the product/service (P/S), the value network (VN), the value delivery (VD) and the revenue model (RM). The first component refers to the question how the sold product or service creates value for customers and partners included in the model and how these products and services are interconnected with each other and other products in the market. The VN covers the key actors, such as partners and customers. The way, how value is delivered to these key actors, is outlined by the third component (VD). Therefore, a business model should always describe how a firm gets in touch with its customers and how value is delivered to the firm's partners. Last but not least, the RM describes how a firm makes money, i.e. how it generates financial revenue from delivering its products and services.

Switching over to the placement of the concept within the business environment, Veit et al. (2014) understand the business model as an intermediary between the firm's strategy and processes, along with various other IS researchers (Di Valentin et al., 2012; Morris et al., 2005). We adopt that view for our research. Bringing definition and placement together, Figure 1 thus presents or definitory framework for this paper.



Methodology

From a methodological point of view, we followed the approach of Webster and Watson (2002) for our systematic literature review. It incorporates the most suitable search strategy for theory-based reviews like this one and therefore is the most commonly used approach for that type of studies (Paré et al., 2015).

It consists of three steps. In the first step, one starts with identifying relevant publications through a database search. Afterwards, this preliminary list of works is extended by two further steps, an additional backward search and eventually a forward search. Searching backward means that the citations and reference lists of the identified publications are screened to recognize further relevant sources which were not covered by the database search. In a forward search one uses a web-based database to identify publications citing the key articles found in the previous steps and include them, too, if necessary (Webster & Watson, 2002).

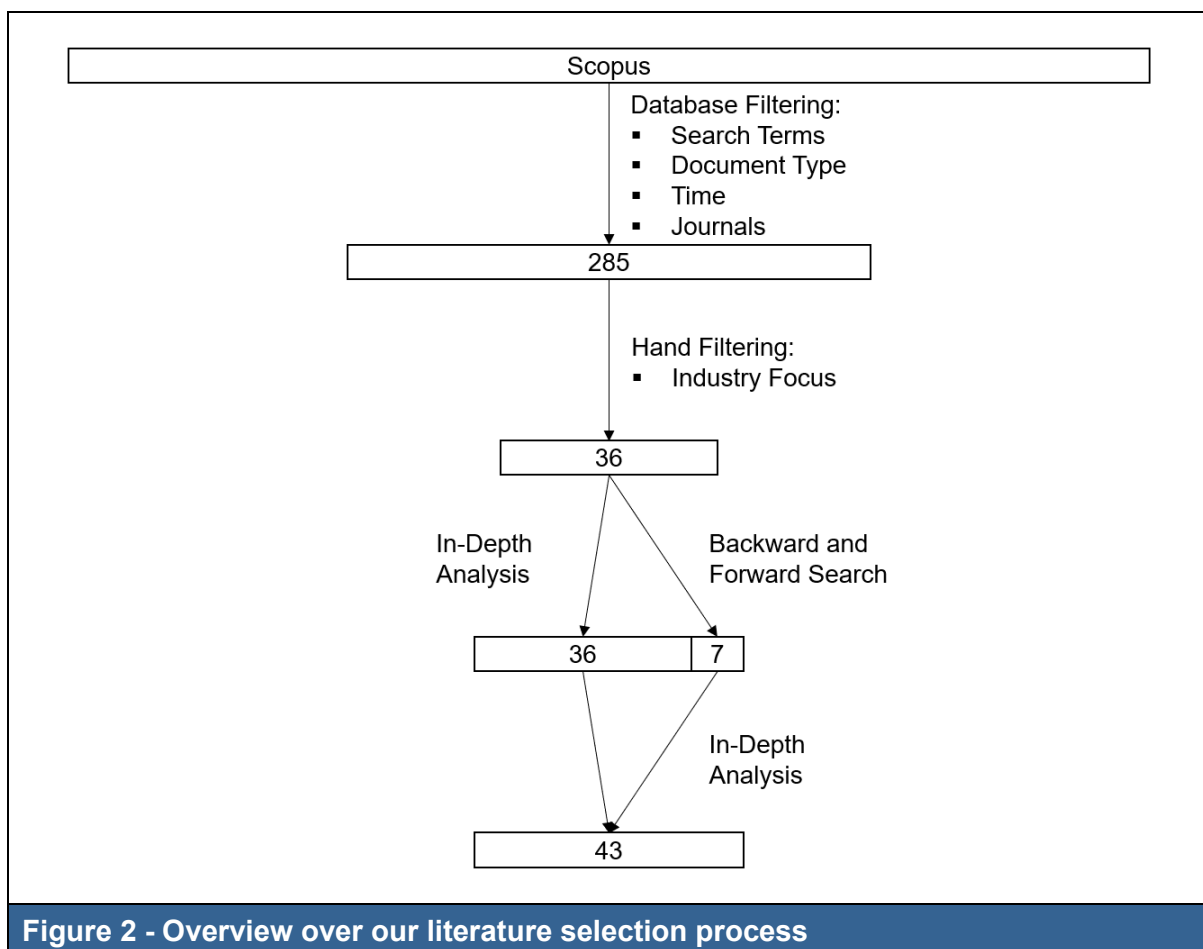
As they have typically been peer-reviewed before publication, journal articles and conference proceedings are commonly regarded as the two scientific formats which ensure the highest level of content quality. Therefore, many authors suggest to limit scientific literature reviews solely to these two types of publications (vom Brocke et al., 2009; Webster & Watson, 2002). Given the aim of our study to provide a valid theoretical basis for future research endeavors on the digital transformation in the manufacturing sector, we followed this suggestion.

We used Scopus as the only database for our screening. Scopus is the world's largest abstract and citation database, which means that it does not host the research articles itself but lists the publicly available parts like authors, title, abstracts, key words and publication data. It is therefore not primarily intended to give access to research papers (as most scientific databases are, e.g. ABI/Inform or ScienceDirect) but to provide an exhaustive overview over what has been published in almost all scientific fields, including medicine, social sciences, engineering, business, economics and several more. With specific regard to IS research, it covers a very wide spectrum of journals and conferences, including the complete Senior

Scholars' Basket of Journals, the whole ranking published by Lowry et al. (2004) and 302 of 312 sources that are ranked as A+, A or B in the VHB Jourqual 3 Ranking. This makes Scopus the ideal tool for comprehensive literature reviews not just for IS but for all social and technological research areas and reduces the risk of individual mistakes while comparing and mapping data sets from different databases.

We used the terms “digital transformation”, “digitalization”, “digitization”, “digitalisation” and “digitisation” for our search query. We connected them with the “OR” operator and limit the search to the titles, abstracts and keywords of the respective articles. To ensure the currentness of our results on a topic that is heavily influenced by the fast changes in modern days' technology (Mertens and Wiener 2018), our analysis is limited to articles that have been published between January 2014 and the end of June 2019, when we ended our data collection.

That search query resulted in over 9,000 results. Therefore, it was inevitable to integrate a further filtering step to ensure an appropriate level of content quality (vom Brocke et al. 2009). As not only the IS community is increasingly engaging in research on the digital transformation, we did not want to limit ourselves strictly to IS journals and conferences. This eliminated the already mentioned IS-only options of the Senior Scholars' Basket of Journals or the ranking published by Lowry et al. (2004). Instead, we limited it to journals and conference proceedings that are ranked as A+, A or B in the more widely spread VHB Jourqual 3 Ranking. This means that 302 renowned international scholarly journals or conference proceedings in the fields of business, economics, engineering, information technology (IT) and IS served as potential sources for our review.



The resulting search query lead to a list of 285 scientific publications which match the chosen requirements. As we limited our research to the manufacturing sector, we then had to manually identify all articles that lack a connection to that industry. Due to the broad search approach, many of them deal with topics in the healthcare and retail sector or with social, legal or other implications. These were excluded which leads to a list of 36 publications that were then analyzed in depth. Searching backward and forward with the same requirements regarding document type, publication time and journals revealed another seven publications. After all, we rely on 43 works dealing with various questions around the digital transformation in manufacturing (and occasionally other industries in addition). Figure 2 sums up our literature selection at one glance.

Defining the Digital Transformation of the Manufacturing Industry

Seeking to answer our first research question (R1), we took a closer look at these publications from a literal point of view. Five out of the 43 articles stick solely to the term digitization, nine to digitalization and four to digital transformation. 18 works use two of these terms as equivalents and leave out the third. Six other publications use all three terms as synonyms. The work of Arnold et al. (2016), which was found in the backward search, does not use any of these terms but “digital” in various constellations. Ultimately, they contentwise all address the same phenomenon.

Thereby, only one article pays regard to this lack of wording precision. Mocker and Fonstad (2017) do this by including a second sentence into their defining footnote saying “We refer to digitisation to mean the application of digital technologies to transform how business is being conducted. We do not distinguish it from the term digitalisation.” In the other works, not a single word about this vagueness can be found.

When it comes to defining these terms, few of the revised publications render real assistance. In only nine out of 43 an explicit definition can be found (Coreynen et al. 2017; Denner et al. 2018; Echterfeld & Gausmeier, 2018; Heavin & Power, 2018; Lenka et al. 2017; Loebbecke & Picot, 2015; Mocker & Fonstad, 2017; Nwankpa & Roumani, 2016; Piccinini et al. 2015). These nine are collected in Table 1. All together, they are far away from homogeneity, reaching from the very vague statements by Piccinini et al. (2015) (“advancements in digital technology are reshaping a wide range of activities in society at large, which we may refer to in short as digital transformation”) and Loebbecke & Picot (2015) (“changes of established patterns [...] in our economy and society”) to the highly specific definition of Nwankpa & Roumani (2016). They explain the digital transformation as an “organizational shift to big data, analytics, cloud, mobile and social media platforms.” The other six definitions lie somewhere in between.

After all, it is impossible to quickly synthesize a universal version from the explicit definitions by just referring to these statements as they can be found in Table 1. This can only be done by looking deeper into the content and searching for implicit definitions. A common element in all articles is that the practice of taking something that used to be physical or analog and transforming it to be primarily digital makes up the core of the digital transformation (or digitization/digitalization process, respectively). Obviously, differences exist regarding the question which “somethings” can be counted as inductive for this process and which cannot. This becomes particularly clear when the statements of Nwankpa & Roumani (2016) and Piccinini et al. (2015) are compared.

Considering that, three different main views on how far the process reaches can be identified, two of which seem to be primarily relevant for today’s researchers and practitioners. The remaining one is the technical definition which is stressed by Loebbecke & Picot (2015) (and heavily supported by Legner et al. (2017) within the current debate). They limit “digitization” in

its “originally (...) technical sense” to the conversion of analog to digital signals in order to decouple information from physical carriers and simplify its transmission. However, as they focus on digital transformation-induced changes of societal and economic patterns rather than their underlying technological foundations, they do not use it as a stand-alone definition for their research paper. They rather mention it to draw a comprehensive picture of the whole subject area including its origins. They therefore start to refer to the term “digital transformation” as soon as they move away from the analog-binary-conversion to the societal and economic impacts in the further course of their work. In the other 42 works the technical definition is not mentioned at all.

Between the two remaining approaches, setting clear boundaries is more difficult. They differ about the question whether the digital transformation leads to changes in the business model of the respective company or not. In 32 of the 43 revised publications the digital transformation is understood as a holistic phenomenon, reaching from modifications in production processes over shifts in the way people and/or machines collaborate to extensive changes in the business models of the affected companies. On the other side, there is not a single word about business model implications in the remaining twelve articles which rather focus on the increased level of automation and interoperability enabled by various digital innovations.

Table 1 - Explicit definitions addressing the digital transformation phenomenon

Source	Definition
Coreynen et al., 2017	“Digitization refers to the increasing use of digital technologies for connecting people, systems, companies, products and services.”
Denner et al., 2018	“As the impact of digitalization is boosted by the fast emergence of digital technologies (Mattern et al. 2012), digitalization can be defined as the adoption of digital technologies to improve or disrupt business models, business processes as well as products and services (Gartner 2016).”
Echterfeld & Gausmeier, 2018	“Digitisation is basically a broad and multifaceted term that drives innovations in manifold ways [...].”
Heavin & Power, 2018	“Digital transformation is defined as ‘the use of technology to radically improve performance or reach of enterprises’ (Westerman et al., 2014). Westerman et al. (2014) note that ‘executives are digitally transforming three key areas of their enterprises: customer experience, operational processes and business models’.”
Lenka et al., 2017	“The industrial management literature defines the digitalization of manufacturing as the phenomenon of intelligent connected machines that information and digital technologies power (Lerch & Gotsch, 2015; Parida et al., 2015).”
Loebbecke & Picot, 2015	“Digitization originally describes the conversion of analog to digital information and processes in a technical sense (Negroponte, 1995). We, however, are primarily interested in changes of established patterns caused by the digital transformation and complementary innovations in our economy and society.”
Mocker & Fonstad, 2017	“We refer to digitization to mean the application of digital technologies to transform how business is being conducted. We do not distinguish it from the term digitalization.”
Nwankpa & Roumani, 2016	“Within an enterprise, digital transformation is defined as an organizational shift to big data, analytics, cloud, mobile and social media platforms.”
Piccinini et al., 2015	“We witness how advancements in digital technology are reshaping a wide range of activities in society at large, which we may refer to in short as digital transformation.”

Furthermore, we can infer that, as only Mocker and Fonstad (2017) and Loebbecke & Picot (2015) get in touch with the issue of differentiation, the vast majority of scientists and practitioners use the terms digitization, digitalization and digital transformation as synonyms.

Hence, answering our first research question (R1) and thereby outlining the status quo in the scientific community, the following three definitory approaches can be identified in the manufacturing-related literature on the digital transformation.

Definitory approach 1 (technical sense, mentioned in one out of 43): The term digitization is used to label the conversion of analog to digital signals.

Definitory approach 2 (narrower sense, used by eleven out of 43): The terms digitization, digitalization and digital transformation are used to label the practice of taking objects that used to be analog (or physical) to some extent and transforming them to be primarily digital in order to increase the degree of automation and interoperability.

Definitory approach 3 (broader sense, used by 32 out of 43): The terms digitization, digitalization and digital transformation are used to label the practice of taking objects that used to be analog (or physical) to some extent and transforming them to be primarily digital with inherent effects on the business models of the affected companies.

This outcome is in line with the results from the screening of Mertens et al. (2017), which has been conducted without any specific industry focus and included both scientific and non-scientific publications (e.g. financial reports and grey literature). In consequence, it has to be argued that the structural differences between the manufacturing industry and other, more hardware-independent industries are not so far reaching as that they would lead to significant differences between the most basic theoretical elements of each study, i.e. the definition(s) of the researched phenomenon.

Nevertheless, as our intention is provide a thorough theoretical fundament on the digital transformation of the manufacturing sector with all its features and peculiarities as the basis for future research endeavors, we would like to suggest a twofold definition approach which we regard as the best fit in that environment. But due to the insight that the definition itself is untouched by the physicality of that industry, we refer to and suggest two previous definitions stemming from studies investigating the digital transformation at the general level. We do so, as we are convinced that specification for the sake of specification does not provide any value for the IS community, but instead researchers should stick to the least common factor wherever possible. Nevertheless, as we can only conclusively speak for the manufacturing sector, we add the affix of “within the manufacturing context”.

Further, we support the call of Legner et al. (2017) to clearly differentiate the term digitization from the other two as it refers to the original technical definition. We therefore propose the following Definition 1, solely addressing the term digitization:

Definition 1: Within the manufacturing context, the term digitization constitutes the conversion of analog to digital signals (Legner et al., 2017).

In contrary, taking into account that we did not find any evidence within our review that there is any prevalent differentiation within the scientific community between the terms digital transformation and digitalization, as it is occasionally proposed by some researchers (Shivajee et al., 2019; Sikora, 2017), we suggest that these two terms might as well be regarded as synonyms in the future. Our Definition 2 understands the two of them alike, thereby covering both identified definitory approaches 2 and 3. We thereby make use of the latest and by far most thoroughly crafted definition from the discussion at the general level, i.e. the one from Vial (2019).

Definition 2: Within the manufacturing context, the terms digital transformation and digitalization equally comprise a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies (Vial, 2019).

Delimiting the Digital Transformation of the Manufacturing Industry

Besides the confusion about the general definition of the phenomenon and the correct terminology to be used, there is also no general understanding about which technological concepts or domains belong to it and which do not (Denner et al., 2018; Mertens et al., 2017).

As our intention is to provide a valid theoretical basis for future research endeavors on the digital transformation in the manufacturing sector, we are convinced that a mere definition is not enough to do so due to the peculiarity of that industry. More precisely spoken, we find it hard to imagine that the popular umbrella of SMAC (social, mobile, analytics, cloud) technologies, which is usually called for when people talk about concrete digital transformation-related technological innovations (Denner et al., 2018; Legner et al., 2017), is sufficient to outline the scope that the digital transformation covers in that context from a technical point of view.

Again, we try to close that gap by evaluating and synthesizing the opinions of various distinguished scientists and practitioners which have been published in the leading scientific formats in the last years.

Just as within the last section on the definitory problem, we first outline the status quo as it can be found in the literature by now. We then enhance that status quo by the insights that were gained when bringing all sources together.

Doing the former, and thereby answering our second research question (R2), Table 2 presents an overview over the technological concepts and domains that can be found in the literature addressing the digital transformation in the manufacturing sector. Overall, we were able to identify 34 different technological concepts, which can be found in the second column of Table 2. Those 34 cover a very wide spectrum of applications and underlying ideas, ranging from completely new ways of producing physical parts to the use of advanced software systems to create transparency on the increasingly complex processes in that industry. Nevertheless, it was obvious when reading those publications that typically different technological domains are seen as closely connected to each other by the respective authors. We therefore decided to further group those 34 quite different concepts into eleven different clusters which follow the different lines of argumentation that can be found in the manufacturing environment in general and in the 43 different publications analyzed in special. Those eleven clusters are listed in the first column of Table 2. In the third column, the number of publications in which the respective technological concept is mentioned is listed. In the last column these references are presented explicitly.

As Table 2 is intended to picture solely the status quo as it can be found in the literature, we also list which technological cluster is seen under which of the definitory approaches that were identified and presented in Section 4. Thereby, none of the groups is located within definitory approach 1 (technical sense), which is why we only report the numbers for the definitory approaches 2 and 3. These numbers can be found in the fourth column.

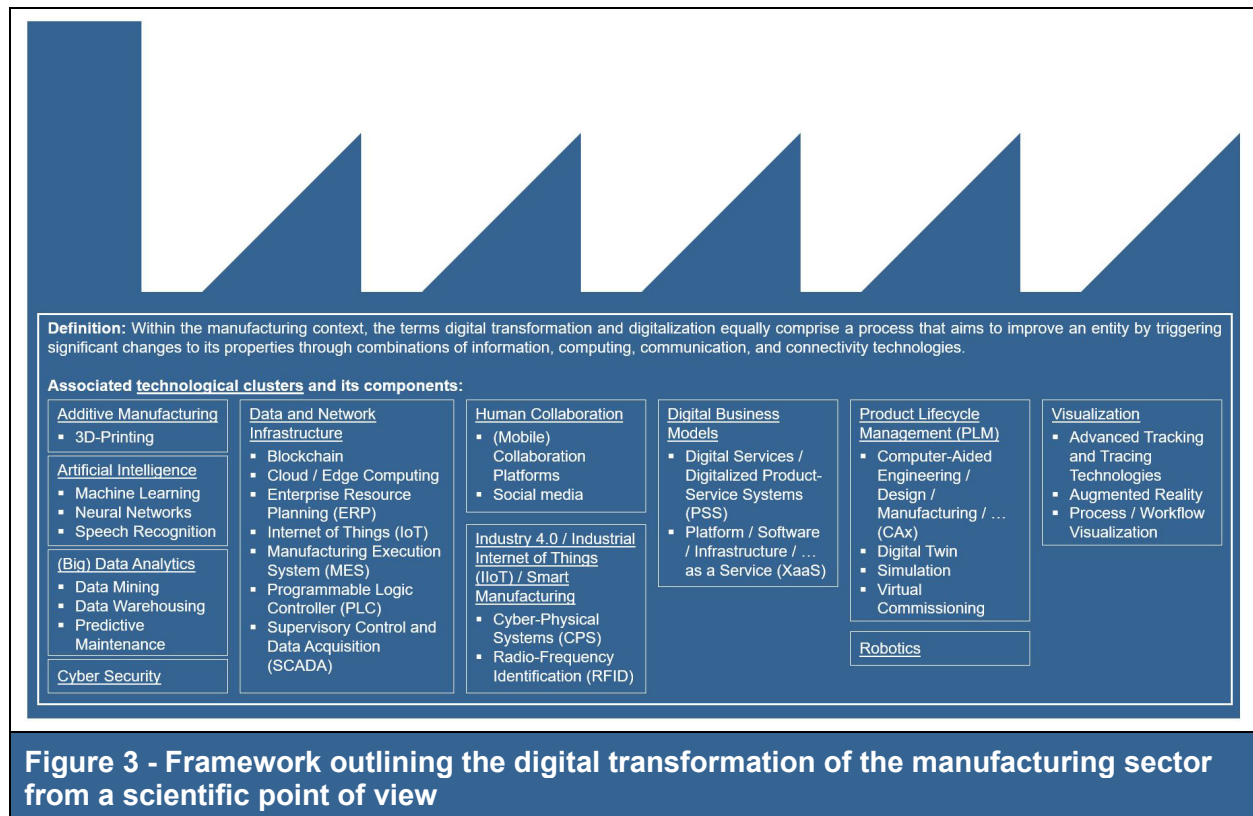
Table 2 - Identified technological concepts and domains

Cluster	Assigned techno-logical concepts	# of Ref.	Def. 2 / 3	Sources
Additive manufacturing	3D-Printing	7	2/5	Bienhaus, 2017; Coreynen et al., 2017; Dalenogare et al., 2018; Denner et al., 2018; Frank et al., 2019b; Ivanov et al., 2019; Srαι et al., 2016
Artificial intelligence	Machine learning	1	0/1	Heavin & Power, 2018
	No specification	4	2/2	Arntz et al., 2017; Frank et al., 2019b; Khan et al., 2019; Kusiak, 2017
	Speech recognition	1	0/1	Heavin & Power, 2018
(Big) data analytics	Data mining	3	1/2	Kusiak, 2017; Loebbecke & Picot, 2015; Shuradze et al., 2018
	Data	1	0/1	Shuradze et al., 2018
	No specification	12	3/9	Andersson & Jonsson, 2018; Bienhaus, 2017; Bilgeri & Wortmann, 2017; Dalenogare et al., 2018; Denner et al., 2018; Frank et al., 2019b; Frank et al., 2019a; Ivanov et al., 2019; Khan et al., 2019; Nwankpa & Roumani, 2016; Sebastian et al., 2017; Srαι et al., 2016
	Predictive maintenance	6	2/4	Bokrantz et al., 2017; Dremel et al., 2017; Echterfeld & Gausmeier, 2018; Frank et al., 2019b; Kusiak, 2017; Lenka et al., 2017; Subramaniyan et al., 2018
Cyber security	No specification	3	2/1	Bienhaus, 2017; Kusiak, 2017; Miehle et al., 2019
Data & network infrastructure	Blockchain	1	1/0	Denner et al., 2018
	Cloud / edge	11	3/8	Bilgeri & Wortmann, 2017; Dalenogare et al., 2018; Denner et al., 2018; Du et al., 2016; Frank et al., 2019b; Frank et al., 2019a; Kusiak, 2017; Lenka et al., 2017; Miehle et al., 2019; Mockler & Fonstad, 2017; Mourtzis, 2019
	ERP	8	2/6	Du et al., 2016; Frank et al., 2019b; Lasi et al., 2014; Loebbecke & Picot, 2015; Miehle et al., 2019; Sebastian et al., 2017; Srαι et al., 2016; Trantopoulos et al., 2017
	IoT	13	5/8	Bienhaus, 2017; Bilgeri & Wortmann, 2017; Denner et al., 2018; Du et al., 2016; Frank et al., 2019b; Frank et al., 2019a; Heavin & Power, 2018; Ivanov et al., 2019; Khan et al., 2019; Kusiak, 2017; Loebbecke & Picot, 2015; Sebastian et al., 2017;
	LAN	1	0/1	Trantopoulos et al., 2017
	MES	5	1/4	Dalenogare et al., 2018; Frank et al., 2019b; Lasi et al., 2014; Miehle et al., 2019; Subramaniyan et al., 2018
	PLC	1	0/1	Frank et al., 2019b
	SCADA	1	0/1	Frank et al., 2019b

Table 2 - Identified technological concepts and domains (continued)				
Cluster	Assigned techno-logical concepts	# of Ref.	Def. 2 / 3	Sources
Digital business models	Digital services / digitalized PSS	10	0/10	Bilgeri & Wortmann, 2017; Cenamor et al., 2017; Chester Goduscheit & Faillant, 2018; Coreynen et al., 2017; Dalenogare et al., 2018; Frishammar et al., 2019; Herterich et al., 2016; Lerch & Gotsch, 2015; Sebastian et al., 2017; Zheng et al., 2018
	XaaS	1	0/1	Sebastian et al., 2017
Human collaboration	(Mobile) collaboration platforms	5	1/4	Denner et al., 2018; Hildebrandt et al., 2015; Mocker & Fonstad, 2017; Nwankpa & Roumani, 2016; Sebastian et al., 2017
	Social media	3	1/2	Denner et al., 2018; Nwankpa & Roumani, 2016; Sebastian et al., 2017
Industry 4.0 / IIoT / Smart manufacturing	CPS	12	3/9	Bienhaus, 2017; Bokrantz et al., 2017; Dalenogare et al., 2018; Frank et al., 2019b; Frank et al., 2019a; Ivanov et al., 2019; Kusiak, 2017; Lasi et al., 2014; Miehle et al., 2019; Mourtzis, 2019; Müller et al., 2018; Richter et al., 2018
	No specification	3	1/2	Butschan et al., 2019; Echterfeld & Gausmeier, 2018; Subramaniyan et al., 2018
	RFID	4	0/4	Dalenogare et al., 2018; Lasi et al., 2014; Müller et al., 2018; Srai et al., 2016
PLM	CAx	3	1/2	Dalenogare et al., 2018; Mauerhoefer et al., 2017; Mourtzis, 2019
	Digital twin	3	1/2	Bienhaus, 2017; Mourtzis, 2019; Zheng et al., 2018
	Simulation	6	2/4	Bienhaus, 2017; Dalenogare et al., 2018; Frank et al., 2019b; Kusiak, 2017; Lenka et al., 2017; Mourtzis, 2019
	Virtual commissioning	1	0/1	Frank et al., 2019b
Robotics	No specification	7	2/5	Arntz et al., 2017; Bienhaus, 2017; Echterfeld & Gausmeier, 2018; Frank et al., 2019b; Ivanov et al., 2019; Miehle et al., 2019; Mourtzis, 2019
Visualization	Advanced tracking and tracing	2	0/2	Frank et al., 2019b; Ivanov et al., 2019
	Augmented / virtual reality	3	1/2	Bienhaus, 2017; Ivanov et al., 2019; Mourtzis, 2019
	Process / workflow visualization	6	1/5	Coreynen et al., 2017; Frank et al., 2019b; Khan et al., 2019; Mocker & Fonstad, 2017; Shuradze et al., 2018; Trantopoulos et al., 2017

In contrast, going one step further, Figure 3 is crafted by combining the status quo from Table 2 and the insights gained from dealing with the definitory issue in the last section. This framework draws a neatly arranged picture of what constitutes the digital transformation of the manufacturing sector from a scientific point of view. On the one hand, it lists and clusters the numerous buzzwords and technologies that can be found in the scientific literature of today and thereby tells at one glance which facets belong to the digital transformation in the manufacturing industry from a scientific point of view and which do not. On the other hand, it solves the much-discussed definitory and nomenclatural chaos of today for the most important

industry of the modern economy also at the first glance by including our definitory synthesis elaborated in Section 4.



Analyzing the Impact of the Digital Transformation on Companies within the Manufacturing Industry

We intend to answer our third research question (R3) by capturing the impact that the digital transformation has in the manufacturing industry by relying on the business model concept. We therefore analyzed the 43 scientific publications in depth to figure out two things: First, whether they deal with digital transformation-induced impacts on the business model level or just on the process level. For those works that report an implication on the business model level, we further examined which business model elements are affected, i.e. P/S, VN, VD or RM or a combination of those (cf. Figure 1). Table 3 presents the outcomes of that analysis.

On the one side, eleven out of 43 solely stay on the process level with their remarks and do not mention business model-relevant aspects. Those eleven can basically be separated into the proposition of process improvement approaches (Andersson & Jonsson, 2018; Bienhaus, 2017; Denner et al., 2018; Du et al., 2016; Khan et al., 2019; Kusiak, 2017; Loebbecke & Picot, 2015; Richter et al., 2018; Subramaniyan et al., 2018) and quantitative studies analyzing the impact of the digital transformation on specific processes (Arntz et al., 2017; Mauerhoefer et al., 2017).

On the other side, a majority of 32 articles do mention business model impacts coming with the digital transformation of manufacturing companies. A collection of seven works even place those right in the middle of their research (Arnold et al., 2016; Bilgeri & Wortmann, 2017; Bokrantz et al., 2017; Dalenogare et al., 2018; Müller et al., 2018; Piccinini et al., 2015; Sebastian et al., 2017). Eight publications deal with servitization, i.e. the extension of the existing physical product portfolio by additional service offerings and the optimization of those

bundles all the way up to smart product-service systems (Cenamor et al., 2017; Chester Goduscheit & Faullant, 2018; Coreynen et al., 2017; Frank et al., 2019a; Herterich et al., 2016; Lenka et al., 2017; Lerch & Gotsch, 2015; Zheng et al., 2018). The largest group with nine contains works that propose specific methods or decision guides (Dremel et al., 2017; Echterfeld & Gausmeier, 2018; Frank et al., 2019b; Heavin & Power, 2018; Miehle et al., 2019; Mocker & Fonstad, 2017; Mourtzis, 2019; Shuradze et al., 2018; Tesch, 2016). The remaining articles cover a quite heterogenous spectrum of topics which is why a further grouping makes no sense.

Nevertheless, a somewhat deeper view is worthwhile for those 32 as not all of them can keep what they promise. Bilgeri and Wortmann (2017), for instance, start their paper with the sentence “Executives across industries are challenged to rethink current business models as well as their companies’ organizational structures”. Later in their paper they extensively deal with questions on how large manufacturing companies can make use of the digital transformation in terms of a higher degree of internal collaboration but barely touch the business model aspect again. They mention that those kinds of firms should think of creating their own IoT platform to be able to collect data along the way of day-to-day operational business with their partners and that existing partnerships have to be reevaluated with that idea in the back of the mind. Nevertheless, they do not go any further than mentioning that idea and do neither explain how economic benefit could be created out of this nor do they describe any other business model-related aspect. The same accounts for Lasi et al. (2014) who mention (and nothing more) the implementation of new sales and procurement systems as digital transformation-related effects on the business model level, but else stay solely on the process level. Trantopoulos et al. (2017) as well go that way by briefly touching the business model level with the sentence “Already today networked machinery collecting performance data has allowed manufacturers to develop pay-per-use business models, effectively changing machinery from a capital expenditure to an operating expenditure” whereas the rest of the paper remains on the process level. Pretty much the same can be said about the works of Dalenogare et al. (2018) and Srari et al. (2016). Last but not least, Miehle et al. (2019) touch the business model level only within their introduction explaining the concept of smart factories in which “the comprehensive interconnection and resulting real-time availability of information enable innovative production principles and business models offering extensive advantages (e.g., increased flexibility and efficiency of production)”. Beside of that statement they stay on the process level by developing an approach that allows the analysis of digital threats in interconnected production environments.

Further valuable insights can be generated by looking at the business model aspects that are addressed by the authors of the 32 articles that mention business model impacts. 28 of them see changes in the offered product or service (P/S) as a major part of the digital transformation-induced business model eruptions. Only the already mentioned works of Bilgeri and Wortmann (2017), Lasi et al. (2014), Miehle et al. (2019) and Trantopoulos et al. (2017) do not mention any changes in that category. A frequent example thereof is the creation of product-service bundles, i.e. the enhancement of the existing physical products through additional service.

A little bit less popular are changes in the way how revenue is generated (RM) as 21 publications fit into that category. Especially those articles dealing with servitization refer to developments in that environment as they propose to generate additional value streams by offering services that fit their physical portfolio.

Table 3 - Literature review results regarding the business model impact (n=43)					
Source	Claimed transformation level(s)	P/S	VN	VD	RM
Andersson & Jonsson, 2018	Process level				
Arnold et al., 2016	Process and business model level	X	X	X	X
Arntz et al., 2017	Process level				
Bienhaus, 2017	Process level				
Bilgeri & Wortmann, 2017	Process and business model level		X		
Bokrantz et al., 2017	Process and business model level	X			X
Butschan et al., 2019	Process and business model level	X			
Cenamor et al., 2017	Process and business model level	X		X	X
Chester Goduscheit & Faullant, 2018	Process and business model level	X		X	X
Coreynen et al., 2017	Process and business model level	X		X	X
Dalenogare et al., 2018	Process and business model level	X	X	X	X
Denner et al., 2018	Process level				
Dremel et al., 2017	Process and business model level	X		X	X
Du et al., 2016	Process level				
Echterfeld & Gausmeier, 2018	Process and business model level	X	X	X	X
Frank et al., 2019b	Process and business model level	X	X	X	X
Frank et al., 2019a	Process and business model level	X	X	X	X
Frishammar et al., 2019	Process and business model level	X	X	X	X
Heavin & Power, 2018	Process and business model level	X			
Herterich et al., 2016	Process and business model level	X		X	X
Hildebrandt et al., 2015	Process and business model level	X			
Ivanov et al., 2019	Process and business model level	X	X	X	
Khan et al., 2019	Process level				
Kusiak, 2017	Process level				
Lasi et al., 2014	Process and business model level		X		
Lenka et al., 2017	Process and business model level	X	X	X	X
Lerch & Gotsch, 2015	Process and business model level	X		X	X
Loebbecke & Picot, 2015	Process level				
Mauerhoefer et al., 2017	Process level				
Miehle et al., 2019	Process and business model level		X		
Mocker & Fonstad, 2017	Process and business model level	X		X	X
Mourtzis, 2019	Process and business model level	X			
Müller et al., 2018	Process and business model level	X	X	X	X
Nwankpa & Roumani, 2016	Process and business model level	X	X		
Piccinini et al., 2015	Process and business model level	X	X	X	X
Richter et al., 2018	Process level				
Sebastian et al., 2017	Process and business model level	X	X	X	X
Shuradze et al., 2018	Process and business model level	X			
Srai et al., 2016	Process and business model level	X	X	X	
Subramaniyan et al., 2018	Process level				
Tesch, 2016	Process and business model level	X	X	X	X
Trantopoulos et al., 2017	Process and business model level				X
Zheng et al., 2018	Process and business model level	X		X	X
Σ		28	17	21	21

Also receiving less attention than those two portfolio elements (P/S) is the way how value is delivered (VD) to the customers. Again, 21 articles mention changes in that category, e.g. through the introduction of a novel platform approach.

The least amount of attention with 17 articles falls upon changes in the value network (VN), i.e. changing key actors like customers or business partners. Adding up to the already mentioned example of Lasi et al. (2014), a brief look into Lenka et al. (2017) provides another example of what kind of modifications fall under that category. They regard a situation in which both the service provider and the customer mutually interact in the value (co-)creation process as the most promising way to make the most out of the digital transformation.

Four articles out of the 43 are of particular interest as they contain quantitative statements regarding business model changes in manufacturing companies induced by the digital transformation. Bokrantz et al. (2017) report in their Delphi study, which is designed to analyze the impacts of the digital transformation on maintenance in manufacturing, a probability of 63% for business model changes with a relative impact of 3,1 on a Likert scale from 1 (very low) to 5 (very high). Piccini et al. (2015) use the same methodological approach for identifying the major managerial challenges caused by the digital transformation. Within their study, business model changes are ranked on the first spot on a list of 35 initially envisioned challenges with a 67% selection rate when the participants were asked to select the ten most important points.

Furthermore, Arnold et al. (2016) use a multiple case study approach in their work to analyze the impact of the Industrial Internet of Things (IIoT) on the business models of 69 companies of which 54 belong to the manufacturing sector. As they only report to which share the interviewed companies reported impacts to the business model elements of Osterwalder and Pigneur (2010), it cannot be said whether there were companies among them that did not experience a single impact. Nevertheless, it is a useful reference for this work as it confirms the major findings regarding the question which business model elements are affected the most.

Of particular interest for our research is the work of Müller et al. (2018). They use a multiple case study approach to find out how small and medium sized manufacturing companies innovate their business models in the face of the IIoT. They report that 36 out of 68 have experienced business model effects yet. 26 negate the existence of business model impacts with another six more who are, at the best, expecting them within the next five to ten years.

Overall, it is eye striking that over one third of the analyzed publications do not describe any (11 out of 43) or at least not a big impact (6 out of 43) of the digital transformation on manufacturing business models. In contrast, without any exception all publications describe notable changes at the process level of firms within that industry. As especially the former is a quite remarkable result, we will extensively discuss and put it into the context of our other findings within the next section.

Discussion

With this study, we add a completely new approach to the ongoing discussion within the IS community about the theoretical fundamentals of the digital transformation (Demlehner & Laumer, 2019; Legner et al., 2017; Mertens et al., 2017; Mertens & Wiener, 2018; Riedl et al., 2017; Vial, 2019). We do so by taking a deep vertical look into one single industry, in this case the manufacturing industry, instead of the repeatedly tried and rarely successful horizontal view across all sectors or an even wider scope. With this approach, we were able to create various viable insights and implications for both research and practice, which we will discuss in the following.

First, our results clearly show that the manufacturing industry is indeed very different compared to other industries regarding the impact that the digital transformation has on it. On the one hand, many of the technological concepts and domains that are subsumed under that

label in the context of the manufacturing industry are very specific and solely applicable within that particular environment, as it can be seen in Figure 3. They go far beyond the popular umbrella of SMAC (social, mobile, analytics, cloud) technologies, which is usually called for when people talk about concrete digital transformation-related technological innovations (Denner et al., 2018; Legner et al., 2017). On the other hand, we were not able to find an indication in the literature that the manufacturing industry is currently undergoing a radical or business-endangering revolution caused by the digital transformation as other branches like the music industry through streaming (Trefzger et al., 2015) or the banking industry through FinTechs (Eickhoff et al., 2017). In only eleven out of 43 reviewed articles simultaneous effects on all four business model elements were reported whereas in 21 at least one element was not reported as affected. Eleven out of 41 do not describe any business model changes coming with the digital transformation at all, not even a slight increase of collaboration along the supply chain (e.g. through extended data sharing) which would already be enough to at least touch the business model level. Additionally, six articles of the aforesaid ones do not go much further than just mentioning the possibility of occasional consequences on the business model level. Therefore, 17 out of 43 works do not see any or at least not a big impact on manufacturing business models caused by the digital transformation. This is supported by the recent findings of Müller et al. (2018), in whose study 32 firms out of 68 did not report any digital transformation-related business model repercussions in the last years. As these numbers are too high to refer to those companies (or articles, respectively) as isolated outliers, one might suppose that the digital transformation does not necessarily come to impact on the business model level in all companies in the manufacturing sector at the moment. Alternatively, one might infer that the fact that due to the long-lasting nature of these main assets and their long amortization times business models in that industry tend to be of very long-lasting nature could possibly lead to a time lag regarding the transformation of that industry compared to other industrial sectors. In contrary, however, our review clearly shows that the digital transformation already has a severe impact on the process level within that specific industry. Shortened product life cycles and an increasing demand for customization force those firms to further optimize their operations to stay competitive (Arnold et al., 2016). The digital transformation is a key enabler for procedural improvements as it lays the foundation for an effective utilization of the increasing amount of available production data. Both insights further help to put the current boom around the digital transformation into context, at least for that particular industry.

Second, our analysis contributes to the small set of publications that try find out which business model elements in manufacturing companies are mostly affected by the digital transformation or its correlated developments (Arnold et al., 2016; Müller et al., 2018). Those impacts primarily take place within the portfolio offered to the customers, as in 88% of the respective articles digitalization efforts towards the firms' products and services are mentioned. 66% report effects on the way how revenue is generated and in the delivery of value. The lowest value with 53% is attributable on the key actors like customers or business partners. Therefore, it is obvious that the effects of the digital transformation on the value networks of existing manufacturing companies require further research (Ivanov et al., 2019), whereas the impacts on their products and (most of all) services are quite well outlined. This insight is in line with the results gained by Arnold et al. (2016), who report considerably smaller impacts on the target customers or the partner networks of manufacturing firms than, for instance, on their value propositions. Further valuable insights might be created by comparing branches as soon as the same analysis is done for other industries than manufacturing (Laumer et al., 2013).

Third, we nevertheless have to admit that against our initial suspicion, we were not able to find evidence that the structural differences between the manufacturing industry and other, more hardware-independent industries are so far reaching as that they would lead to significant differences between the most basic theoretical elements of each study, i.e. the definitions of the researched phenomenon. Instead, the two definitions that seem to have come up as the

ones that are principally able to reach consensus within the current discussion (Legner et al., 2017; Vial, 2019) are also applicable to the context of manufacturing. Nevertheless, by neither defining the three terms “digital transformation”, “digitalization” and “digitization” nor ensuring at least a common understanding or a clear distinction between them right from the beginning, the (IS) research community has made life hard for itself for a long time. We end that deficiency at least for the manufacturing sector by providing evidence that these two definitions are fully applicable within this particular context.

Fourth, our study is one of the very few works that help to put both the emerging research trends of the digital transformation and Industry 4.0 (or IIoT or Smart Manufacturing, respectively) into context to each other by providing credible evidence. As a matter of fact, many of the technologies that we found as often subsumed under the label of the digital transformation of the manufacturing industry, can also be found in many publications labelled with the term Industry 4.0 (Arnold et al., 2016; Müller et al., 2018). What is indeed different is the strong fixation in many Industry 4.0 publications on the horizontal integration of supply chains and/or CPS (Hausberg et al., 2019), which does not account for most of the 43 works we reviewed. Also, digital technologies that rather stem from the consumer world than from the manufacturing context itself (e.g. mobile collaboration platforms and social media) are usually not implied in publications under the label of Industry 4.0 but indeed in those under the label of the digital transformation (Denner et al., 2018; Sebastian et al., 2017). Besides of those two aspects however, strong contentual overlaps are unmissable between these two research streams at numerous points. Therefore, it might be argued that the digital transformation of the manufacturing industry incorporates the wider idea or concept of the two, whereas Industry 4.0 covers a large but not the whole lot of its overall scope.

Fifth, there are controversies within the IS community about whether the digital transformation is a new and disruptive development or just a new label for things that have already been discussed and researched in the past (Baiyere et al., 2017; Demlehner & Laumer, 2019; Legner et al., 2017; Mertens et al., 2017; Mertens & Wiener, 2018; Riedl et al., 2017). The numerical results of the review we have conducted within the manufacturing-related part of that literature body, which are presented in Table 2, contribute to that. Noticeable is that with ERP a technology that has already been discussed heavily in the literature over 20 years ago has been mentioned quite frequently. The same applies for cloud or edge computing or digital services, as they have already been discussed to a considerable extent before the digital transformation hype has started in 2014 (Mertens et al., 2017). On the other side, it is evident that very young concepts like Blockchain, a term that has not been mentioned in literature before 2015 (Risius & Spohrer, 2017), or digital twins have received little attention from the scientific community so far. Even if one takes the possibility into account that several research projects on these newer digital technologies might currently still be in the process of writing and reviewing, these widely divergent numbers anyway suggest that a significant part of the manufacturing-related publications labeled with digital transformation, digitalization or digitization do not contain new or disruptive elements but rather present “old wine in new bottles” (Baiyere et al. 2017). Although this does not allow any inference to the whole body of literature, it has to be regarded as a dangerous thing. It bears the danger of redundant research endeavors and the non-consideration of previous projects and results (Mertens and Wiener 2018), regardless of the question whether this is done intentionally or not. It is now up to the IS community to build bridges between older research projects and their outcomes and the current ones as to prevent a break in the IS research time axis.

Sixth, as there have no exhaustive literature reviews been done addressing the intersection of the business model concept and the digital transformation within the manufacturing environment, this paper is the first one that provides an indication of where already some research has been conducted and where gaps can be found (cf. Table 2), even though it focuses on one single industrial sector. Unfortunately, this intersection still lacks a high-quality research roadmap to build future research on, as for example Kumar et al. (2018) have

developed for the interface of IS and Operations Management research. That might be a valuable contribution to the IS research landscape and worth a future research project. Our review might be a useful basis for such an endeavor.

Beside these contributions, by their very nature, our review and its results cannot be understood as conclusive and are therefore limited by several factors. First, our scope lies on the manufacturing environment and leaves out other considerable ISIC sectors like healthcare or retail. Second, our limitation to journals and conference proceedings that are ranked as A+, A or B in the VHB Jourqual 3 ranking could lead to the neglect of relevant works of appreciable quality that have not been published in one of these formats. Ultimately, associated topics and works might be left out as the authors did not use the term digital transformation or any of its substitutes within their respective papers, although addressing the same phenomenon that we are talking about in this research, which were then not covered by the search string.

Conclusion

The digital transformation is a popular research topic right now. Since 2014, the number of publications under that label has soared into the air. Unfortunately, this topic lacks a common and sustainable theoretical fundament. Reacting to that, René Riedl and colleagues have started a discussion in 2017 on how the IS discipline can find a way towards a uniform understanding within the scientific community (Demlehner & Laumer, 2019; Legner et al., 2017; Mertens et al., 2017; Mertens & Wiener, 2018; Riedl et al., 2017; Vial, 2019). This paper contributes to that debate by adding a completely new approach to the existent body of literature. We do so by taking a deep vertical look into one industry that differs significantly from the other industries that are also touched by this socio-technical phenomenon, i.e. the manufacturing industry.

In the course of that, we display and analyze the definitory status quo as present in the manufacturing-related literature on the digital transformation. Based on that and the latest insights from the general discussion around that phenomenon, we then give a concrete suggestion for a sustainable future theoretical fundament in that environment. Also, we identify 34 technological concepts and domains that are regarded as relevant for the manufacturing sector by the experts airing those publications. Grouped into eleven clusters, we combine them together with our new definitory approach to a framework outlining the digital transformation of the manufacturing industry from a scientific point of view. To complete our vertical look, we further analyze what impact the digital transformation has on manufacturing companies in terms of business model effects, which creates further valuable insights for understanding the digital transformation of that industry sector.

Thereby, it becomes obvious that the manufacturing sector is indeed different to other industries regarding the impact that the digital transformation has on it. Many of the technological concepts and domains that are subsumed under that label are solely applicable within that particular environment. Also, a notable share of authors does not report any or at least not a big impact of the digital transformation on the business model level but rather on the process level until now. However, for our initial suspicion that the structural differences between the manufacturing industry and other, more hardware-independent industries might be so far reaching as that they would lead to significant differences between the most basic theoretical elements of each study, i.e. the definitions of the researched phenomenon, no evidence was found. Taking these things into account in a combined fashion, the results of our study show that the context one is looking at, like the respective industry or market, clearly does matter when it comes to the digital transformation. Therefore, when talking or conducting research on that phenomenon, close attention should be paid to the question whether one is dealing with elements that are depending on the context of the societal entity at hand (in our study scope and impact) or that are not (in our study the definitions).

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