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# THE CURRENT STATE AND FUTURE OPPORTUNITIES OF DIGITAL INNOVATION: A LITERATURE REVIEW

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# THE CURRENT STATE AND FUTURE OPPORTUNITIES OF DIGITAL INNOVATION: A LITERATURE REVIEW

*Research paper*

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## Abstract

*Digital innovation has already disrupted numerous industries and is challenging extant theories about innovation. However, until now there is no comprehensive review that systemizes the current state of knowledge on digital innovation. Since publication rates on digital innovation increased fivefold since 2015, it is especially important to understand how the field is developing. The purpose of this paper is to provide an overview on how the field has developed, identify under-researched topics and under-used methods to guide future research. In our structured literature review, we systemize the findings by differentiating between two dimensions - digital innovation as a process and as an outcome. Furthermore, we explore determinants of digital innovation by taking three different levels of analysis into consideration: individual, organizational and environmental. By including extant research until today, we provide a comprehensive summary on current knowledge on digital innovation and identify opportunities for future research.*

*Keywords: digital innovation, literature review, multilevel perspective.*

## 1 Introduction

Along with the ever more prevalent digitization of work and private life a new breed of innovation – namely digital innovation – rapidly redefines how individuals, companies and society at large think, function and interact (Nambisan et al., 2017). During the last decade, we have witnessed the dawn and subsequent rise of numerous digital innovations such as cloud- and mobile computing, the internet of things, digital control systems, and 3D printing. Each of which has the potential to disrupt and creatively destroy established industries as described by Christensen (1997) and Schumpeter (1950). In an attempt to shed light onto the characteristics and underlying mechanisms that make digital innovation so powerful, numerous leading journals from different fields such as MIS Quarterly (2017) and Organization Science (2012) published special issues to take on this challenge.

Important insights are that digital technology is dressed up with new characteristics such as homogenous data formats and re-programmability which “[...] provide environments of open and flexible affordances that result in two unique characteristics of organizational innovation with digital technologies: convergence and generativity” (Yoo et al., 2012, p. 1399). Extant research investigates the effects of these new characteristics and finds for example that they affect how companies innovate along and within a supply chain (Lee and Berente, 2012), change boundary relations (Barrett et al., 2012), and reinforce platform thinking by underscoring the importance of heterogeneous contributors (Boudreau, 2012).

However, even though recent studies state that some of our underlying assumptions about innovation “may be challenged or fundamentally changed by the digital revolution [...]” (Benner and Tushman, 2015, p. 498) there still exists a lot of confusion about the nature of digital innovation. Existing literature reviews on digital innovation contribute valuable insights but cannot depict the whole picture due to conceptual or timeframe restrictions. Examples for conceptual restrictions are Herterich and Mikusz (2016), which focus exclusively on digitized artefacts and Barrett et al. (2015), which solely explore literature on service innovation. Hence, both reviews do not consider the whole breadth of digital innovation research. Another review by Kohli and Melville (2018) is conceptually more comprehensive but considers in its’ primary search only papers published up to 2010. Thereby, the review excludes almost a decade of research and misses very influential papers (e.g., Kallinikos et al., 2013; Yoo et al., 2012) that describe the implications of pervasive digitization for innovation. Furthermore, the reviews are silent on key developments within the field, which clearly differentiate digital innovation from traditional innovation. For example, innovation research commonly distinguishes between innovation process and innovation outcome (Crossan and Apaydin, 2010). Nambisan et al. (2017) claim that the boundaries between innovation process and outcome are increasingly blurring due to pervasive digitization. This represents a contradiction, which challenges the general conceptualization of digital innovation and may strongly influence future research on digital innovation. Thus our first research question is:

*(RQ1) How has the conceptualization of digital innovation changed over time?*

Furthermore, traditional innovation literature stresses the importance of using a multi-dimensional framework to fully understand the phenomena of innovation (Crossan and Apaydin, 2010). However, until now reviews on digital innovation do not build upon multi-dimensional frameworks. The lack on specific insights about, for example, the individual dimension of digital innovation has already led to calls for further, more detailed research (Holmström, 2018). To systemize the insights of extant literature on different dimensions of digital innovation, our second research question is:

*(RQ2) Which determinants influence digital innovation on the individual, organizational and environmental level?*

Considering that the field on digital innovation is still nascent and currently in a growth spurt, we argue that a comprehensive review of key developments in the field will help systemize current knowledge and uncover fruitful avenues for future research. Thus, this paper conducts a structured literature review by focusing on the top publication outlets and including literature up to 2018. Furthermore, we apply an established, multi-level framework from traditional innovation research in our coding process (Crossan and Apaydin, 2010) to uncover where the traditional paradigms of innovation no longer fit the new reality of digital innovation. We differentiate between the two dimensions of digital innovation as a process and digital innovation as an outcome. Additionally, we analyze determinants of digital innovation on three levels – individual, organizational and environmental. These two dimensions and three levels of determinants have been highlighted by extant research as being important components for organizational innovativeness (Crossan and Apaydin, 2010).

The following chapters are structured as follows: First, section two explains different views on digital innovation as defined and understood in the literature. Subsequently, we describe the methodology of our structured literature review. In section 4, we present the descriptive statistics and findings of our content-based analysis. In section 5, we outline our limitations. Finally, we identify opportunities for future research.

## **2 Conceptualization of Digital Innovation**

The phenomenon of innovating in a digitized environment is subject to examination within a multiplicity of different research streams, which is why until now there has not emerged an overarching, unified perspective on digital innovation. Following the framework of Crossan and Apaydin (2010) it is possible to differentiate between two different dimensions of innovation which are innovation as a process and innovation as an outcome. Innovation as a process aims at explaining *how* innovation is created (Crossan and Apaydin, 2010). A widely cited definition of digital innovation by Yoo et al. (2010, p. 725) builds

on the Schumpeterian concept of recombination (Schumpeter, 1934): “[...] we define digital innovation as the carrying out of new combinations of digital and physical components to produce novel products”. Thereby, their focus lies first and foremost on product innovation (Yoo et al., 2010), however, operates with an underlying understanding of digital innovation as a process (Kohli and Melville, 2018). The process of recombining physical and digital components results in a digitized product with novel characteristics (Yoo, 2010).

In contrast, innovation as an outcome takes a closer look on *what* innovation is and investigates factors such as the novelty, magnitude and form of the outcome (Crossan and Apaydin, 2010). Along these lines Fichman et al. (2014, p. 330) define digital innovation as: “[...] product, process, or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT”. This view includes any kind of outcome such as products, services, work-routines and even business models (Fichman et al., 2014). Hence, papers building upon the perception of digital innovation as an outcome describe *what* the eventual outcome is rather than *how* it was created.

In addition to the two dimensions of innovation (process and outcome), a number of determinants can influence organizational innovation, which can be divided into three levels: individual, organizational and environmental. While the individual level covers actors as well as their characterization, the organizational level incorporates organizational characteristics, such as strategy, structure and resource allocation. The environmental level describes the competitive landscape and organizational environment (Crossan and Apaydin, 2010). Earlier literature has mostly taken either a micro or a macro level perspective; even though single-level perspectives are not able to fully capture complex IS phenomena. Following Crossan and Apaydin (2010), we follow a multi-level approach that accounts for different levels of analysis simultaneously (Zhang and Gable, 2017). By distinguishing between individual, organizational and environmental-level we are able to better understand the different implications of digital characteristics such as, for example, re-programmability and data homogenization as discussed by Yoo et al. (2012).

### 3 Research Methodology

In order to answer the research question, we conducted descriptive literature review following a systematic methodology (Paré et al., 2015). Our methodological approach is composed of three steps based on Rowe (2014): selection of publication outlets, search process, and screening of the relevant literature.

As a first step, we identified 46 high-quality journals and conference proceedings, including, for example, the AIS Senior Scholars’ Basket of 8. Due to the emerging nature of the topic of digital innovation we not only incorporated management information systems outlets, but also included the fields of general business administration and strategy, organization behavior, and human resource management innovation as well as entrepreneurship in our literature review. Our selection of the publication outlets was based on the Journal Quality List (Harzing, 2018), a meta-ranking comprising 12 journal rankings that includes, for instance, the Financial Times 50 Ranking 2016 and German VHB-JOURQUAL3. The chosen journals and conference proceedings were categorized as top publication outlets in the majority of these rankings. For instance, with respect to the VHB-JOURQUAL3 rating we selected journals that were ranked in the categories A+ and A. We did not impose any restrictions on the time frame of our search and included all research articles published until the end of May 2018.

Next, we searched all 46 selected publication outlets using the search term “digital innovation” and relying on a meta-search engine, based on 202 different databases (e.g., EBSCO Business Source Complete). The search term was derived from our research interest and research question and had to be present in the title, abstract or keywords. The following search returned a total of 26 potentially relevant research articles.

During the subsequent screening, we applied two inclusion criteria to identify relevant literature: Thus, we evaluated whether the respective research article (1) focused on digital innovation and (2) analyzed either one of the two dimensions of digital innovation (i.e., process or outcome) or determinants of

digital innovation (i.e., individual, organizational or environmental level). Subsequently, three researchers deductively coded all relevant articles according to these two dimensions and three levels of determinants. Subsequently, we took a more granular look within each category and coded inductively for any emerging themes. Overall, we accomplished an percentage agreement of 91 percent, representing the interrater reliability (Tinsley and Weiss, 1975). Discrepancies in the coding were solved in discussions among all researchers. In order to ensure a comprehensive coverage of the literature on digital innovation we further applied backward and forward search to all research articles identified as relevant. Therefore, we reviewed papers that cited or were cited by research articles identified as relevant during our search and filtering process (Webster and Watson, 2002). The final sample contained 24 papers from six different publication outlets. Among other publications, this sample includes papers from two special issues on digital innovation by MIS Quarterly (2017) and Organization Science (2012).

## 4 Results

In the following, we present the results of our analysis on digital innovation. Before presenting the results of our content-based analysis on digital innovation, we give an overview of the descriptive statistics of the studied sample of research papers.

### 4.1 Descriptive Statistics

With respect to the descriptive statistics of our sample, we find a concentration of the relevant literature in a few publication outlets. Table 1 depicts all examined journals that published relevant research article on digital innovation. The largest share of relevant research articles, namely 58.3% has been published in the Proceedings of the International Conference on Information Systems. Management Information Systems Quarterly is the second most important publication outlet with a share of 16.7%. The third most significant journal represents Organization Science which published 12.5% of the relevant literature. Only 4.2% articles were published in the Information System Research, Journal of Strategic Information Systems and Research Policy respectively. The amount of research articles in each year increased over time. Up to and including the year 2014 on average only 1.3 papers were published each year. However, in the years between 2015 and 2017 this increased to an average of five research articles per year.

With respect to the method of data collection, that we categorized according to Palvia et al. (2003), 20.8% of relevant research articles rely on a non-empirical methodology, namely conceptual models. Among the almost four fifth of all relevant research articles relying on empirical-behavioral data collection, case study is the most popular method of data collection with a share of 37.5%. Secondary data is the second most used data source with 16.7%, followed by interview and experiment, which were each performed by two relevant research articles. Among the studies that rely on empirical-behavioral data, 5 out of 19 rely on quantitative analysis, while 13 studies in literature use qualitative data analysis. Only one study employs both quantitative and qualitative analysis. Content analysis is the most used method of data analysis as it is used by 12 out of 19 studies. All other methods are only used by two studies, such as regression analysis, or one research article, for example variance analysis and grounded theory.

Journal	2009/10	2011/12	2013/14	2015/16	2017/18	Total
International Conference on Information Systems	2	0	1	8	3	14
Management Information Systems Quarterly	0	0	1	0	3	4
Organization Science	0	3	0	0	0	3
Information Systems Research	1	0	0	0	0	1
Journal of Strategic Information Systems	0	0	0	1	0	1
Journal of Information Technology	0	0	0	0	1	1
<b>Total</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>9</b>	<b>7</b>	<b>24</b>

Table 1. Number of research articles per publication outlet

## 4.2 Dimensions and Determinants of Digital Innovation

Our content-based analysis follows the well-established insights of Crossan and Apaydin (2010). Accordingly, we analyze and categorize innovation along the two dimensions of innovation as a process and innovation as an outcome, whereby the first precedes the latter. Thereby, we are able to analyze how the focus of the field is developing. Furthermore, with respect to determinants of organizational innovation, the framework proposes three distinct levels: individual, organizational and environmental (Crossan and Apaydin, 2010, p. 1182). In order to provide an extensive analysis on the state-of-the-art literature we cover the two dimensions and determinants of all three levels in the following.

**Dimension of Digital Innovation: Process.** We found 14 papers that provide specific insights about digital innovation as a process. Viewing innovation as a process aims at explaining *how* innovation is created rather than what the eventual outcome is (Crossan and Apaydin, 2010). First, digital innovation processes are increasingly distributed. During the process of digital innovation physical products are combined with digital components which increases the complexity of products (Yoo et al., 2010). The increased complexity makes it necessary to include actors from beyond the traditional boundaries (organizational or discipline-related) in the innovation process (Nambisan et al., 2017). Thus, the innovation process is increasingly distributed throughout a network of changing contributors (Lyytinen et al., 2016; Lakhani and Panetta, 2007). Or as Yoo et al. (2012, p. 1401) put it: “[...] the notion of boundaries within and across firms becomes increasingly muddled as any boundary - be it across firms, functions, or ecosystems - limits innovation and growth”. A perfect example is the increasing reliance on innovation processes that span the entire supply chain (Lee and Berente, 2012) or generally innovation networks (Lyytinen et al., 2016).

Second, digital innovation processes appear to be more flexible. The increasing digitization of our environment introduces a new level of uncertainty and serendipity (Hippel and Krogh, 2016; Kallinikos et al., 2013), thereby, requiring a higher level of flexibility throughout the innovation process (Nambisan et al., 2017). Organizations are meeting these new circumstances by developing the ability to “keep design spaces open across product lifecycles” (Svahn et al., 2017, p. 247), shortening innovation cycle times (Fichman et al., 2014), immediately releasing products and instantly implementing user feedback (Huang et al., 2017). By keeping design spaces open companies are able to constantly iterate between releasing and updating their offerings which also increases the dynamic of the innovation process (Nambisan et al., 2017). Furthermore, companies shift from a focus on specific solutions to rather universal design patterns which can be repurposed for newly emerging problems (Svahn et al., 2017). This trend signifies a departure from established - rather static – innovation process logics such as stage gate (Grönlund et al., 2010) towards more dynamic approaches as for example ‘dynamic problem-solution design pairing’ which characterizes a continuous combination and recombination of problems with potential solutions (Hippel and Krogh, 2016). In summary, digital innovation as a process is characterized by greater distribution across various contributors and a higher flexibility in general.

**Dimension of Digital Innovation: Outcome.** This section is intended to shed light on digital innovation as an outcome, thus, focusing on *what* the eventual outcome is rather than how it was created. Our review returned 10 articles that discuss novel perspectives on digital innovation as an outcome. First, digital technology is equipped with digital characteristics such as “(1) the reprogrammability, (2) the homogenization of data, and (3) the self-referential nature of digital technology” (Yoo et al., 2010, p. 726). These digital characteristics decouple device, network, service and content from each other which creates a ‘layered modular architecture’ in digitized products (Yoo et al., 2010). This allows for a high level of flexibility when recombining the different layers with each other and enables rapid and inexpensive scaling due to reproduction costs approaching zero (Huang et al., 2017). Another outcome is the increasing personalization, as well as flexible pricing and delivery options of organizational offerings (Fichman et al., 2014).

Second, whereas with non-digital innovations it was possible to determine a successful innovation outcome by measuring the monetary value created, digital innovations are oftentimes free of charge and mainly compete for attention or user data (e.g., YouTube, Facebook) which makes it nearly impossible to define value creation along our established (predominantly monetary) metrics (Brynjolfsson and Oh,

2012). This underscores the importance of creating a large user-base instead of merely focusing on a large customer-base, as the first precedes the latter (Huang et al., 2017). Consequently, companies had to re-align their business models with the reality of a digital context by adopting a strong focus on services rather than products (Hildebrandt et al., 2015). In conclusion, digital innovation as an outcome is characterized by more opportunity for recombination due to developments such as the layered modular architecture, and the increasing difficulty of measuring the real value of a certain outcome. Table 2 summarizes our findings concerning the influence of digital technology on the dimensions of innovation:

Digital Technology leads to...	Reason:
Cooperation between more heterogeneous contributors	<ul style="list-style-type: none"> <li>• Convergence of different areas of expertise lead to more distributed forms of cooperation (Lyytinen et al., 2016; Yoo et al., 2012)</li> </ul>
Convergence of process and outcome due to more flexibility	<ul style="list-style-type: none"> <li>• Open design spaces (Svahn et al., 2017)</li> <li>• Faster cycle times (Fichman et al., 2014)</li> <li>• Instant releases and updates (Huang et al., 2017)</li> <li>• Universal design patterns (Svahn et al., 2017)</li> <li>• Modular layered architecture (Yoo et al., 2010)</li> <li>• Digital characteristics (e.g., malleability) (Fichman et al., 2014)</li> <li>• ‘Wakes of innovation’ (Dougherty and Dunne, 2012)</li> </ul>
Service-oriented business models	<ul style="list-style-type: none"> <li>• Digitization of products enables continuous service offerings (e.g., infotainment in cars) (Hildebrandt et al., 2015)</li> </ul>
New forms of measuring success	<ul style="list-style-type: none"> <li>• Monetary based measurements are not able to adequately measure value of digital offerings / organizations (Brynjolfsson and Oh, 2012)</li> <li>• User baser is more important than customer baser (Huang et al., 2017)</li> </ul>

Table 2. Influence of Digital Technology on the Dimensions of Innovation

**Blurring of Process and Outcome.** However, digital technology makes it increasingly difficult to define an outcome as it allows for unintended, new ways of collaborating which has the potential to constantly change the initial aim of an innovation process (Dougherty and Dunne, 2012). This can be observed in innovation processes that constantly iterate between releasing a product and immediately implementing feedback. Thus, the final outcome oftentimes sparkes several ‘wakes of innovation’ after the fact (Boland et al., 2007) by creating new knowledge, which can be implemented right away. This interdependence between process and outcome makes a distinction between the two increasingly difficult (Nambisan et al., 2017). Especially as managers must attempt to square the circle by finding the right equilibrium between a focus on innovating processes and outcomes (Svahn et al., 2017). Thus, the delineation between process and outcome is increasingly blurred, making it more difficult to theoretically distinguish between innovation as a process and innovation as an outcome. This development is further underscored by the current conceptualization of digital innovation in the latest publications.

During the process of reviewing the identified articles a citation pattern regarding the definition of digital innovation emerged, which is displayed in Figure 1. The arrows indicate which definition a respective paper built upon and in which year the paper was published.

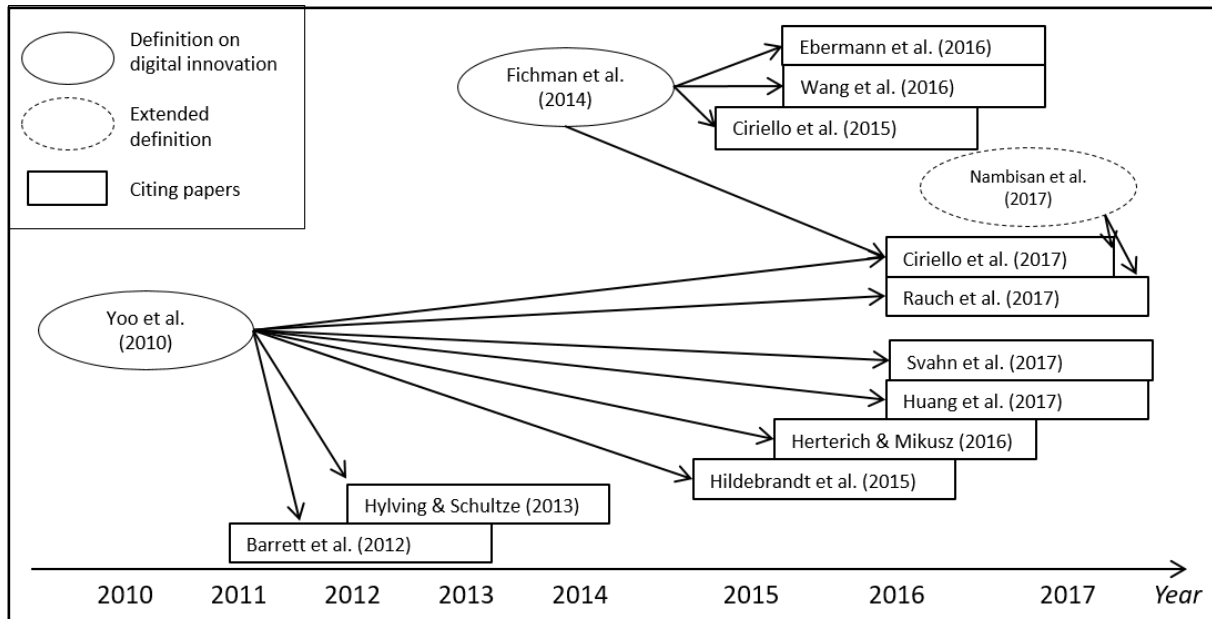


Figure 1. Citation map - definitions of digital innovation

As we elaborated above, Yoo et al. (2010) have a stronger focus on innovation as a process. Initially, most publications followed this view. In 2014, Fichman et al. (2014) established a definition of digital innovation with a stronger focus on innovation as an outcome, which was also regularly cited. Interestingly, in 2017 several publications build upon both definitions simultaneously. Furthermore, the definition put forward by Nambisan et al. (2017) also views innovation as a process and as an outcome simultaneously. Thus, Figure 1 provides an overview over the general conceptualization of digital innovation within the field. Three main insights are important: (1) Nine papers refer to the definition by Yoo et al. (2010) which define digital innovation as a process. (2) Five papers cite Fichman et al. (2014) which define digital innovation as an outcome. (3) In 2017 50% of the published papers build on Nambisan et al. (2017), thus, conceptualizing digital innovation as process and outcome simultaneously, which underscores the increasingly blurred boundaries between process and outcome. We will elaborate further on the implications of this development in the discussion section.

**Determinants on the Individual Level.** 14 studies mention individual determinants of digital innovation (i.e., digital innovation actors) in a digital context. Two different actor groups can be distinguished: those involved in the development process (such as developers) and those who use and execute the digital innovation (users). Ten articles cover the first group of actors, and only four articles examine the user perspective of digital innovation.

Articles within the research stream covering innovation actors in the development process emphasize the presence of several and heterogeneous innovation actors referred to as innovation communities (Barrett et al., 2012). Thus, collective creativity is a central phenomenon in digital innovation (Ciriello et al., 2017). Nambisan et al. (2017) agree with this view and extend it by proposing less predefinition in innovation agency. Hereby, the authors claim, that with digitization, a shift has occurred from predefined sets of focal innovation agents to emerging, innovation collectives with different motives, goals, and capabilities. Following this, Svahn et al. (2017) state that in a diverse material basis (software and physical components), different innovation regimes are distinguished by different social structures. Wang et al. (2009) confirm this and go one step further by describing that digital technology facilitates a loose coupling between different stages of innovation. As a consequence, different stages of the innovation process such as the conception and development, can be split between diverse innovation actors due to an increased tolerance of change (Wang et al., 2016). Actors with various backgrounds establish a high number of heterogeneous practices of which other actors are able to benefit from (Wang et al., 2016). Utilizing such heterogeneity, actors then become more versatile in creating ideas with fruitful information from various aspects (Wang et al., 2016). Overall, digital innovation increasingly requires that



others actors, left unattended earlier, have to be enabled to innovate and create new ideas (Yoo et al., 2012).

The emergence of innovation collectives are attributed to certain aspects of digital innovation. Therefore, in the articles examined the collectives are often described as a consequence of particular effects of digital innovation. For instance, Yoo et al. (2010) highlight that within a layered modular architecture, an organization could attract heterogeneous actors to design and produce novel components on layers outside of its digital product platform. Additionally, the structure of organizational boundaries is sufficiently loose to enable interpretive flexibility among various actors. Loose boundaries, enable collaboration among various groups and support innovative actors in organizing their collaborative discovery (Ciriello et al., 2017). Moreover, the possibility of data and process sharing facilitated by digital tools challenges common norms and rules of ownership and imitating new configurations of relationships and roles among different innovation actors (Boland et al., 2007). Hence, more heterogeneous modules may be combined to create new innovations (Polykarpou and Barrett, 2017).

Only a few articles (e.g., Ciriello and Richter, 2015; Polykarpou and Barrett, 2017) cover the characteristics of actors. In the line with other research, Huang et al. (2017) describe human actors in digital innovations as reflective agents who are capable of situating themselves in the context of rapid scaling. Moreover, other actors (such as intrapreneurs) share the drive and zeal of entrepreneurs, relying on their technical, financial, and professional resources (Ciriello and Richter, 2015). As the only article, Polykarpou and Barrett (2017) indicate a shift in the personal identity of actors, which can be challenging for the multidisciplinary collaboration in the process of digital innovation.

Turning to the user perspective of digital innovation, only four paper cover this topic superficially. Svahn et al. (2017) emphasize that digital technology renews and improves the end-user experience, thus creating new revenue streams. Furthermore, the network effects of digital technology have opened up implications for organizations with respect to technology adopters (e.g., how to optimize adoption timing) (Fichman et al., 2014). Design elements determine the adoption of digital innovations by digital natives, since these adopters have other requirements for the use of digital innovation (Ebermann et al., 2016). Taken together, articles covering the individual level declare that digital technologies radically transform the nature of established innovation practices on the side of developers and users, triggered by an environment of open and flexible affordances which facilitate the heterogeneity of actors (Ciriello and Richter, 2015). The results on the determinants of digital innovation are summarized in Table 3.

**Organizational Determinants of Digital Innovation.** Ten articles in our analysis cover the topic of the organization in relation to digital innovation. Hereby, many articles remain very generic. For example, Yoo et al. (2012) posit that layered architecture encourages profound changes in the ways that organizations position themselves for innovation in the future. Ciriello and Richter (2015) agree and state that idea-driven organizations emerge as increasingly important phenomenon. Industrial organizations are transformed by digital innovation, and the resulting managerial challenges will be more radical than the IT-enabled business transformations in the past (Piccinini et al., 2015). Furthermore, organizations need to meet the requirement for a broader range of knowledge, such as external knowledge in addition to digital knowledge (Hildebrandt et al., 2015).

Some of the articles examine labor in relation to digital innovation. Lee and Berente (2012) observe that a new division of labor among different actors and organizations, for example manufacturer and supplier, could emerge due to digital innovation. Yoo et al. (2012) extend this thought by highlighting that generative potential is only fully realized when it is paired with a new organizing logic that involves heterogeneous actors, many of them pursuing their own innovation strategies. Svahn et al. (2009) acknowledge this requirement but underscore that established organizations might face too much resistance to realize a new organizational structures. In contrast, such organizations might induce slight changes to the existing structure, such as the formation of informal networks, to accommodate their need of higher informality and flexibility. This enables both specialization and division of labor as well as heterogeneity and multiplicity across horizontal organizational layers, both being significant factors in digital innovation (Svahn et al., 2009). In this context, it is important to balance incentives for stimulating value co-creation and formal contracts for requirement validation (Svahn et al., 2017). Additionally,

the distinctive materiality of digital innovations, such as robots, could reorganize the process of diverse occupational labor groups, leading to a reconfiguration of boundary relations (Piccinini et al., 2015).

Some authors deal with cooperation beyond the boundaries of organizations in regard to digital innovation. Barrett et al. (Barrett et al., 2012) stated that occupational boundaries are changing and collaboration between constituents is possible using digital innovations. Furthermore, organizations increasingly participate in ecosystems for tapping into knowledge flows outside their boundaries (Selander et al., 2010). According to Selander et al. (2010), boundaries are newly defined. Consequently, external collaboration enabled by digital innovation with new partners is possible (Svahn et al., 2017). In sum, boundaries within and across firms become increasingly dynamic and permeable (Yoo et al., 2012). Accordingly, organizations have to break up the silo mentality among their employees and departments in order to cross-fertilize the organization (Svahn et al., 2017).

The importance of platform thinking for organizations is outlined by some articles (e.g., Huang et al., 2017). Thereby, in the age of digital technologies the user base is more important than mere profitability (Huang et al., 2017). Furthermore, the articles show that the introduction of pervasive digital technology (such as platforms) in organizations could generate hidden and unanticipated faults, such as new forms of risk (e.g., Yoo et al., 2012). Therefore, organizations have to carefully deal with those faults in order to take full advantage of new digital technologies (Yoo et al., 2012). Finally, one article describes how important organizational characteristics workplace conditions are despite the digitization of innovation (Polykarpou and Barrett, 2017). The authors provide an understanding of how the workplace conditions are implicated in the innovation process. Their findings show that the workplace conditions where groups work is constitutive of their practices, countering or enabling collective collaborative work in the innovation process (Polykarpou and Barrett, 2017). Consequently, digital innovations are necessarily enacted through situated practices at particular places.

**Environmental Determinants of Digital Innovation.** Every identified research article is also analyzed with respect to the environment of digital innovation. Interestingly, we found that only five articles cover the environmental level superficially.

Focusing on the macro-level Yoo et al. (2012) state that digital technology can bring together previously separated industries. Specifically, through an environment of open and flexible affordances distributed innovation could lead to the emergence of new industrial structures. Fichman et al. (2014) confirm that by stating that industry formations are possible through digitalization and Moore's law. Huang et al. (2017) take an alternative view by proposing that the distinct characteristics of digital innovation lead to the dominance of one organization in the market, by creating a winner-takes-all market. Moreover, Wang et al. (2016) cover the topic of organizations' environment for digital innovation by applying organizational ecology theory to propose an industry-level, ecological model for understanding the novelty of IT products. They find that the legitimation of products in a market niche and competition between market niches improves product innovations. When turning to the interaction between an organization and the environment, one paper focuses on the managerial constraints that are triggered by the environment in a digital innovation context (Piccinini et al., 2015). For example, one constraint for organization is to ensure IT security in the adoption and implementation of innovative digital technologies. Furthermore, dealing with regulatory uncertainty and regional restrictions, as well as solving regulatory issues around automatized activities and eliminating concerns is important for a successful implementation of digital innovation (Piccinini et al., 2015).

Level of analysis	Digital Technology leads to...	Description
<b>Individual Determinants</b>	More heterogeneous innovation actors in the development process	<ul style="list-style-type: none"> <li>Emerging innovation communities (Ciriello et al., 2017; Barrett et al., 2012)</li> <li>Less predefinition in innovation agency (Nambisan et al., 2017)</li> <li>Loose coupling between different stages of innovation enable diverse innovation actors due to an increased tolerance of change (He and Wang, 2009; Wang et al., 2016)</li> <li>Digital innovation requires others actors to innovate and create new ideas (Yoo et al., 2012)</li> </ul>
	Emergence of innovation collectives	<ul style="list-style-type: none"> <li>Layered modular architecture attracts heterogeneous actors to produce novel components on layers outside of its digital product platform (Yoo et al., 2010)</li> <li>Loose structure of organizational boundaries enables interpretive flexibility among various actors (Ciriello et al., 2017)</li> <li>Common norms and rules of ownership are challenged and new configurations of relationships and roles among different innovation actors arise (Boland et al., 2007).</li> </ul>
	Changing characteristics of innovation actors	<ul style="list-style-type: none"> <li>Reflective agents, capable of situating themselves in the context of rapid scaling (Huang et al., 2017)</li> <li>Intrapreneurs relying on their technical, financial, and professional resources (Ciriello and Richter, 2015)</li> <li>Shift in the personal identity (Polykarpou and Barrett, 2017)</li> </ul>
	Changes regarding the involvement of users in innovation practices	<ul style="list-style-type: none"> <li>Digital technology renews and improves the end-user experience (Svahn et al., 2017)</li> <li>Network effects of digital technology opened up implications for organizations with respect to technology adopters (Fichman et al., 2014)</li> <li>Other requirements for the use of digital innovation by digital natives (Ebermann et al., 2016)</li> <li>Environment of open affordances facilitate the heterogeneity of actors (Ciriello and Richter, 2015)</li> </ul>
<b>Organizational Determinants</b>	Changes in organizational positioning	<ul style="list-style-type: none"> <li>Layered architecture encourages profound changes in the ways that organizations position themselves for innovation in the future (Yoo et al., 2012)</li> <li>Idea-driven organizations emerge (Ciriello and Richter, 2015)</li> <li>Organizations need to meet the requirement for a broader range of knowledge (Hildebrandt et al., 2015)</li> </ul>
	Changes in labor in relation to digital innovation	<ul style="list-style-type: none"> <li>New division of labor among different actors and organizations emerge (Lee and Berente, 2012)</li> <li>Established organizations face resistance to realize new organizational structures (Svahn et al., 2009)</li> <li>Formation of informal networks due to the need of higher informality and flexibility (Svahn et al., 2009)</li> <li>Balance incentives for stimulating value co-creation and formal contracts for requirement validation (Svahn et al., 2017)</li> </ul>
	Increased cooperation beyond the boundaries of organizations	<ul style="list-style-type: none"> <li>Organizations increasingly participate in ecosystems for tapping into knowledge flows outside their boundaries (Selander et al., 2010)</li> <li>Boundaries within and across firms become increasingly dynamic and permeable (Yoo et al., 2012)</li> <li>Organizations have to break up the silo mentality among their employees and departments in order to cross-fertilize the organization (Svahn et al., 2017)</li> </ul>
	Integration of platforms in organizations	<ul style="list-style-type: none"> <li>User base is more important than mere profitability (Huang et al., 2017)</li> <li>Importance of organizational characteristics (Polykarpou and Barrett, 2017)</li> <li>Workplace conditions countering or enabling collective collaborative work in the innovation process (Polykarpou and Barrett, 2017)</li> </ul>
<b>Environmental Determinants</b>	Emergence of new industrial structures	<ul style="list-style-type: none"> <li>Industry formations through digitalization and Moore's law (Fichman et al., 2014)</li> <li>Creating a winner-takes-all markets (Huang et al., 2017)</li> <li>Legitimation of products in a market niche and competition between market niches improves product innovations (Wang et al., 2016)</li> </ul>

Table 3. Summary: Determinants of Digital Innovation

## 5 Limitations

Even though this structured literature review synthesizes the contemporary level of knowledge on digital innovation up to 2018 and identifies several potential areas of future research, there are some limitations, which have to be taken in consideration. First, our search was intentionally designed to include only high-quality journals with a high standard of peer-review. Taking this approach guarantees the high quality and reliability of the reviewed literature. However, there might be the risk of missing relevant papers, which were published in less established outlets. Second, while every step of the search and categorization process was conducted with the utmost care, there always looms the risk of human errors. However, by adhering to the standards of established, well-structured frameworks (e.g., vom Brocke et

al., 2009) and constantly peer-reviewing results by three different authors we are confident to have mitigated any risks as much as possible. Third, a classification of the literature on digital innovation into two dimensions (i.e. process and outcome) and determinants on three levels (i.e. individual, organizational and environmental) could be perceived as restrictive, since dimensions and determinants may overlap and interweave. Nevertheless, only by using an established categorization from extant literature, clear implications for theory and practice can be derived. Finally, our selection is limited due to the used search string “digital innovation” and the subsequent selection criteria. Yet, using this approach we are able to clearly delimit the scope of our research article.

## 6 Discussion

This paper set out to capture the current state of digital innovation. We searched publications up until 2018 and focused during the multiple iterations of the reviewing process on categories established in extant literature about innovation (Crossan and Apaydin, 2010). Hence, we provide the - to our knowledge - first comprehensive literature review on digital innovation that includes research papers until May 2018. Thus, we are able to portray how the field of research on digital innovation has developed (Figure 1) and which methodological approaches are potentially under-researched. Therefore, this review is able to indicate fruitful areas for future research. The first research question of our paper investigates how the conceptualization/definition of digital innovation changed over time. Here, our results show that digital innovation as a process is mainly characterized by greater distribution across various contributors and a higher flexibility in general (Lyytinen et al., 2016). For digital innovation as an outcome, we found that there is more opportunity for recombination due to the layered modular architecture (Yoo et al., 2010), and that it is increasingly difficult to measure the real value of a certain outcome (Brynjolfsson and Oh, 2012). However, most importantly, we uncovered that the distinction between process and outcome is increasingly redundant. As depicted in Figure 1, there is a trend among highly ranked publications to build upon conceptualizations of digital innovation as a process and an outcome simultaneously (Rauch et al., 2017; Ciriello et al., 2017). This trend might be rooted in the fact that process and outcome are increasingly interwoven, which makes it difficult to differentiate between the two dimensions. Thereby, our findings support the prediction made by Nambisan et al. (2017) and show that the field of digital innovation is developing towards a new direction. In light of these insights, we see the need for novel theorizing to bring the current developments on a common denominator.

The second research question concerns determinants on three different levels: “Which determinants influence digital innovation on the individual, organizational and environmental level?” Here, we found that digital technology changes the innovation process so that organizations need to develop distinct capabilities to empower independent, individual actors and motivate external actors, such as developers from outside the organization (Svahn et al., 2017). On the organizational level, digital innovation is determined by changes in the division of labor, more dynamic and permeable boundaries and a higher strategic importance of digital innovation platforms to exploit users’ innovation potential. Research on environmental determinants is largely scattered, but overall emphasizes the growing importance of considering environmental characteristics.

Based on these findings we identified numerous opportunities for future research. Regarding the two dimensions of digital innovation, we identified a lack of concise definitions of digital innovation. Figure 1 illustrates how digital innovation was initially (mostly) defined by building upon the definition of Yoo et al. (2010), thus, indicating a process view. From 2014 onwards numerous papers built on Fichman et al. (2014), thereby, indicating an outcome view. However, the delineation between process and outcome dimension appears to vanish, best illustrated by the popular definition of Nambisan et al. (2017) that embraces both dimensions simultaneously. Future research can benefit from understanding how the field of digital innovation is currently developing (Figure 1) and aim at the development of new frameworks and theories that are aligned with the characteristics of digital innovation. Furthermore, since the field on digital innovation is rapidly growing, future research should closely monitor the latest developments in order to determine how the interplay of both dimensions can help conceptualize the phenomena of digital innovation.

With regard to determinants of digital innovation on the individual level, our results demonstrate a lack of research on actors of digital innovation. The literature agrees that the innovation agency is less pre-defined (Nambisan et al., 2017). Thus, actors in a digital innovation context are more distributed and heterogeneous. Authors emphasize the presence of several innovation actors referred to innovation collectives with diverse goals, motives, and capabilities (e.g., Barrett et al., 2012). Nevertheless, the authors remain very generic and superficial. Specific aspects and research with focus on innovation actors are rare and ambiguous across the literature. For example, only one article examined digital innovations with focus on the actors within the innovation process (Ebermann et al., 2016). The remaining papers have other research foci and the results on actors were mainly side effects of their actual research. Consequently, a comprehensive understanding of innovation actors in a digital context is indispensable. Therefore, this research area should be further explored in the future.

Moreover, the literature on innovation without a digital context has identified a number of different actors, who share common goals and characterized by the same knowledge types, skillsets and behaviors (e.g., Hayton and Kelley, 2006; Howell and Higgins, 1990). In general our sample indicates that there is a stronger focus on heterogeneity among actors (Nambisan et al., 2017) in digital innovation, however, there also exists research on networks that propose the contrary (Lyytinen et al., 2016). Therefore, future research should cover this topic by exploring the differences between actors of innovation and actors of digital innovation with respect to their characteristics and capabilities. Taken up to this point, one article (Polykarpou and Barrett, 2017) suggests possible identity changes in the context of digital innovation. As existing literature in the context of digital age has already acknowledged that digital technologies can lead to an identity shift of individuals, a so called IT identity (Carter and Grover, 2015).

Further research in this area could generate additional value for research and practice, by investigating the adoption of digital innovation from both a developer and a user perspective. Furthermore, only little is known concerning the researched user perspective. Although this topic is especially important in digital innovation (due to the important characteristics of digital technology), there are only a few papers that cover this perspective (e.g., Ebermann et al., 2016). Therefore, future research needs to investigate the phenomenon of digital innovation actors with the help of other data collection and analysis methods to extend the extant anecdotal and conceptual body of literature to also include empirically based research knowledge. Table 4 gives an overview over fruitful avenues for future research:

Recommendation	Research question for future research
<b>Process and Outcome:</b> Researchers should explore how the convergence of process and outcome challenges current innovation frameworks	<ul style="list-style-type: none"> <li>• How does pervasive digitization challenge extant innovation frameworks and theories?</li> <li>• Can extant innovation frameworks and theories be adapted to fit digital innovation or is there need for novel theorizing?</li> <li>• How can organizations handle the increasing complexity caused by an unprecedented amount of internal and external knowledge?</li> </ul>
<b>Individual Determinants of Digital Innovation:</b> Researchers should explore the heterogeneity of actors in the development process	<ul style="list-style-type: none"> <li>• What roles do individual, heterogeneous actors play for the development of digital innovation?</li> <li>• How do heterogeneous actors collaborate when developing digital innovation?</li> <li>• How are digital innovation actors characterized with respect to their personality, skills and knowledge?</li> </ul>
<b>Individual Determinants of Digital Innovation:</b> Researchers should explore the emergence of innovation collectives	<ul style="list-style-type: none"> <li>• How do digital innovation collectives evolve?</li> <li>• What characterizes digital innovation collectives?</li> </ul>
<b>Individual Determinants of Digital Innovation:</b> Researchers should explore the changing characteristics of innovation actors	<ul style="list-style-type: none"> <li>• What differences exist between innovation actors and digital innovation actors?</li> <li>• How do innovation actors and digital innovation actors differ with respect to their characteristics and capabilities?</li> <li>• What characterizes the identity of digital innovation actors? What are the components of an IT identity?</li> <li>• How does the identity of innovation actors change when moving from a non-digital to a digital context?</li> </ul>

Table 4. Recommendations and Research Questions for Future Research

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