

The Nature of Digital Innovation and What Can Be Learned for Information Systems Management

Stefanie Kaczmarek^a, Martin Benedict^b and Marcel Susky

Chair of Wirtschaftsinformatik, esp. Systems Development, Technische Universität Dresden, Dresden, Germany

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Abstract: In all spheres of life, the ongoing digital transformation has led to an increasing variety of definitions, types, and characteristics of digital innovation. However, the diversity of terminology regarding digital innovation may cause confusion about the general concepts in this context. Therefore, the objective of this study is to provide a descriptive insight into the nature of digital innovation. Our paper shows how digital innovation has altered since its emergence in the field of information systems re-research. This change of understanding has an impact on the design of information systems. Following a systematic literature review, a quantitative and qualitative analysis of the identified vocabulary was conducted to gain types and characteristics of digital innovation. Based on these characteristics, we describe how digital innovation influences information systems. We focus on hospital information systems as a case example from the healthcare sector.

1 INTRODUCTION

The use of novel digital technologies, such as virtual reality, cloud computing, and artificial intelligence, leads to changes in business models, internal company processes, products, and services. For companies and their customers, new opportunities in information acquisition, communication and consumption arise through digital technology (Rachinger et al., 2018). These changes by novel digital technology are named as Digital Innovation (DI). Not only traditional IT companies such as *Apple* or *Google* are involved in the development of DI, but also companies in finance, mobility and other industries (Fichman, Dos Santos & Zheng, 2014). Well-known success stories for business models based on DI include *Airbnb*, *Uber*, and *Spotify*, which conduct their business activities via digital peer-to-peer platforms. While *SAP's Simple Finance Add-on* is a highly automated and standardized solution for digitizing business processes, *Fitbit* and *Amazon's Kindle* are examples of digital product innovations (de Reuver et al., 2018).

The term "Digital Innovation" was coined by Yoo, Henfridsson & Lyytinen (2010) and refers to the possibility of developing new products by combining

physical components with digital technologies. Since digitalization offers the opportunity to fundamentally change former product experiences, DI are an essential step and foundation for competitive advantage for companies (Yoo, 2010). It is undisputed that DI plays a central role in the context of companies and in research on business information systems too (Hevner et al., 2019). However, as several different definitions, types, and characteristics of DI have prevailed, there is still confusion about the nature of DI and what DI means in the context of specific information systems. This diversity needs to be considered when aiming to improve existing information systems through DI. Different objectives may arise from different understandings of DI in different sectors of the economy.

For example, the healthcare domain is essential for every society and economy, but the potential for integrating DI into this domain has not been fully exploited yet (Jung & Padman, 2015). Especially hospitals, as major medical care providers, are affected by DI. However, it is less researched which aspects of DI may improve the success and utility of information systems in hospitals.

Addressing this gap, this paper analyses the nature and understanding of DI in information systems

^a  <https://orcid.org/0000-0001-8204-7010>

^b  <https://orcid.org/0000-0003-4262-9029>

research. Based on this analysis, the paper derives implications for the management of Information Systems (IS) in hospitals. Consequently, the paper addresses the following research question:

RQ: How have Digital Innovations changed in the course of digital transformation and what implications can be derived for the management of Information Systems in hospitals?

The remainder of this paper is structured as follows. After this introductory chapter, the research method used for the study is explained in chapter 2. The results of the systematic literature review are presented in chapter 3 and discussed in chapter 4. The paper concludes with a conclusion and gives an outlook on further research needs.

2 METHOD

2.1 Literature Analysis and Review

In order to gain a comprehensive understanding of DI, we conduct a systematic literature review following Fettke (2006) and Cooper & Hedges (1994). We analyze the existing literature using a quantitative description of the literature and a qualitative analysis of the full texts to conceptualize the understanding of DI. The knowledge gained from the quantitative and qualitative data analysis contributes both to a broader conceptualization of DI and to the provision of implications for theory and practice in the management of HIS. The quantitative analysis supports understanding of the context, in which DI is used and conceptualized. Therefore, we analyze the meta-data of the papers.

For a broader overview of papers, we searched in the electronic databases *Scopus* and *Web of Science*. These interdisciplinary databases were selected because DI is a phenomenon that can be found in all scientific disciplines. Hence, the search term “digital innovation“ was used in title, abstract and keywords. The search carried out in July 2019 yielded in a total of 677 (*Scopus*) and 318 (*Web of Science*) hits. After the removal of duplicates and incomplete sources, 792 publications remain for further consideration. The aim was to analyze the most important publica-

tions regarding DI. Therefore, we sorted and recorded the literature sources according to their citation frequency. Publications cited at least 50 times were included in a detailed qualitative analysis. In this case, 50 was chosen as the reference value, since the citation frequency of subsequent publications was rapidly decreasing. After examining the full-text of the most frequently cited publications, two of them were excluded. Thus, 12 publications remain (see Table 1, upper part). To expand the data basis for analysis, further papers were searched from the resulting list of the database search. Six additional publications (see Table 1, lower part) were identified. These were selected by their title. In the backward search, we selected papers that directly treat digital innovation in the title.

Table 1 shows the publication year and the number of citations of the twelve most frequently cited publications in the field of DI. The number of citations of publications from the reference list search refers to the citation frequency of *Scopus*. In addition, the subject areas to which the publications can be assigned are presented. According to the two selected databases, it is possible to search/classify document results by subject area. Since both databases use different categories in relation to the subject areas, a new classification has been created for reasons of comparability. For this purpose, five superordinate areas – Science, Humanities and Social Sciences, Engineering Sciences, Civil and Environmental Engineering, Medicine – were identified, to which 17 newly created classes of subject areas can be assigned.¹

The next step is to evaluate the identified literature, i.e. the check for relevance, the processing and systematization, as well as the analysis and interpretation of the results against the background of the problem (Fettke, 2006). In the full-text analysis, we analyzed the definitions of DI and screened the papers for DI characteristics.

2.2 Case Study

The characteristics of DI are used to systematize implications for Hospital Information Systems argumentatively. As a case study, we selected the healthcare sector because this sector is faced with a lot of barriers and issues regarding the implementation of digital technology (Alkrajji et al., 2013; Lluch, 2011).

¹ The area *Science* covers Mathematics; Biology; Psychology; Physics and Chemistry. *Humanities and Social Sciences* consists of Social Sciences (SS); Education, Linguistics; Cultural Studies, Arts and Humanities (CSAH) as well as Law and Public Administration. Computer Science (CS); Engineering (E) and Mechanical Science belong to the su-

perordinate area *Engineering Sciences*. To *Civil and Environmental Engineering* count Architecture, Civil Engineering; Transportation and Traffic Sciences; Business, Management and Economics and also Environmental Sciences (ES). The fifth area includes Medicine.

As a specific digital innovation, we selected the implementation of the Health Level Seven Fast Healthcare Interoperability Resources (HL7 FHIR) standard in Hospital Information System (HIS). A HIS is a comprehensive and integrated subsystem of a hospital that includes information on administrative, financial and clinical aspects. The HIS serves to map all information acquisition, information processing and information storage processes resulting from the interaction between human and machine actors. It supports the people involved in clinical everyday life in carrying out daily work processes, such as planning bed occupancy, optimal utilization of operating rooms or diagnosis, in all functional areas of the hospital (Khalifa & Alswailem, 2015; Moghaddasi et al., 2018; Moser, 2013; Winter et al., 2011). The goal of a HIS is to contribute to adequate patient care that considers the concept of cost-effectiveness on the one hand and satisfies legal framework conditions on the other hand. The HIS has the task of providing the right information about patients to the right recipient at the right time, at the right place, in the required quantity and quality. The automated subsystems of HIS are referred to as Hospital Application Systems (HAS). Examples of HAS are the Clinical Documentation and Management System (CDMS), the Laboratory Information System as well as the Picture Archiving and Communication System (Haux, Winter, Ammenwerth & Brigl, 2013; Moser, 2013). We selected HIS because they are important for the implementation of DI in the healthcare sector (Scheplitz et

al., 2019). They are a focal point of data management in integrated care settings and store versatile data about the patient's treatment chain.

Besides the installation of new digital devices, the integration of DI into HIS is also the implementation of software or the reconfiguration of existing HAS and the integration of them. For example, the implementation of a generic and reusable Application Programming Interface (API) for third party applications can be treated as DI. The HL7 FHIR standard provides such an approach (Bender & Sartipi, 2013). It describes a generic resource-oriented representation of clinical data structures. Like a building block system, these resources can be combined for different use cases. A CDMS could publish such resources and another HAS can use them for different use cases.

3 RESULTS

3.1 Quantitative Analysis

A total of 792 publications with regard to time perspective, the geographical perspective, and the subject area were examined in the course of the quantitative analysis. For this purpose, data sets from *Scopus* and *Web of Science* were recorded in spreadsheets. Afterward, the data sets were graphically processed using diagrams.

Table 1: Digital Innovation papers and their publication year, number of citations, country, subject area.

No.	Reference	year	# citations	Subject area
1	Yoo, Henfridsson & Lyytinen	2010	545	CS, SS, BME
2	Yoo, Boland, Lyytinen & Majchrzak	2012	428	BME
3	Lusch & Nambisan	2015	240	CS, CSAH, BME
4	Boudreau	2012	198	BME
5	Fichman, Dos Santos & Zheng	2014	169	CS, BME
6	Y. Yoo	2013	103	CS
7	Barrett, Oborn, Orlikowski & Yates	2012	92	BME
8	Nylén & Holmström	2015	84	BME
9	Nambisan & Lyytinen	2017	66	CS, CSAH, BME
10	Nambisan	2013	65	CS, SCAH, BME
11	Svahn, Mathiassen & Lindgren	2017	51	CS, BME
12	de Reuver, Sørensen & Basole	2018	50	CS, SS, BME
13	Lee & Berente,	2012	38	BME
14	Huang, Henfridsson, Liu & Newell	2017	36	CS, BME
15	Henfridsson, Mathiassen & Svahn	2009	27	CS
16	Sørensen & Landau	2015	23	SC, BME
17	Svahn & Henfridsson	2012	23	E
18	Selander, Henfridsson & Svahn	2010	21	CS
19	Svahn, Lindgren & Mathiassen	2015	7	E
20	Yoo, Lyytinen, Boland, Berente, Gaskin, Schutz & Srinivasan	2010	not specified	CS, BME

Time Perspective. Figure 1 shows the development of the number of publications over time. The number of publications increased continuously, especially since 2010. Since 2010, the number of publications almost increased by thirty times and has had a strong increase up to 202 publications in 2018.

Geographical Perspective. In total 881 authors were counted from 58 different countries of origin. For 56 authors (about 6 percent) no assignment to a given country was possible due to missing information. Figure 2 shows the continental distribution of authors with the region of origin and publications devoted to DI (n = 825). Nearly 61 percent (n = 507) of the authors originate from Europe, followed by North America with about 20 percent (n = 164) and Asia

with about 11 percent (n = 88). The remaining 8 percent (n = 66) of authors originate from Australia, Africa and South America. At the level of countries, the five topmost are: United States (about 18 percent, n = 145), United Kingdom (12 percent, n = 99), Germany (about 10 percent, n = 79), Italy (about 7 percent, n = 54) and Sweden (about 6 percent, n = 48).

Subject Area. Figure 3 depicts the number of assignments per subject area and highlights the five superordinate subject areas build from the 17 created subject areas shown. As the figure illustrates, most of the publications on DI are found in the superordinate subject areas Engineering Sciences (white, n = 514), Civil and Environmental Engineering (middle gray, n = 437) and Humanities and Social Sciences (light gray, n = 386). By comparison, those in the areas of

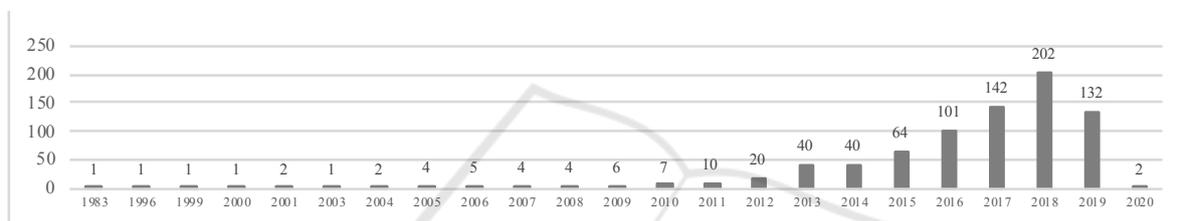


Figure 1: Number of Publications focusing on Digital Innovation per Year.



Figure 2: Regional distribution of publications focusing on Digital Innovation.

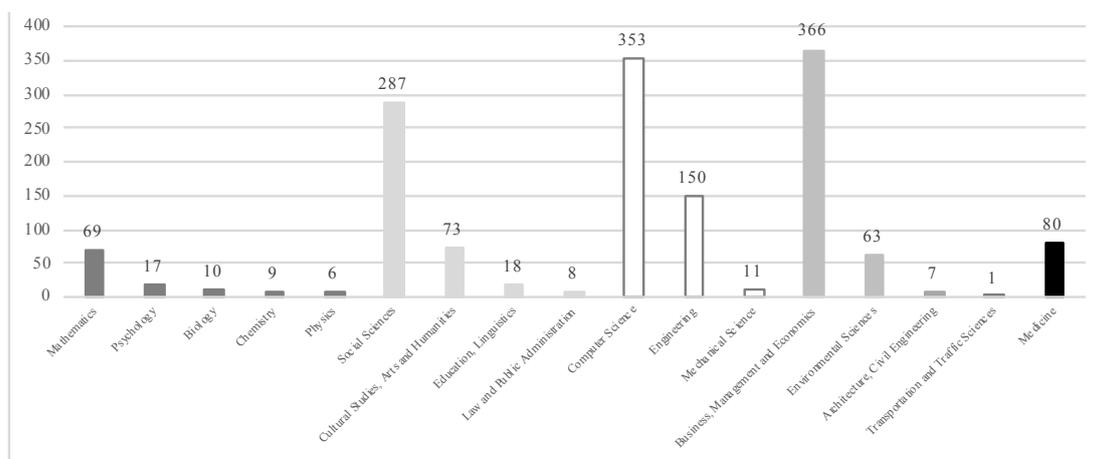


Figure 3: Number of Publications focusing on Digital Innovation per subject.

Science (dark gray) and Medicine (black) are low. With respect to the illustrated disciplines, publications on DI are mainly found in Business Management and Economics (n = 366), Computer Sciences (n = 353) as well as Social Sciences (n = 287).

3.2 Qualitative Analysis

A total of 20 publications with regard to the underlying definition of DI, type of innovation and characteristics of DI was examined in the qualitative analysis. Table 2 depicts the seven distinct definitions found, except those that refer repeatedly to the fundamental publication by Yoo, Henfridsson & Lyytinen (2010) or without novelty content with respect to the other publications analyzed.

Definition and Types of DI. Seven of the 20 publications propose an own definition of DI (Fichman, Dos Santos & Zheng, 2014; Huang, Henfridsson, Liu & Newell, 2017; Lusch & Nambisan, 2015; Nambisan & Lyytinen, 2017). Among them are three definitions by Yoo et al. (2010; 2010; 2012) which differ marginally. They define *DI as a product innovation* in which physical and digital components merge. They see the advancing digitalization as a necessary prerequisite for this. In the other 13 cases, their definition was reused. As adoption to the fundamental definition, Lusch & Nambisan (2015) as well as Huang, Henfridsson, Liu & Newell (2017) emphasize the aspect that DI can create a new kind of benefit or value in a certain context. The advantage of this definitional approach is that it is not the value of the result

Table 2: Definitions, types, and characteristics of Digital Innovation.

No.	Definition	Type	Characteristic
1	„We define digital innovation as the carrying out of new combinations of digital and physical components to produce novel products. [...] A necessary but insufficient condition for digital innovation is that the new combination relies on digitization [...]” (Yoo, Henfridsson & Lyytinen, 2010 , p. 725)	product innovation	reprogrammability, data homogenization, self-referential nature
2	“A defining characteristic of pervasive digital technology is the incorporation of digital capabilities into objects that previously had a purely physical materiality.” (Yoo, Boland, Lyytinen & Majchrzak, 2012, p. 1398)	product innovation	convergence, generativity
3	„Service innovation can then be considered the rebundling of diverse resources that create novel resources that are beneficial (i.e., value experiencing) to some actors in a given context; [...]” (Lusch & Nambisan, 2015, p. 161)	service innovation	service ecosystem, service platforms, value cocreation
4	“We define digital innovation quite broadly as a 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.” (Fichman, Dos Santos & Zheng, p. 330)	product, process, business model innovation	not specified, but in accordance to (Yoo, Henfridsson & Lyytinen, 2010)
5	„We conceptualize digital innovation as the creation of (and consequent change in) market offerings, business processes, or models that result from the use of digital technology. Stated differently, in digital innovation, digital technologies and associated digitizing processes form an innate part of the new idea and/or is development, diffusion, or assimilation.“ (Nambisan & Lyytinen, 2017, p. 224)	product, platform, service, customer experience, other value pathway innovation	malleable, editable, open, transferable, continue to evolve, unpredictability, dynamic
6	“We define digital innovation as the recombination of digital components in a layered, modular architecture to create new value-in-use to users or potential users of a service.” (Huang, Henfridsson, Liu & Newell, 2017, p. 302)	service innovation	separation of function and form, separation of contents and medium
7	“By digital innovation, we mean an innovation enabled by digital technologies that leads to the creation of new forms of digitalization.“ (Yoo, Lyytinen, Boalnd, Berente, Gaskin, Schutz & Srinivasan, 2010, p. 13)	product innovation	programmability, addressability, senesability, memorability, traceability, communicability, associability

as such that is considered, but the value perceived by the customer. The customer, therefore, plays an active role in the development of digital service innovations. The bundling of different resources in digital service innovation depends on the degree of digitization (Lusch & Nambisan, 2015). According to Fichman, Dos Santos & Zheng (2014), *DI not only refer to products but also to processes and business models*, which implies a broader view of DI. A further adaptation of the initial definition lies in the requirement that users have to change. Nambisan & Lyytinen (2017) provide the most comprehensive view by defining DI as *the introduction of novel “market offerings”*. The term “market offerings” is deliberately kept open, as it conceals a multitude of outcomes, such as products, platforms, services, customer experiences, and value pathways. To enable these outcomes, different digital technologies (digital tools, infrastructure) are needed, which themselves represent an essential component of innovation and “may be diffused, assimilated, or adapted to specific use contexts [...]” (Nambisan & Lyytinen, 2017, p. 224). Furthermore, DI can also be seen as a means for creating DI, but also as a result of it, and thus lead to new forms of digitization (Yoo, Lyytinen, Boland, Berente, Gaskin, Schutz & Srinivasan, 2010).

Most often, DI is associated with product innovation (Fichman, Dos Santos & Zheng, 2014; Nambisan & Lyytinen, 2017; Yoo, Boland, Lyytinen & Majchrzak, 2012; Yoo, Henfridsson & Lyytinen, 2010; Yoo, Lyytinen, Boland, Berente, Gaskin, Schutz & Srinivasan, 2010), but also with service innovations (Huang Henfridsson, Liu & Newell, 2017; Lusch & Nambisan, 2015). Fichman, Dos Santos & Zheng (2014) define DI more broadly and include process and business model innovations. Ultimately, DI are much more than that: they can be product, service, process, business model, application software, platform, customer experience or other value innovations (Nambisan & Lyytinen, 2017).

Characteristics of DI. Yoo, Henfridsson & Lyytinen (2010) describe an initial set of the key characteristics of DI. They name reprogrammability, data homogenization, and self-referencing. *Reprogrammability* signifies the separation of the form of the physical object and its function. This means, that the behavior of physical products can be changed during their lifetime. An example is the implementation of programmable operating systems on different physical devices. *Data homogenization* offers the opportunity to capture, process and display any type of digital content on the same digital device. An example is the use of smartphones, which allows access to different

kinds of data and services. These can be integrated by defined technological interfaces. Different digital data can be combined and accomplish different functions because the content is separated from the medium. These two fundamental aspects are underpinned by Huang, Henfridsson, Liu & Newell (2017). *Self-reference*, as the third unique characteristic, points to the fact that the usage of digital technology broadens the availability of digital devices and in consequence leads to lower entry-barriers and higher diffusion rates.

Also, Yoo, Lyytinen, et al. (2010) propose a more detailed view and introduce six dimensions of DI: digital materiality (and its properties program-mability, addressability, senseability, memorability, communicability, traceability and associability), heterogeneity, locus of innovation, pace, convergence and generativity (Yoo, Lyytinen, et al., 2010). *Digital materiality* is described as the inseparable integration of social, physical and digital aspects. *Heterogeneity* denotes the variety of data, knowledge, and tools used by DI. The *locus of innovation* draws on the location-independent development of DI to save communication and storage costs. The speed at which new solutions could be developed is referred to as *pace*. This is possible because existing physical components as well as established digital infrastructures are reused, and re-combined. *Convergence* means the integration of devices, networks, services and contents enabled through data homogenization. *Generativity* is used as a synonym for the ambiguity of DI due to the fact, that DI is reinterpreted, expanded and refined permanently. Yoo, Boland, Lyytinen & Majchrzak (2012) generalized the latter two dimensions, convergence and generativity, two years later, in 2012. According to the generalization, convergence suggests the use of digital technologies that creates a link between previously separated user experiences and industries as well as embeds digital technologies into physical products. Whereas their previous description of generativity is summarized to the terms dynamic and malleability. Nambisan & Lyytinen (2017) refer to the terms *malleable*, *editable*, *open* and *transferable* as characteristics of digital artifacts. Further, since the nature of DI is subject to constant change, they also characterize DI by *unpredictability* and *dynamism*. Lusch & Nambisan (2015) address central themes of digital service innovations instead of characteristics.

3.3 Course of Digital Innovation

To show how the nature of DI have changed in the course of the ongoing digital transformation, Figure 4

illustrates the development of DI over time. The horizontal axis indicates the publication years, whereas the vertical axis denotes the emerged innovation types. A number in square brackets represents the reference and the publication year accordingly. Each of those is enclosed by an ellipse, covering the innovation types named in the respective publication. The DI characteristics mentioned in the publication is represented as label. Ellipse overlaps illustrate the intersection of characteristics. Ellipses below the next higher innovation type mark do not include this innovation type. The central themes of digital service innovation have been included to complete the figure (see dashed ellipse), but are not considered further (see chapter 3.2).

Figure 4 shows that two papers by the same authors were published almost simultaneously. While one paper, published as a report, deals very thoroughly with six dimensions of DI (Yoo, Lyytinen, et al., 2010), the other paper focuses on the distinction between digital and conventional technologies (Yoo, Henfridsson, Lyytinen, 2010). Two years later, the authors published a third paper highlighting the characteristics convergence and generativity (Yoo, Bolland, Lyytinen & Majchrzak, 2012), which were already part of the six dimensions of the report. Over a period of four years, the three characteristics of the fundamental paper (reprogrammability, data homogenization, self-referencing) were considered as the prevailing view. In 2017, the aspect of dynamism and unpredictability became prominent, and emphasized the need for editability, openness, and transferability. At the same time, the separation of function and form, as well as the separation of contents and medium, was established.

Concerning the innovation type, it is obvious, that DI arise from digital product innovation. In addition, there is a trend for DI in the direction of digital service innovation. The innovation types of customer experience innovation and other value innovation were not mentioned before its appearance in 2017.

3.4 Implications for the Management of Information Systems in Hospitals

When questioning how the conceptualization of digital innovation influences the implementation and management of HIS, the characteristics of DI can help to systematize design criteria. In the following, we use the characteristics of YOO ET AL. (2010) as guiding characteristics. The implementation of DI in HIS is challenging both from a technological and an organisational perspective. Different barriers exist on

different layers. We mainly focus on the enablers and barriers at the information, application and infrastructural layer following SCHEPLITZ ET AL. (2019). These layers mainly comprise the view on products and technological services. Therefore the selection of the three characteristics of YOO ET AL. (2010) is adequate as they focus on digital innovation with a product focus. The implementation of FHIR addresses the enabler of the concerted definition of contents of medical records and the barrier of faulty and incompatible data models.

Reprogrammability in HIS implies that the HIS must be able to react at any time to changing requirements by adapting HAS functions. The requirements resulting from new tasks and goals in care of patients. These are formulated by the healthcare professionals. New functionality needs to be included, immediately when it is needed. The implementation of FHIR in HIS gives this opportunity because it enables third-parties to connect to well-defined interfaces and to add functionality through new applications. Furthermore, FHIR supports the migration of HAS to modularized systems and allows the implementation of technological decoupled services. As an example, an architecture for pathway-based patient integration can be named (Benedict et al., 2019). New applications can be connected to FHIR interfaces and create unanticipated functionality. This saves costs since the interfaces are purchased once, but used multiple times in different ways.

Data homogenization means that the HIS must support the acquisition of health-related data with a high degree of reusability and interoperability. For example, a smartwatch measures the patient's heart rate permanently and sends the data via FHIR Observations to the vital data API of the CDMS. Due to homogeneity of data, the measurement data can be transferred from one digital device to another system, (in this case from the smartwatch to the CDMS). It can be directly interpreted by the CDMS, because FHIR ensures the interoperability. At the same time, the physician is able to examine and integrate the findings in a case record, including the patient's heart rate. He can use different vital data provided by different sensors via FHIR graphically on his tablet pc. He can mix data of the patient for individual dossiers and share them with colleagues. For example, he can retrieve the data via a web-interface created by the informaticians in the hospital's IT department. This web-interface also accesses the FHIR interfaces of the CDMS to gain the relevant observations which result from the smartwatch.

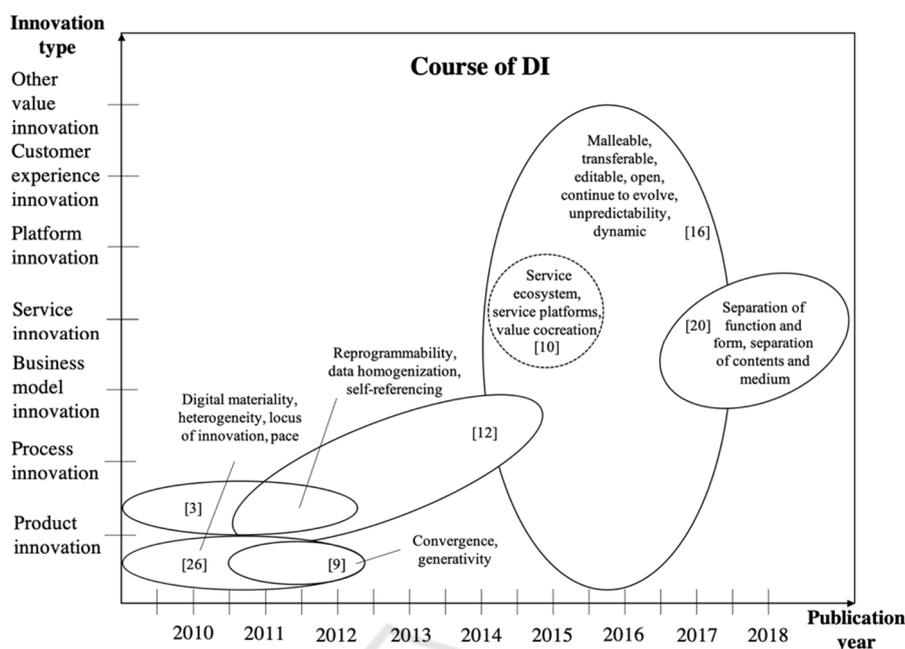


Figure 4: The Course of Digital Innovation since 2010.

Self-reference in the context of HIS means, that the availability of reusable technology eases the integration of new DI into the HIS. The availability of FHIR interfaces eases the integration of new digital technologies. For example, the integration of legacy patient sensor systems can be more facilitated by providing a standard-based vital data FHIR interface which is originally created to record the heart rate. The implementation of FHIR in a hospital eases access to machine-readable data. The knowledge about the existence of standardized interface lowers the barriers for investing in interfaces.

4 DISCUSSION

Based on the findings of the literature analysis described in the previous chapter, the results obtained are discussed in more detail below. The explanation starts with general or methodological aspects, followed by a discussion of the quantitative and qualitative results.

Methodological Aspects. The amount of the most frequently cited publications which were analyzed (n = 12) in relation to the total number of identified articles (n = 792) is 1.5 percent. This amount is comparatively too low to be able to draw general conclusions about the nature of DI. Nevertheless, the citation frequency is an appropriate measure to assess the

relevance of scientific contributions. However, by focusing on the citation frequency, relevant publications may have been excluded. In order to address this problem and to expand the database, a search using backward references was included in the literature search process. A detailed analysis of the 18 publications has shown that the majority (65 percent) of all contributions refer to the contents published by Yoo, Henfridsson & Lyytinen (2010).

Quantitative Analysis. The number of publications on DI has been growing steadily since 2010. This can be explained by the growing pace of digitalization and by the seminal work of YOO, HENFRIDSSON & LYYTINEN (2010) that has laid the foundation for research in the field of DI. The number of publications (n = 202) reached a high level in 2018 and the trend seems to continue. More than 101 publications have already been published in the first half of the year 2019. However, it is possible that some publications of 2018 and the first half of 2019 were not yet registered in the databases.

The majority of publications descend from Europe. One possible explanation for this could be the fact that two of the three authors of the initial paper (Henfridsson and Lyytinen) come from Scandinavia. With their ten respectively four publications on DI, they have made a significant contribution to the research in this field. Most publications have been published in the United States and United Kingdom. This is probably because papers are usually published in

the English-speaking field of information systems research and organizational management to be accessible to a wide audience and there are fewest language barriers.

The majority of publications are assigned to the subject area Business, Management and Economics. Classically, innovations have been the subject of Business Administration. Depending on the point of view, Business Administration is understood as Humanities or Social Science and thus explains the high number of publications in this field. In addition, there are numerous publications in the field of Computer Science. This can be explained by the fact that the authors of the fundamental work have an economical background, but also explore the field of Computer Science.²

Qualitative Analysis. The seven identified definitions have in common that digitization respectively the use of digital technologies or IT are necessary prerequisites for the creation of DI. While Yoo et al. (Yoo, Boland, Lyytinen & Majchrzak, 2012; Yoo, Henfridsson & Lyytinen, 2010; Yoo, Lyytinen, Boland, Berente, Gaskin, Schutz & Srinivasan, 2010) inevitably associate DI with a combination of digital and physical components, other authors do not emphasize the physical aspect in their definition. This is due to the fact that the authors focus on different topics (e.g. product development, business process optimization, business model creation). In contrast, the definition of Nambisan & Lyytinen (2017) is open so that any market offering can be regarded as an innovation. The reason for this is that the authors consider DI as a variable socio-technical phenomenon and that this character can only be considered by looking at it very broadly.

DI is inseparably associated with the innovation type product innovation because 67 percent (12 out of 18) of the publications refer to Yoo, Henfridsson & Lyytinen (2010). The authors consider product innovations opposed to process innovations, which have already been extensively studied in IT research. Ultimately, innovations can arise in the product or service area. Software application and platform innovations are examples of subtypes of service innovations. The evolution from product innovation type to service innovation type over time can be explained by the fact that service enhancements only become relevant once a product to which the service relates has been developed. We observed that the understanding of DI as a

concept was getting more comprehensive over time. This can be explained by the ongoing digital transformation of the economy, which leads to new business models and a change to service-dominant logics (Lusch & Nambisan, 2015).

In summary, it can be stated that the characteristics of DI are named differently in almost every publication. In two publications two characteristics are proposed, in other publications three or even seven. Hereby it becomes clear that the categories are sometimes narrower, sometimes broader and often overlap. Of particular interest is that although two publications by the same authors were published in 2010, DI characteristics were named differently. The report published in January (Yoo, Lyytinen, et al., 2010) distinguishes between characteristics of digital technologies (data homogenization, programmability, self-referencing), properties of digital materiality and dimensions of DI (convergence, digital materiality, heterogeneity, generativity, locus of innovation, pace). The publication (Yoo, Henfridsson & Lyytinen, 2010) describes reprogrammability, data homogenization and self-referencing as key characteristics of DI. In 2012 (Yoo, Boland, Lyytinen & Majchrzak, 2012), the authors are talking about only two unique characteristics – convergence and generativity. Thus, the use of terms is not consistent. For example, the separation of function and form is assigned in (Yoo, Lyytinen, Boland, Berente, Gaskin, Schutz & Srinivasan, 2010) to the characteristic digital materiality, in (Yoo, Henfridsson & Lyytinen, 2010) reprogrammability and in (Yoo, Boland, Lyytinen & Majchrzak, 2012) as generativity. The two publications from 2017 (Huang, Henfridsson, Liu & Newell, 2017; Nambisan & Lyytinen, 2017) describe the properties of the characteristics of (Yoo, Henfridsson & Lyytinen, 2010) in other words and augment them (e.g. malleable, dynamic).

5 CONCLUSIONS

In the last years the understanding of DI has become more holistic. While the early innovation discussions focused more on the materiality of DI, the later discussions investigated networks and logics of innovation. When integrating DI into existing IS, IS managers need also consider whether their existing subsystems of the IS are “ready for innovation”. Consequently, there is a need to analyze the ability of IS to

² Yoo is a Korean professor of Entrepreneurship and Information Systems in Design and Innovation at Weatherhead School of Management/Case Western Reserve University. Henfridsson is a Swedish professor at Warwick Business

School and was once Head of the Information Systems Group. Kalle Lyytinen is a Finnish professor of Management Design and Design and innovation at Weatherhead School of Management/Case Western Reserve University.

both integrate and create DI. This paper contributes by introducing different fields of DI from which different characteristics for subsystems of IS (e.g. reprogrammability, data homogenization, self-referencing) can be derived. These properties may be used to analyze, evaluate and to re-engineer existing IS. By describing implications for HIS, the paper shows how the characteristics of DI can be instantiated in a specific domain. Since our focus was on the technological implications an analysis of organizational implications for HIS design is outstanding and needs to be treated in further research.

This paper offers a detailed description of the nature of DI, but also contains limitations that provide directions for further research. In order to verify and extend the analysis results, a much larger data basis should be considered in the following investigation. In addition, the results of the descriptive analysis offer the potential to find out, through an in-depth inductive analysis, why new definitions and innovation types have developed and why certain characteristics emerged or disappeared – even if this is already partly the case in this paper. An ontology would be an appropriate approach to visualize and clearly distinguish the diversity of terminologies used.

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