Digitalization of Business Processes:

Methods and Frameworks for Project Selection and Implementation

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“*Remember to look up at the stars and not down at your feet. Try to make sense of what you see […]. Be curious. And however difficult life may seem, there is always something you can do and succeed at.*”

Stephen Hawking (1942-2018)

I would like to thank all those who have supported me on my way to writing this doctoral thesis. In particular, I would like to thank my mother Christine, my sister Ann Catherine, my brother in law Martin, and of course my future husband Maximilian – thank you for your continuous support and for making my life such a great journey!

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Abstract

Digitalization, which relies on the ever faster adoption of digital technologies, fundamentally changes societal conventions and organizational routines. The omni-presence of digital technologies entails an opportunity-rich, fast-moving, and connected environment, which is characterized by the availability of new data sources, the fusion of the digital and the physical world, and the pervasive connectivity of individuals, organizations, and real-world objects. For organizations, these changes pose threats and give rise to new opportunities alike. Besides advantages related to product and service offerings, digitalization enables the more effective and efficient handling of business processes. Despite the great number of promising opportunities, organizations still struggle with systematically embedding digital technologies into their business processes and deriving value from digitalization. Against this backdrop, this doctoral thesis is cumulative and consists of five research papers located at the intersection of digitalization, business process management, and project management. It investigates the digitalization of business processes by providing well-founded methods and frameworks that help organizations derive, prioritize, and implement process improvement ideas in line with digital technologies. Thus, the thesis does not only cover a scientific perspective, but also gives practical guidance, being relevant for both academics and practitioners alike.

In times of digitalization, the business process management discipline faces new challenges requiring to manage business processes in multiple contexts simultaneously. As the status quo of existing methods reveals an overall lack of context awareness, the thesis first provides a method on how to assess and select business process management methods in a context-aware manner (research paper #1). In response to this call for context-aware methods, the thesis further presents a method that supports organizations in the identification and prioritization of suitable digital technologies for their business processes (research paper #2). As the method's application to real-world processes revealed a substantial lack of knowledge regarding the existence and opportunities of digital technologies, additional frameworks are provided. First, the thesis presents a taxonomy and nine archetypes of digital technologies to improve their understanding (research paper #3). As these archetypes are independent of specific domains and contexts, they are contextualized to a specific discipline, revealing a framework of digital technology affordances in intra-logistics (research paper #4). Finally, the thesis enhances the project management perspective and investigates the successful implementation of selected digital technologies. Therefore, existing success factors of PDPs are compiled, validated, and refined in multiple case studies. Being aware of the final framework and its PDP success factors, managers – or other persons responsible for the successful implementation of digital technologies – can systematically drive digitalization of business processes to success (research paper #5).

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I. Introduction[1]

Digitalization, which relies on the ever faster adoption of digital technologies (DTs), fundamentally changes societal conventions and organizational routines (Gimpel et al. 2018; Legner et al. 2017). Therefore, DTs are the subject of many discussions in academic (Yoo et al. 2010) and professional literature (Accenture 2019). The Gartner Hype Cycle for Emerging Technologies (GHC), for example, listed over 100 DTs in the last few years. While long-standing technologies such as the telephone needed 75 years to reach 100 million users, recent developments achieved similar coverage about two years (Statista 2017). This rapid advancement has led to several efforts in structuring the broad field of DTs (Bharadwaj et al. 2013). The well-known SMAC acronym, for example, classifies DTs into social, mobile, analytics, and cloud technologies (Dewan and Jena 2014; Evans 2016). Another approach, the so called DARQ acronym, names distributed ledger, artificial intelligence, extended reality, and quantum computing as 'the next set of technologies' (Accenture 2019). Further, the increasing connectivity of ever more DTs gave rise to the term 'Internet of Everything', which is substantiated by the foresight of 30 billion connected devices (O'Neil 2016) and a worldwide revenue expectation of USD 7 trillion by 2020 (Wortmann and Flüchter 2015). Regardless of the underlying classification, all DTs have one thing in common: Transforming entire businesses and industries (Gilbert 2003), digitalization entails an opportunity-rich, fast-moving, and connected environment, which is characterized by the availability of new data sources, the fusion of the digital and the physical world, and the pervasive connectivity of individuals, organizations, and real-world objects (Matt et al. 2015). On the one hand, these changes pose major threats to organizations, but – on the other hand – they also give rise to new opportunities providing avenues for business growth (Lucas Jr. and Goh 2009).

The *threats* of digitalization relate to the essence of the digital age, which is characterized by volatility, uncertainty, complexity, and ambiguity (Bennett and Lemoine 2014). Corresponding challenges are manifold, including rapidly changing customer demands, increasingly strict regulatory requirements, and increasing competitive pressure, to name but a few (Legner et al. 2017). To succeed in the digital age, many organizations must undergo a substantial socio-technical transformation (Legner et al. 2017; Porter and Heppelmann 2014), which requires to understand and align different elements such as people, skills, business processes, machines, infrastructure, and transformation projects, for example (Davenport and Westermann 2018;

[1] This section is partly comprised of content taken from the research papers included in this thesis. To improve the readability of the text, I omit the standard labeling of these citations.

Gimpel et al. 2018). Further, organizations need to understand, where to focus time and resources, how to scope digital transformation initiatives (including their interplays), how to assess the (added) value of digital transformation endeavors, and how to redefine business processes and organizational structures (Davenport and Westermann 2018; Denner et al. 2018). Even though the threats and related challenges seem great at first sight, digitalization also offers major *opportunities*, which have been investigated by various research communities (e.g., innovation management, strategic management, or marketing). Besides numerous opportunities related to product and service offerings or the development of new business models (Legner et al. 2017), digitalization enables the improvement, i.e., the more effective and efficient handling, of business processes, which is the focus of this thesis. In line with the uptake of new DTs, digitalization transforms existing (and enables new) processes due to its impact on individual behavior and needs, intra- and inter-company collaboration, and new forms of automation (Berger et al. 2018; Gimpel et al. 2018). Social collaboration platforms, for example, facilitate the assembly of teams working on knowledge-intensive processes independently (Colbert et al. 2016), whereas robotics and cognitive process automation enable the automation of unstructured tasks (van der Aalst et al. 2018; Zarkadakis et al. 2016). DTs have further shown their potential to transform business processes in line with the Internet of Things (IoT) or blockchain, which enable decentralized and trusted processes (Oberländer et al. 2018; Viryasitavat et al. 2018). To conclude: Beyond their implementation within products, DTs are contextualized by means of processes (Melville et al. 2004; Tallon et al. 2000), whereas organizations must embed DTs within their business processes to generate value from digitalization (Denner et al. 2018).

As the related discipline, *business process management* (BPM) refers to the science and practice of overseeing how work is performed to ensure consistent outcomes and to take advantage of improvement opportunities (Dumas et al. 2018). Over the years, BPM significantly evolved and – coupled with the increasing importance of technologies – matured into an inclusive management discipline (Harmon 2014; Rosemann and Vom Brocke 2015). Topics of interest are all types of processes, which are most commonly split into the areas of core, support, and management processes. Further, they are often characterized by repetitiveness, knowledge intensity, interdependence, and variability, for example (Vom Brocke et al. 2016; Zelt et al. 2018). Today, BPM encompasses activities along the whole lifecycle of a process, i.e., identification, discovery, analysis, redesign, implementation, execution, monitoring, controlling, improvement, and innovation (Macedo de Morais et al. 2014; Recker and Mendling 2016), whereas improvement and innovation are considered the most value-adding parts (Denner et al. 2018). Process improvement has long been recognized as an important topic and continues to be a top priority topic for process managers (Harmon and Wolf 2016). The 2019 study by the Harvey Nash Group and KPMG confirms that improving businesses processes is still ranked as number two of the top five priorities by company boards (Harvey Nash Group and KPMG 2019). Common goals of process improvement are reduced costs and throughput times, increased flexibility and quality, and process innovation (Dumas et al. 2018). To successfully apply BPM in general or business process improvement in particular, a mature portfolio of supportive principles, methods, and tools along the whole BPM lifecycle has been developed (Recker and Mendling 2016).

As outlined above, digitalization has an ever-increasing influence on the processes of organizations, leading to significant changes in their existing work routines (Legner et al. 2017). The rise of new DTs enables organizations and their related BPM to accelerate the *digitalization of business processes*, which is henceforth defined as the proper embedment of suitable DTs within business processes (Denner et al. 2018). Through processes, organizations can implement DTs in activities, tasks, and interactions within the organization as well as with customers and suppliers (Harmon 2014; Rosemann and Vom Brocke 2015). Even though the digitalization of business processes opens up many opportunities, organizations still struggle with successfully implementing and systematically deriving value from DTs (Davenport and Westermann 2018). This is not due to a general lack of business process improvement ideas. Some researchers have, for example, investigated how to structure the derivation of improvement ideas by compiling process enhancement patterns or redesigning best-practices (Mansar and Reijers 2007; Recker and Rosemann 2014). Others examined how to prioritize process improvement projects, e.g., via process assessment heat maps or decision models that valuate improvement projects in terms of their impact on process performance (Darmani and Hanafizadeh 2013; Mansar et al. 2009). Further, Vanwersch et al. (2016) proposed a framework that enables practitioners to generate process improvement ideas on their own. What is missing, is a structured approach that helps organizations derive, prioritize, and implement process improvement ideas in line with DTs, or – in other words – guidance on the digitalization of business processes (Denner et al. 2018).

As the digitalization of business processes entails transformational efforts, organizations should proceed in projects to achieve pre-defined goals. Thereby, the *project management* (PM) discipline differentiates the phases of project selection (Petit 2012), planning, execution, and control (Clarke 2016; Tatikonda and Rosenthal 2000). Whereas, project selection describes the identification of projects to achieve an organization's strategic goals (Elonen and Artto 2003), project planning encompasses the definition of requirements and allocation of resources. Next, project execution fosters the implementation activities and – together with project control – measures the effectiveness (e.g., user adoption) and efficiency (e.g., Devil's Quadrangle) of the project to decide on its success or failure (Belout 1998; Drucker 2007). Regarding the digitalization of business processes, this thesis specifies a project to be a 'process digitalization project' (PDP) and gives particular attention to PDP selection and PDP implementation. Whereas PDP selection refers to the selection of suitable DTs to improve a business process, PDP implementation coordinates all activities related to the implementation of the selected DT(s) and decides on the projects' success or failure.

Against this backdrop, this doctoral thesis is cumulative and consists of five research papers located at the intersection of BPM, digitalization, and PM. It investigates the digitalization of business processes by providing two methods and three frameworks for the effective selection and successful implementation of PDPs. As the thesis does not only cover a scientific perspective, but also gives practical guidance for organizations, it is relevant for both academics and practitioners.

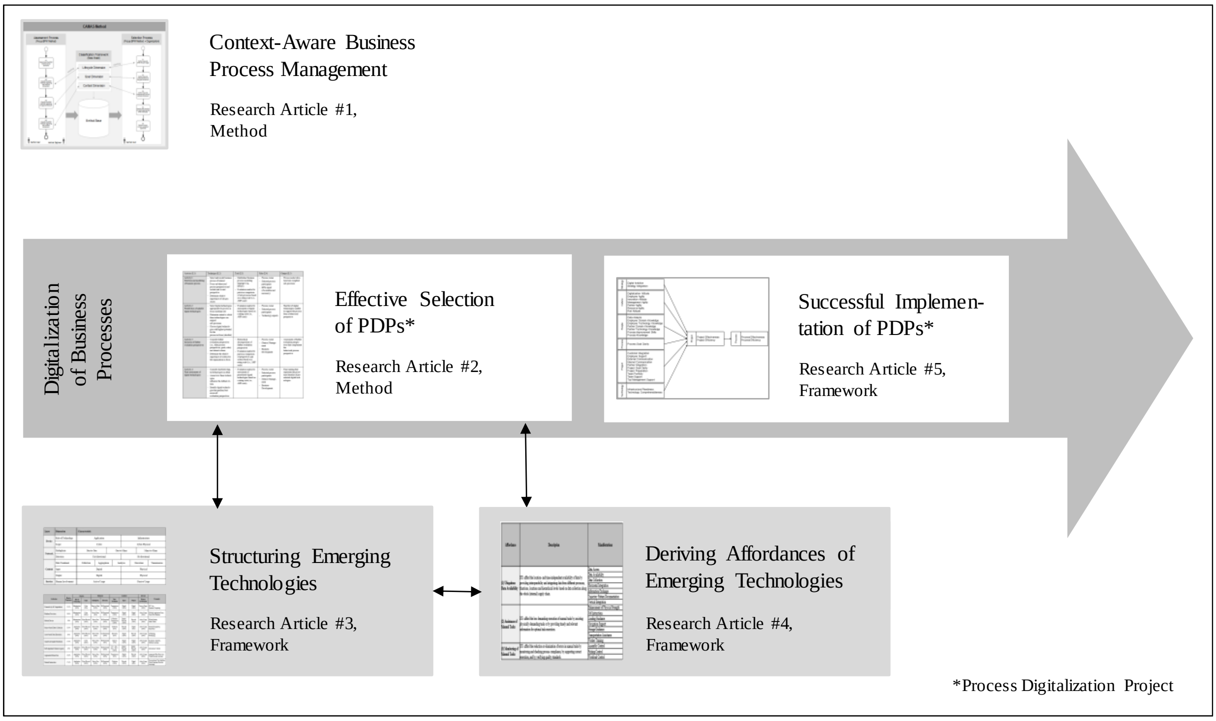

Figure 1: *Digitalization of Business Processes: Selection and Implementation of PDPs*

Figure 1 shows how the individual research papers are assigned to the overarching topics of *context-aware BPM*, *effective selection of PDPs*, and *successful implementation of PDPs*. The same structure can be found in Section II. Firstly, the thesis examines the BPM discipline in terms of new challenges such as the increasingly rapid emergence of DTs, changing customer expectations, or new business models. As digitalization forces organizations to manage business processes in multiple contexts simultaneously, the thesis proposes the 'Context-Aware BPM Method Assessment and Selection Method' (CAMAS Method) and highlights the importance of *context-aware BPM*. Interlinking the perspectives of digitalization and BPM, this part constitutes the basis of the doctoral thesis and frames all of the following content (Section II.1 – including research paper #1).

In response to this call for context-aware BPM, the thesis secondly presents the 'Method for Exploiting the Digitalization Potential of Business Processes', a method which guides its users through the selection and prioritization of suitable DTs, i.e., *the effective selection of PDPs*. As the presented method's application to real-world processes revealed a substantial lack of knowledge regarding the existence and opportunities of DTs, additional frameworks for their better understanding are provided. On the one hand, the thesis presents an integrated framework of a 'Multi-Layer Taxonomy of DTs', which enables an in-depth classification of individual DTs, and related 'Archetypes of DTs', which provide an abstract foundation for their investigation. On the other hand, the thesis contextualizes the archetypes with respect to the intra-logistics discipline, presenting a 'Framework of DT Affordances in Intra-Logistics' (Section II.2 – including research papers #2, #3, #4).

Thirdly, the thesis enhances the PM perspective and investigates *the successful implementation of PDPs*. Building on an extensive literature review at the intersection of IS, BPM, and PM, as well as on the conduction of two multiple case studies in the German manufacturing industry, success factors of PDPs are identified, compiled, evaluated, and presented in a 'Framework of PDP Success' (Section II.3 – including research paper #5). Finally, Section III concludes with a summary and suggestions for future research. In addition to the references (Section IV), an appendix is attached (Section V), which provides further information about all included research papers (Section V.1), my individual contributions (Section V.2), and the research papers themselves (Section V.3-V.7).

II. Overview and Context of the Research Papers[2]

1. Context-Aware Business Process Management

As outlined above, BPM is an important discipline deriving corporate success (Vom Brocke and Mendling 2018). Since organizations must exploit opportunities and overcome challenges of new technologies, customer expectations, business models, and competitors, modern BPM needs to manage business processes in multiple contexts simultaneously (Harmon and Wolf 2016; Kerpedzhiev et al. 2017). Therefore, research has recognized context awareness as an important principle of successful BPM (Vom Brocke et al. 2016) and started to investigate the overall goal(s) of BPM, organizations' specific business surroundings (e.g., company size or competitive environment), and the nature/characteristics of business processes. These investigations have resulted in several frameworks that capture existing context factors, i.e., circumstances that affect the management of business processes (Günther et al. 2008; Melão and Pidd 2000; Ploesser and Recker 2011). One well-established example is vom Brocke et al.'s (2016) BPM context framework, which gives a comprehensive overview of an organization's contextual dimensions (i.e., goal, process, organization, and environment), each of which comprises further factors and characteristics.

Even though research has increasingly addressed the factors relevant to context-aware BPM, most BPM approaches still follow a one-size-fits-all approach, leaving organizations uncertain when implementing successful BPM (Vom Brocke et al. 2016). In particular, investigations on context awareness at the level of BPM methods are missing. Generally, a method is a collection of problem-solving approaches (Dumas et al. 2018), which offer a systematic structure to perform work steps to achieve defined goals (Braun et al. 2005). In the context of BPM, a BPM method is further defined as a set of tools and techniques that supports and enables consistent activities along the process, i.e., the BPM, lifecycle (Rosemann and vom Brocke 2015). Disregarding context awareness, a mature body of BPM methods that cover all stages of the BPM lifecycle is available (Dumas et al. 2018; van der Aalst 2013). Amongst others, well-known examples are Six Sigma, data-based process discovery, and value-added analysis (Conger 2010; Dumas et al. 2018). Even though some researchers have already called for context-aware BPM methods (Kohlborn et al. 2014; van der Aalst 2013; Vom Brocke et al. 2016), existing research offers limited insights into the question concerning how BPM methods can be assessed and

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selected in a context-aware manner (Rosemann et al. 2008; Vom Brocke et al. 2016; Zelt et al. 2018). In particular, research on the application possibilities of BPM methods and their design for specific contexts is lacking (Dumas et al. 2018; Rosemann and Vom Brocke 2015; Vom Brocke et al. 2016). Against this backdrop, research paper #1 proposes the so called 'Context-Aware BPM Method Assessment and Selection Method' (CAMAS Method), which consists of an 'Assessment' and a 'Selection Process', complemented by the joint meta model called 'Classification Framework' (Figure 2).

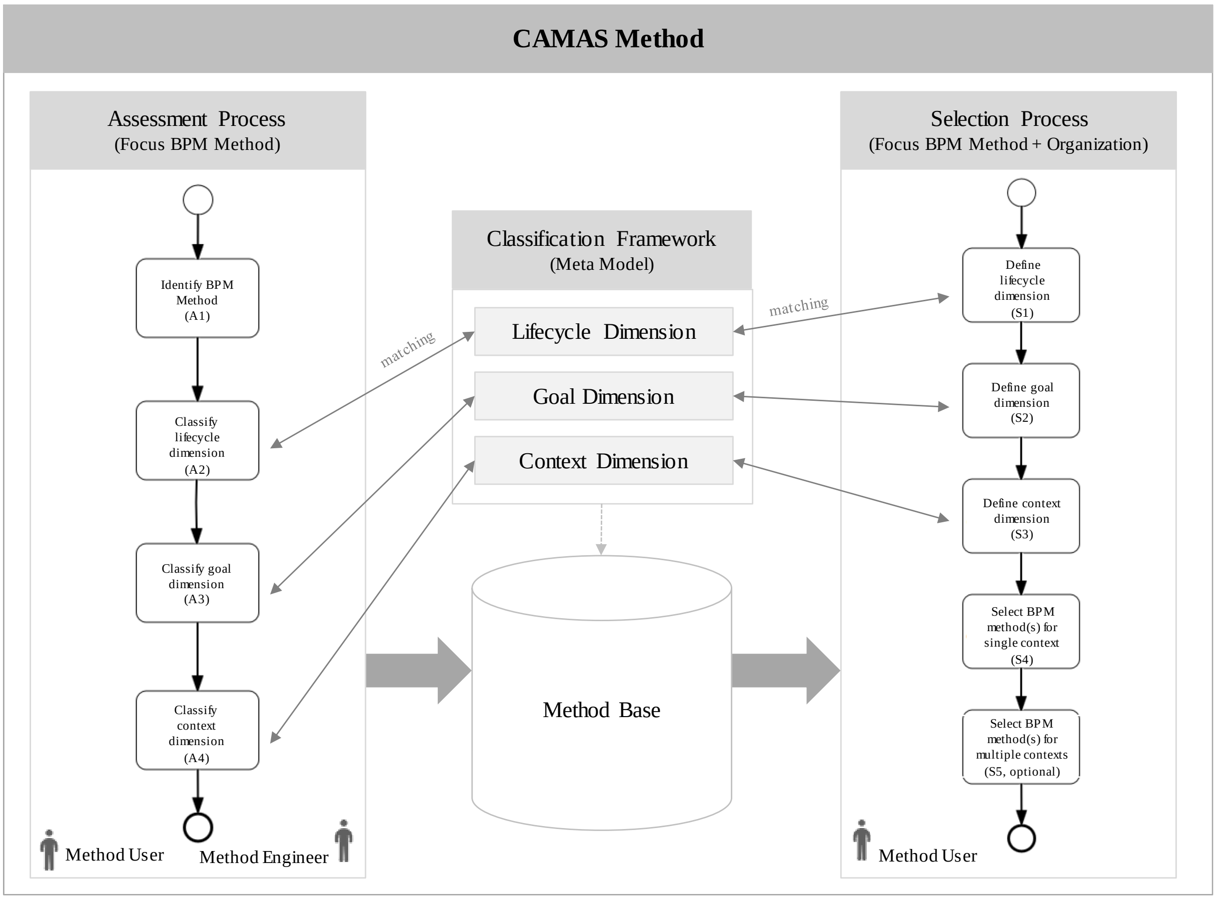

***Figure 2:** Context-Aware BPM Method Assessment and Selection Method*

The 'Classification Framework', i.e., the meta model, is a theoretically derived classification and facilitates assessing and selecting the applicability of BPM methods for use in specific contexts. It structures context along three dimensions that build on the BPM lifecycle (Rosemann and vom Brocke 2015) and the BPM context framework (Vom Brocke et al. 2016). The 'Assessment Process', which is specified in four sequential activities (Figure 2), can be used by two stakeholders. On the one hand, it guides BPM method users (e.g., a process owner or process manager) to assess the applicability of existing BPM methods to a specific context. Practitioners, who come across an unclassified BPM method in the course of their daily business, for example, can check whether the currently used BPM method even fits the context of their organization. On the other hand, the 'Assessment Process' guides BPM method engineers (i.e., those who develop new BPM methods) to specify application possibilities for their developed BPM methods. This results in a more targeted application and higher adoption of BPM methods, which feed into the method base of the CAMAS Method. The 'Selection Process', which comprises four necessary and one optional step (Figure 2), relies on the method base and primarily guides BPM method users to select the BPM methods most applicable to their specific contexts. Further, the 'Selection Process' helps to understand the nature of existing BPM methods in a structured and well-founded manner. This is especially important as many decision-makers are still unaware of the disadvantages related to BPM methods that are not context-aware (e.g., the failure of achieving predefined objectives).

The development of the CAMAS Method, i.e., the underlying research approach, followed the design science research (DSR) paradigm (Gregor and Hevner 2013), which includes two main activities: Constructing the artefact (building) and determining whether the artefact creates utility (evaluation) (Sonnenberg and Vom Brocke 2012). The building of the CAMAS Method followed situational method engineering (SME), an approach in which existing method components are re-used to specify a new method for a pre-defined situation (Ralyté et al. 2003; Ralyté et al. 2007). As the CAMAS method closely relates to business process management and improvement, existing approaches such as the BPM lifecycle (Dumas et al. 2018) and the BPM context framework (vom Brocke et al. 2016) served as foundation for its construction. Thus, the CAMAS method does not constitute an entirely new end-to-end method, but enhances existing ideas against the background of context awareness. While the 'Assessment Process' draws from knowledge on classification techniques, the 'Selection Process' draws from knowledge on multi-criteria decision analysis (MCDA). The second activity, i.e., the evaluation of the CAMAS Method, was based on a sample of existing BPM methods and an excel prototype representing the basic functionality of the method. To evaluate the 'Selection Process', BPM method users in two organizations used the prototype to selected BPM methods for their specific context. To evaluate the 'Assessment Process', the prototype was applied to 115 existing BPM methods identified in literature. Having assessed all those BPM methods, the status quo revealed an overall lack of context-aware BPM methods, as most BPM method engineers have not explicated specific application possibilities for their BPM methods. This finding – and the related call for more context-aware BPM methods – constitutes the basis of the doctoral thesis and frames all of the other research papers (Figure 1).

2. Effective Selection of Process Digitalization Projects

In response to the call for context-aware BPM methods (research paper #1), Section II.2 presents methods and frameworks that support organizations in the selection and prioritization of suitable DTs to improve their business process, i.e., in the effective selection of PDPs. As outlined in Section I, such guidance on the digitalization of business processes has been lacking so far (Denner et al. 2018). Therefore, research paper #2 first presents the 'Method for Exploiting the Digitalization Potential of Business Processes' (Figure 3), which consists of five elements (E), namely: Activities (i.e., E.1 – tasks with the goal of creating outputs), techniques (i.e., E.2 – instructions for the execution of an activity), tools (i.e., E.3 – to support the execution of a related activity), roles (i.e., E.4 – actors involved in the execution of an activity), and a distinct output (i.e., E.5 – output such as the documentation of an activity). Besides additional attributes such as goal orientation, systematic approach, principles orientation, and repeatability, methods in general must feature the mentioned elements (E) in order to fulfill the requirements of a method`s definition (Braun et al. 2005; Vanwersch et al. 2016).

In what follows, the individual activities of the method are described briefly (Figure 3): Activity 1 focuses on the 'Selection and Modeling' of an organization's process whose digitalization potential shall be exploited. After modeling the process in focus, its sub-processes are prioritized to provide information about their relative importance. Activity 2 comprises the 'Preselection of Suitable DTs' for the process in focus. After eliminating DTs or sub-processes according to potential knock-out criteria (e.g., excessive costs or no digitalization potential), the remaining DTs are assessed and prioritized according to their potential to support the remaining sub-processes. In addition to the previous process perspective, activity 3 suggests the 'Inclusion of Further Evaluation Perspectives', i.e., organizational factors such as goals or risks that are relevant for the identification and implementation of new DTs as well (Mansar et al. 2009). Activity 4, which builds on all of the previous results (activities 1-3), carries out the 'Final Assessment of DTs', whereas the shortlisted DTs of activity 2 are assessed according to their influence of the identified and prioritized evaluation perspectives of activity 3. The final output of the method is a list of prioritized DTs that are best suited to support the selected business process under the consideration of further organizational interests.

Activity (E.1)	Technique (E.2)	Tool (E.3)	Role (E.4)	Output (E.5)
Activity 1: Selection and Modeling of Business Process	- Select and model business process of interest - Focus on behavioral process perspective and include end-to-end perspective - Determine relative importance of sub-processes	- Established business process modelling language (e.g., BPMN) - Evaluation matrix for pairwise comparison of sub-processes based on a rating scale (i.e., AHP scale)	- Process owner - Selected process participants - BPM expert (if available and necessary)	- Process model structured into weighted sub-processes
Activity 2: Preselection of Suitable Digital Technologies	- Select digital technologies appropriate for process in focus (medium list) - Determine extent to which these technologies can support sub-processes - Choose digital technologies with highest potential for the process in focus (shortlist)	- Evaluation matrix for assessment of digital technologies based on a rating scale (i.e., AHP scale)	- Process owner - Selected process participants - Technology experts	- Shortlist of digital technologies suitable to support the process from a behavioral perspective
Activity 3: Inclusion of Further Evaluation Perspectives	- Consider further evaluation perspectives (i.e., other process perspectives, goals, risks) and related criteria - Determine the relative importance of criteria for the organization in focus	- Hierarchical decomposition of further evaluation perspectives - Evaluation matrix for pairwise comparison of perspectives and criteria based on a rating scale (i.e., AHP scale)	- Process owner - (Senior) Management - Business Development	- Assessment of further evaluation perspectives that complement the behavioral process perspective
Activity 4: Final Assessment of Digital Technologies	- Consider shortlisted digital technologies in detail - Assess how these technologies influence the defined criteria - Identify digital technologies that perform best across all evaluation perspectives	- Evaluation matrix for assessment of preselected digital technologies based on a rating scale (i.e., AHP scale)	- Process owner - Selected process participants - (Senior) Management - Business Development	- Final ranking that represents the prioritized shortlist of preselected digital technologies

Figure 3: *Method for Exploiting the Digitalization Potential of Business Processes*

In line with research paper #1, the 'Method for Exploiting the Digitalization Potential of Business Processes' is specified for the use in a pre-defined situation (Ralyté et al. 2003), whereas situation refers to the combination of a context and a project type (Bucher et al. 2007). As for the context type, the method refers to the dimensions of the BPM lifecycle (Vom Brocke and Rosemann 2015) and the BPM context framework (Vom Brocke et al. 2016). From a lifecycle perspective, the method addresses the incremental redesign, i.e., exploitation, of the business process in focus and thus relies on all activities related to process improvement (Dumas et al.

2018; Recker and Mendling 2016). Regarding the context framework, the method thereby abstracts from radical re-engineering, i.e., exploration, of business processes (Rosemann 2014) and takes a single-process perspective that excludes interactions among processes (Dijkman et al. 2016). Further, the method focuses on core and support processes with medium variability and applies to intra-organizational processes in a production or service industry context. As required skills and roles are not necessarily available in small organizations, the method considers processes of medium or large organizations. As organizations are forced to leverage the potential of DTs, the method focuses on organizations facing medium or high competition and uncertainty. Besides the context type, the method is specified by a project type. The project type describes the initial state as well as the target state of a project, which – in this case – relates to the respective PDP. At the initial state of the method, the process in focus already exists. Although the process might be digitized to some extent, the need for further digitalization has been recognized and a detailed examination is intended. As designated target state, the process in focus should leverage DTs to a higher extent and have enhanced its operational performance and strategic fit (Wu et al. 2015).

The development of the 'Method for Exploiting the Digitalization Potential of Business Processes' followed the action design research (ADR) paradigm, which – compared to DSR – puts more emphasis on an iterative approach when building and evaluating the artifact (Sein et al. 2011). Whereas the building of the method also followed SME, i.e., the re-use of existing method components from extant knowledge on BPM, DTs, and MCDA (Section II.1), the evaluation was carried out in close collaboration with different practitioners and potential end-users from industry to ensure practical relevance (Sein et al. 2011). Besides the conduction of semi-structured interviews, the evaluation included the application of the method to real-world business processes in three organizations. The results showed a substantial lack of knowledge regarding the existence and opportunities of DTs, a circumstance that is in line with the absence of an accepted definition of DTs and hampers the proper execution of the activity 'Preselection of Suitable DTs'. This finding motivates a closer investigation of DTs per se as well as of (existing) classification schemes that improve the understanding of DTs and thereof the effective selection of DTs and related PDPs.

Today, existing literature has recognized that DTs do not create value themselves (Steininger 2019) and that a profound understanding is required for scientific progress and clear-headed decisions in industry. As outlined in Section I, there have been several calls for and efforts in structuring the broad field of DTs (Bharadwaj et al. 2013). Whereas academic literature discusses conceptual ideas about DTs (Benbya et al. 2020; Yoo et al. 2010) or provides in-depth classification schemes (Fahad et al. 2014), professional literature compiles high-level classifications (e.g., the SMAC acronym) as well as comprehensive lists and trend reports (e.g., the GHC). However, neither the cataloging of DTs nor the in-depth analysis of specific DTs yield a profound understanding of DTs, leading to the described uncertainty when deciding on which DTs to use for improving business processes (Denner et al. 2018). Moreover, the great variety of available DTs and the inflationary use of the term cause opacity (Adomavicius et al. 2008).

Against this backdrop, research paper #3 investigates the classification of DTs on two different levels of detail, providing a 'Multi-Layer Taxonomy of DTs' and related 'Archetypes of DTs'. First, the taxonomy enables the systematical classification of individual DTs. Its layers, i.e., 'Service', 'Content', 'Network', and 'Device' (Yoo et al. 2010), comprise eight dimensions that occur in different forms, i.e., characteristics (Figure 4). From an overarching perspective, the 'Device' layer is technical and accounts for characteristics referring to a DT's functionality. The 'Network' layer describes the socio-technical interaction of a DT, and the 'Content' layer, which refers to the key resource of DTs, specifies how a DT receives and provides data. Finally, the 'Service' layer identifies a DT's purpose, i.e., its application functionality.

Layer	**Dimension**	**Characteristic**				
Device	Role of Technology	Application		Infrastructure		
	Scope	Cyber		Cyber-Physical		
Network	Multiplicity	One-to-One	One-to-Many	Many-to-Many		
	Direction	Uni-directional		Bi-directional		
Content	Data Treatment	Collection	Aggregation	Analysis	Execution	Transmission
	Input	Digital		Physical		
	Output	Digital		Physical		
Service	Human Involvement	Active Usage		Passive Usage		

Figure 4: *Multi-layer Taxonomy of Digital Technologies*

The 'Multi-Layer Taxonomy of DTs' carves out basic DT characteristics and therefore increases the current understanding of DTs, e.g., in terms of similarities and dissimilarities of DTs within an organization or on the market. Beyond this contribution, the taxonomy allowed to cluster DTs on the basis of shared characteristics (Nickerson et al. 2013), leading to the inductive inference of nine 'Archetypes of DTs'. Figure 5 lists all of the nine archetypes, highlights their significant taxonomy characteristics, and provides representative examples. The names, which aim to adequately represent each archetype, arise from the taxonomy characteristics as well as the DTs contained. In what follows, additional single-sentence definitions describe each archetype:

The archetype 'Connectivity & Computation' comprises DTs with a focus on efficient data processing or exchange. 'Platform Provision' comprises DTs that provide unified access to data or services. 'Mobile Device' comprises DTs that enable the location-independent access to and use of digital data through portable hardware components. 'Sensor-based Data Collection' comprises DTs that focus on the collection of real-world data and their transformation into digital data. 'Actor-based Data Execution' comprises DTs that transform digital data into physical artefacts in the real world, 'Self-dependent Material Agency' comprises DTs that collect and analyze both digital and physical data to enable self-dependent action in the physical world. 'Analytical Insight Generation' comprises DTs that focus on analyzing digital data to support knowledge creation and decision-making. 'Augmented Interaction' comprises DTs that analyzes digital data and present it in a physical form that supports humans in their tasks. Finally, 'Natural Interaction' comprises DTs that enable human-computer-interfaces perceived as natural by humans.

In contrast to the 'Multi-Layer Taxonomy of DTs', which enables an in-depth classification of individual DTs, the 'Archetypes of DTs' deliberately abstract from individual DTs and rather provide an abstract foundation for their investigation. Being used as an integrated framework, the taxonomy and the archetypes can stimulate and structure strategic discussions among organizational stakeholders like senior managers, process designers, and product developers. Further, the framework enables stakeholders to make informed decisions about the prioritization and implementation of DTs with respect to different action possibilities and use cases. In a second step, the results might even improve digital process innovation by facilitating the DT-based design or adjustment of (new) business processes.

Archetype	Relative Frequency	Device		Network		Content			Service	Examples
		Role of Technology	**Scope**	**Multiplicity**	**Direction**	**Data Treatment**	**Input**	**Output**	**Human Involvement**	
Connectivity & Computation	15.2%	Infrastructure (100%)	Cyber (93%)	Many-to-Many (100%)	Bi-Directional (100%)	Transmission (100%)	Digital (100%)	Digital (100%)	Passive Usage (100%)	802.11ax, Quantum Computing
Platform Provision	10.9%	Infrastructure (100%)	Cyber (100%)	One-to-Many (80%)	Bi-Directional (100%)	Transmission (100%)	Digital (100%)	Digital (100%)	Active Usage (100%)	(Mobile) Application Store, Cloud/Web Platform
Mobile Device	5.4%	Infrastructure (100%)	Cyber-Physical (100%)	One-to-One (100%)	Bi-Directional (100%)	Collection / Transmission (100%)	Digital / Physical (100%)	Physical (100%)	Active Usage (100%)	E-Book Reader, Media Tablet
Sensor-based Data Collection	12.0%	Application (100%)	Cyber-Physical (100%)	One-to-One (100%)	Uni-Directional (100%)	Collection (91%)	Physical (100%)	Digital (91%)	Active Usage (100%)	Gesture Recognition, Smart Dust
Actor-based Data Execution	6.5%	Application (100%)	Cyber-Physical (100%)	One-to-One (100%)	Uni-Directional (100%)	Execution (83%)	Digital (100%)	Physical (100%)	Active Usage (100%)	3D Printing, 4D Printing
Analytical Insight Generation	17.4%	Application (100%)	Cyber (100%)	One-to-One (100%)	Bi-Directional (94%)	Analysis (75%)	Digital (100%)	Digital (100%)	Active Usage (100%)	In-memory Analytics, Machine Learning
Self-dependent Material Agency	2.2%	Application (100%)	Cyber-Physical (100%)	One-to-Many (100%)	Bi-Directional (100%)	Col. / Ana. / Exe. / Tra. * (100%)	Digital / Physical (100%)	Digital / Physical (100%)	Active Usage (100%)	Autonomous Vehicle
Augmented Interaction	13.0%	Application (100%)	Cyber-Physical (100%)	One-to-One (100%)	Bi-Directional (100%)	Transmission (92%)	Digital (100%)	Physical (100%)	Active Usage (100%)	Augmented Data Discovery, Virtual Personal Assistant
Natural Interaction	17.4%	Application (100%)	Cyber-Physical (100%)	One-to-One (100%)	Bi-Directional (100%)	Collection (100%)	Physical (100%)	Digital (69%)	Active Usage (100%)	Conversational User Interface, Natural-language Question Answering

* Col. / Ana. / Exe. / Tra.: Collection / Analysis / Execution / Transmission

Figure 5: *Archetypes of Digital Technologies*

The development of the 'Multi-Layer Taxonomy of DTs' followed Nickerson et al. (2013) and was carried out both deductively and inductively. The dimensions included in the taxonomy are primarily structured in line with established DT architectures from academic literature. The dimensions, which have gradually evolved during the development process, do not only consider existing literature as well, but have been shaped by the classification of exemplary DTs and the validation through focus groups and workshops. In the end, the taxonomy was evaluated and confirmed through the classification of 92 real-world DTs, which were compiled based on the GHC from nine subsequent years. This in-depth classification also enabled the (inductive) development of nine 'Archetypes of DTs', which followed hierarchical clustering, i.e., a statistical technique that groups objects with similar characteristics (Field 2013). In line with Cormack (1971), the number of nine archetypes balances high homogeneity within each cluster and high heterogeneity among the clusters. The evaluation of the archetypes was carried out in several steps: First, the archetypes were compared to existing Information Systems (IS) literature. Moreover, a Q-Sort within the author team as well as with external industry experts challenged the archetypes' validity and reliability. Next, the archetypes' robustness was confirmed by analyzing their occurrence within the sample of 92 DTs over time. Finally, an online questionnaire was send out to 12 industry experts, who confirmed the archetypes to cover the full spectrum of DTs and their nomenclature as well as potential use cases to be intuitive.

Coming back to the presented 'Method for Exploiting the Digitalization Potential of Business Processes' (research paper #2), the 'Multi-Layer Taxonomy of DTs' and 'Archetypes of DTs' act as a filter on the great variety of available DTs, reducing organizational uncertainty of DT selection and supporting the proper execution of activity 2 ('Preselection of Suitable DTs'). Thus, the relationship between the two research papers is reciprocal: On the one hand, research paper #3 is motivated by the evaluation results of research paper #2. On the other hand, the integrated framework of research paper #3 improves the execution of the method in research paper #2, i.e., the effective selection of PDPs (Figure 1). Even though the taxonomy and archetypes contribute to the better understanding of DTs, especially the 'Archetypes of DTs' are independent of specific domains and contexts. Deliberately kept abstract in a first step, their transfer to specific processes serves as an interesting topic for further investigation.

An appropriate example for such specification lies in the intra-logistics discipline, a field in which the physical (spatial and temporal) change of goods heavily depends on the availability of accurate and up-to-date information (Gunasekaran and Ngai 2004; Hult et al. 2004; Turner 1993). Today, DTs offer possibilities such as real-time visibility, smart procurement and warehousing as well as integrated planning and execution systems, for example (Schrauf and Bertram 2016). Willing to seize the opportunities of digitalization (Section I), academic and professional literature has been investigating the integration of DTs in (intra-)logistics processes for quite some time now. Whereas some researchers examined single DTs and their related application possibilities on the one hand (Calatayud et al. 2019; Vogt et al. 2019), lots of publications take a more generic perspective and seek to understand how multiple DTs shape integrated logistics ecosystems (Kayikci 2018). The value of these contributions undisputed, there is no work that investigates application possibilities of DTs with an explicit focus on intra-logistics processes. Accordingly, just like for other domains or business processes in general, organizations struggle with identifying which DTs they should adopt to support their intra-logistics processes (Denner et al. 2018).

Against this backdrop, research paper #4 contextualizes the developed 'Archetypes of DTs' (research paper #3) with respect to the intra-logistics discipline and investigates how they can be used to support intra-logistics processes. In particular, the paper presents the major affordances, i.e., action possibilities, provided by DTs/DT archetypes to fulfill a goal-oriented task in intra-logistics. In the end, the 'Framework of DT Affordances in Intra-Logistics' includes ten organization- and industry-independent affordances, each of which is specified in terms of the DT(s) they relate to, the intra-logistics process element(s) they affect, and related manifestations to exemplify its relevance. The affordances, which are closely described in Figure 6, split into affordances that influence both the flow of goods and the flow of information (1-6) as well as affordances that exclusively refer to the flow of information (7-10). All affordances are operationalized through manifestations, i.e., specific application possibilities, which exemplify their relevance and support the application in industry (e.g., 'job instructions', or 'smart packaging'). The results support organizations on two complementary levels. The affordances serve as a starting point for idea generation and allow practitioners to approach the topic of digitalization in a structured, top-down manner. Abstracting from everyday business and technological fads, they represent abstracted opportunities offered by DTs and support discussions about process improvement potentials. The manifestations, in turn, stimulate ideating about how DTs can be used in specific contexts and might serve as starting point for an analysis of an organization' status quo and self-assessments (research paper #2).

Affordance	Description	Manifestations	DT Archetypes							Process Elements					
			Platform	Connectivity	Actor-based Product	Sensor-based Data Collection	Analytical Insight Generation	Analytical Interaction	Augmented Interaction	Material Handling	Material Storage	Material Transportation	Material Assortment	Disposition & Management	Controlling & Planning
(1) Ubiquitous Data Availability	DTs afford the location- and time-independent availability of data by providing interoperability and integrating data from different processes, functions, locations, and hierarchical levels based on data collection along the whole (internal) supply chain.	Data Access Data Availability Data Collection Horizontal Integration Information Exchange Trajectory Pattern Documentation Vertical Integration	X	X		X		X		X	X	X	X	X	X
(2) Assistance of Manual Tasks	DTs afford the less demanding execution of manual tasks by assisting physically demanding tasks or by providing timely and relevant information for optimal task execution.	Enhancement of Physical Strength Job Instructions Loading Guidance Navigation Support Storage Guidance Transportation Assistance Worker Training			X	X	X	X	X	X	X	X	X		
(3) Monitoring of Manual Tasks	DTs afford the reduction or elimination of errors in manual tasks by monitoring and checking process compliance, by supporting correct execution, and by verifying quality standards.	Assembly Control Picking Control Workload Control		X		X	X	X					X		
(4) Automation of Manual Tasks	DTs afford the automation of manual tasks by intelligently collecting and manoeuvring goods, by performing repetitive and/or physically demanding tasks, or by autonomously recording goods-related information.	Automatic Data Capturing Automatic Goods Inspection Automatic Handling Operations Automatic (Un-)Loading Automatic Picking & Packaging Automatic Transportation			X	X	X	X	X	X		X	X		
(5) Tracking of Goods and Assets	DTs afford the (real-time) localization and identification of goods and mobile assets by autonomously tracking, documenting, checking, and transmitting their positions and movements.	Asset Visibility Automatic Goods Tracking Goods Visibility Inventory Control	X	X	X	X	X				X	X		X	
(6) Condition Monitoring of Goods and Assets	DTs afford the (real-time) condition monitoring of goods and assets in terms of integrity or proper handling, by detecting and transmitting external forces, displacements, environmental changes, or any changes directly affecting the object itself.	Ambient Condition Monitoring Goods Condition Monitoring Predictive Maintenance Smart Packaging Surveillance of Infrastructure		X	X	X	X				X	X		X	
(7) Operational Scheduling Support	DTs support in dynamic planning and control activities for continuous adaption of operations and processes to operational challenges by analyzing (real-time) data and by optimizing resource allocation and utilization.	Dynamic Coordination Fleet Optimisation Route Optimisation	X	X			X							X	
(8) Operational Decision Automation	DTs afford the automation of operational decisions in logistics planning and control, reacting dynamically to changing conditions by applying (intelligent) algorithms analyzing (real-time) data.	Automatic Goods Replenishment Automatic Storage Policy Self-Steering Process				X	X				X			X	
(9) Interruption Management	DTs support the anticipation, identification and management of (operational) interruptions and (tactical) risks by providing (real-time) information on process execution and by potentially providing ad-hoc solution alternatives.	Interruption Identification Interruption Management Origin Tracing Risk Prevention	X	X		X	X							X	X
(10) Strategic Decision Support	DTs support strategic decision-making by filtering relevant data and by providing analytical and predictive capabilities for a better understanding of patterns, impacts and interactions of performance drivers.	Descriptive and Diagnostic Accuracy Facility Planning Support Knowledge Discovery Predictive and Prescriptive Accuracy				X	X	X						X	X
COUNT			4	6	4	9	9	5	2	3	5	5	4	7	3

Figure 6: *Framework of Digital Technology Affordances in Intra-Logistics*

The development of the ‘Framework of DT Affordances in Intra-Logistics’ included two phases. First, a structured literature review at the intersection of the IS and logistics discipline was conducted to compile an initial catalog of affordances and related manifestations. Structuring the extensive results, affordance theory (Gibson 1986) and grounded theory (Wolfswinkel et al. 2013) were used to rigorously review the literature. In the second phase, the results were refined and extended through qualitative interviews with ten subject matter experts from academia and industry. In the course of the research paper, it has turned out that the related research design sets-up a theoretical single-context (i.e., intra-logistics) model, which can serve as a blueprint for the specific contextualization to other disciplines, industries, and organizations. Besides an investigation of the related inter-logistics discipline, the research design can serve as a basis for identifying affordances related to other corporate functions (e.g., production or sales) that might be generalized into affordances of DTs for business processes at large.

To conclude, research paper #4 contextualizes the identified ‘Archetypes of DTs’ (research paper #3) with respect to the intra-logistics discipline and thereof presents the ‘Framework of DT Affordances in Intra-Logistics’. Coming back to the previous results of this doctoral thesis, the relationship of research paper #4 to the other research papers within this section is reciprocal: On the one hand, research paper #4 is motivated by and improves the ‘Method for Exploiting the Digitalization Potential of Business Processes’ (research paper #2). On the other hand, the presented ‘Framework of DT Affordances in Intra-Logistics’ builds on and evaluates the results, i.e., archetypes of DTs, of research paper #3. Whereas the archetypes were deliberately kept abstract at the beginning and during their development, research paper #4 is a first step towards their transfer to specific processes. With this, Section II.2, i.e., investigations on the effective selection of PDPs, is concluded (Figure 1).

3. Successful Implementation of Process Digitalization Projects

As outlined in Section I, this doctoral thesis is located at the intersection of BPM, digitalization, and PM. While Sections II.1 and II.2 dealt with the effective selection of DTs/PDPs and thus especially the subjects of BPM and digitalization, this Section enhances the PM perspective and investigates the successful implementation of the identified DTs/PDPs (Figure 1). In PM, the success (or failure) of projects – in this case the effort of improving business processes by the integration of suitable DTs – is measured via effectiveness and efficiency (Belout 1998; Drucker 2007). Today, research in BPM and PM has sufficiently analyzed criteria and factors related to project success. Whereas Trkman (2010), for example, proposes critical success factors for BPM, McLean and Antony (2014) study the failure factors of various improvement initiatives. Research on successful PM, in turn, already examined the view of specific stakeholders (Pankratz and Loebbecke 2011), or projects (Kirsch and Slaughter 2013). In contrast to the long established disciplines of BPM and PM, digitalization is a relatively new phenomenon, which also holds true for research about related success factors. Even though existing literature has investigated IS success at large (Leidecker and Bruno 1984; Williams and Ramaprasad 1996), research about digitalization success is highly fragmented. In 2003, BarNir et al. investigated the influence of business process digitalization on the success of companies engaging in e-commerce. Holotuik and Beimborn (2017) approximate the challenges of successfully implementing digital business strategies, while Gimpel & Röglinger (2015) offer a framework to support organizations' digital transformation. But as soon as one consolidates extant knowledge on success factors related to BPM, PM, and digitalization, it appears that there is no holistic view about PDP success factors.

Against this backdrop, research paper #5 provides the 'Framework of PDP Success', which consists of 29 factors structured along six PDP success factor categories, i.e., 'Strategy', 'Culture', 'People', 'Process', 'Project', and 'Technology' (Figure 8). Whereas 'Strategy' embraces factors addressing the clarity of goals and the integration of departmental strategies, 'Culture' comprises factors referring to the overall working environment and attitudes of individuals. The 'People' category refers to factors influencing human capabilities and skills. 'Process' categorizes mostly retrospective processual activities from both a capability and a performance perspective, while 'Project' emphasizes the influence of participants during the project. Finally, the 'Technology' category describes attributes that depend on used technology. From a management perspective, the framework supports organizations to systematically control their project activities. In particular, managers – or other persons responsible for the successful implementation of PDPs within an organization – can address factors critical for PDP success when embedding DTs within their business processes.

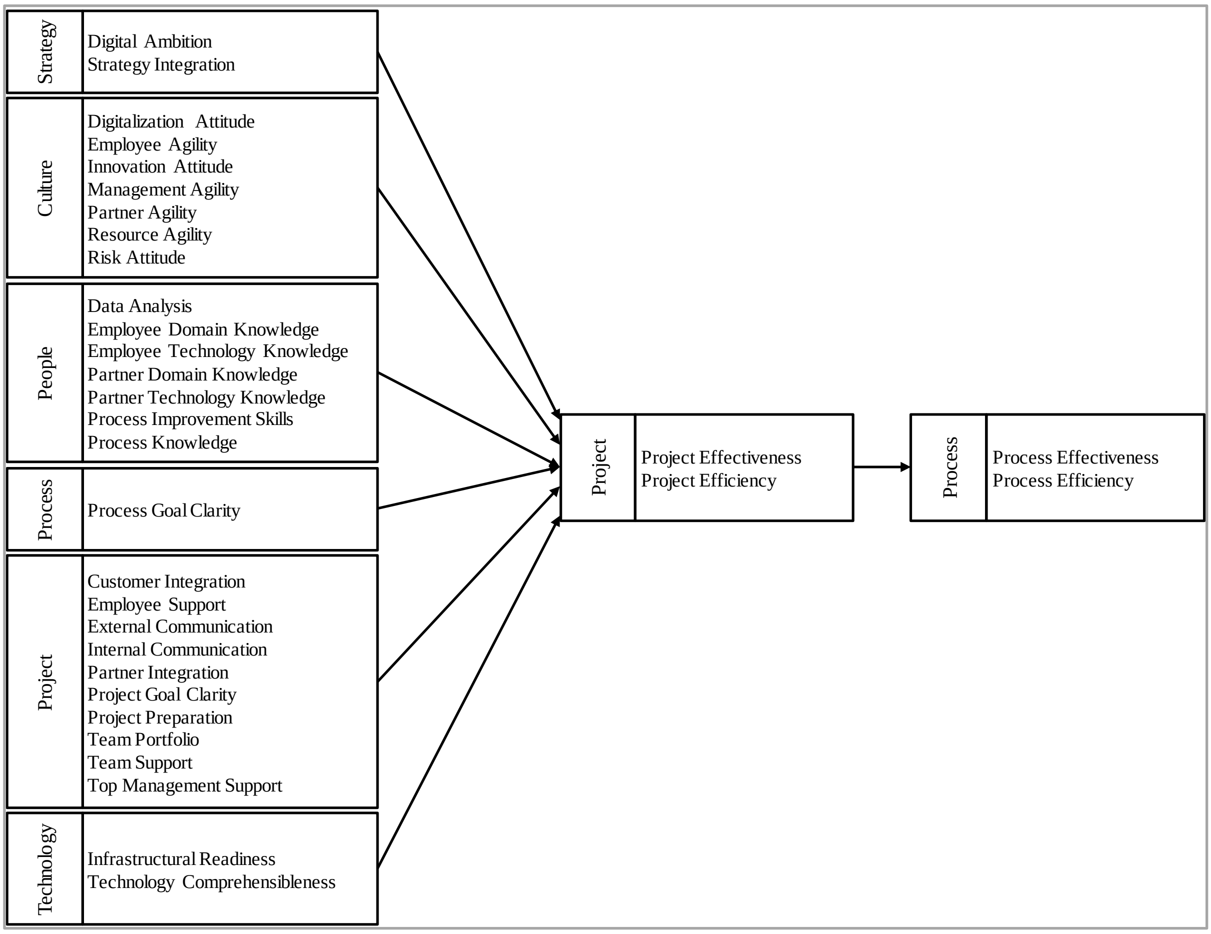

Figure 7: *Framework of PDP Success*

The development of the 'Framework of PDP Success' followed a multi-staged research approach. First, a structured literature review in the fields of IS, BPM, and PM revealed an overview of existing success frameworks, i.e., success categories, as well as a number of candidate PDP success factors (Aladwani 2002; Alter 2013; Petter et al. 2008). Applying multiple coding as per Wolfswinkel et al. (2013), both results were consolidated in a preliminary ex-ante model. Validating and refining the ex-ante model, two cross-sectional multiple-case studies (MCSs) in the manufacturing industry completed the literature-based results by empirical data from real-world PDPs. Conducting semi-structured interviews on three finished and four running PDPs enabled the development of the ex-post model. Compared to the literature-backed ex-ante model, the final framework identifies and emphasizes the importance of seven new PDP success factors, which are shortly described below.

Three of the new PDP success factors highlight the importance of partners as carriers of expertise within a PDP. Beyond 'Partner Domain Knowledge' and 'Partner Technology Knowledge' within the 'People' category, the interviews within the MCSs also emphasized the influence of 'Partner Agility' in the 'Culture' category. The remaining four new PDP success factors fall into different categories. In the 'Strategy' category, the success factor 'Digital Ambition' describes the continuous focus on the digitalization of business processes, i.e., an exhibited affinity towards and actual interest in taking advantage of DTs. In the 'Culture' category, the factor 'Digitalization Attitude' is defined as the PDP participants' willingness-to-change and open-mindedness towards DTs. The 'People' category provides the success factor 'Data Analysis', which previous studies commonly described as the central, decentral, or hybrid usage of analytical and decision-making capabilities for diagnostic, descriptive, prescriptive, and predictive purposes (Porter and Heppelmann 2014; Walsham 2006). Today, digitalization widens the possibilities of data analytics, underlined, for example, by the pronunciation of 'Analytics' in the SMAC classification (Fowler and Horan 2007). In the 'Technology' category, the new factor 'Technology Comprehensibleness' describes the level of abstraction, i.e., the complexity, that influences the understanding and the implementation of DTs used in PDPs (Hughes et al. 2017).

In sum, the thesis highlights the importance of DTs for today's organizations and emphasizes the critical role of related PDPs, i.e., the effective selection and the successful implementation of DTs into business processes to generate value from digitalization. Rising the challenges of the digital age, which is characterized by volatility, uncertainty, complexity, and ambiguity, organizations have to seize opportunities related to the digitalization of business processes. But, due to the ever faster development and adoption of DTs, organizations face high uncertainty when identifying suitable DTs. Against this backdrop, the thesis offers a so far lacking guidance on PDP selection and implementation in the form of different methods and frameworks. Section III concludes this overview with a short summary and suggestions for further research.

III. Summary and Future Research[3]

1. Summary

This doctoral thesis is cumulative and consists of five research papers located at the intersection of Business Process Management (BPM), digitalization, and Project Management (PM). The context of emerging Digital Technologies (DTs) enables, but also forces organizations to accelerate the digitalization of business processes, which – in this thesis – is defined as the proper embedment of suitable DTs within business processes. Even though digitalization opens up so many opportunities and BPM includes a mature portfolio of methods and tools to improve business processes, organizations still struggle with systematically deriving value from DTs. What is missing, is a structured approach that helps organizations derive, prioritize, and implement process improvement ideas in line with DTs. In this regard, this thesis investigates the digitalization of business processes by providing methods and frameworks for the effective selection and the successful implementation of process digitalization projects (PDPs). Whereas PDP selection refers to the selection of suitable DTs to improve the effectivity or efficiency of a business process, PDP implementation coordinates all activities related to the implementation of the selected DT(s) and decides on the projects' success or failure. Overall, the thesis contributes to the existing body of knowledge by introducing two methods and three frameworks that serve as structured approaches on the digitalization of business processes. Thus, it is relevant for both academics and practitioners.

As recent academic work offers limited insights into *context-aware BPM*, Section II.1 examines the BPM discipline in terms of new challenges triggered by digitalization. Assuming that many BPM efforts follow a one-size-fits-all approach, Section II.1 investigates the status quo of existing BPM methods and reveals an overall lack of context-specific BPM methods. Against this backdrop, research paper #1 provides the 'Context-Aware BPM Method Assessment and Selection Method', which – on the one hand – guides BPM method engineers in specifying application possibilities for their developed BPM methods. On the other hand, the method supports BPM method users to assess the applicability of existing BPM methods in a context-aware manner and to select BPM methods applicable to their specific context. Interlinking the perspectives of digitalization and BPM, this Section constitutes the basis of the thesis and frames all of the other research papers.

[3] This section is partly comprised of content taken from the research papers included in this thesis. To improve the readability of the text, I omit the standard labeling of these citations.

Section II.2 captures the call for context-aware BPM methods and addresses the lack of guidance on the selection and prioritization of suitable DTs, i.e., *the effective selection of PDPs*. Therefore, research paper #2 proposes the 'Method for Exploiting the Digitalization Potential of Business Processes', which guides its user through the activities 'Selection and Modeling of Business Process', 'Preselection of Suitable DTs', 'Inclusion of Further Evaluation Perspectives', and 'Final Assessment of DTs'. Although the method gives detailed instructions on each activity, its application to real-world processes revealed a substantial lack of knowledge regarding the existence and opportunities of DTs. As this circumstance hampers the proper execution of the activity 'Preselection of Suitable DTs', research paper #3 provides an integrated framework to improve the understanding of DTs per se. Based on a 'Multi-Layer Taxonomy of DTs', the research paper develops nine 'Archetypes of DTs', named: 'Connectivity & Computation', 'Platform Provision', 'Mobile Device', 'Sensor-based Data Collection', 'Actor-based Data Execution', 'Self-dependent Material Agency', 'Analytical Insight Generation', 'Augmented Interaction', and 'Natural Interaction'. As the developed archetypes are independent of specific domains and contexts, research paper #4 contextualizes them with respect to the intra-logistics discipline and presents a 'Framework of DT Affordances in Intra-Logistics'.

While Sections II.1 and II.2 dealt with the effective selection of DTs/PDPs and thus especially the subjects of BPM and digitalization, Section III.3 enhances the PM perspective and investigates the *successful implementation of PDPs*. While research in BPM and PM has already analyzed several success criteria and factors, research about digitalization success – a relatively new phenomenon – is highly fragmented. Therefore, research paper #5 builds on an extensive literature review at the intersection of IS, BPM, and PM, as well as on the conduction of two multiple case studies in the German manufacturing industry to present a 'Framework of PDP Success'. The framework consists of six PDP success factor categories, i.e., 'Strategy', 'Culture', 'People', 'Process', 'Project', and 'Technology', which are specified in terms of 29 further PDP success factors. Being aware of the provided framework, managers – or other persons responsible for the successful implementation of DTs within business processes – can systematically lead future PDPs to success.

2. Future Research

As with all research, this doctoral thesis has limitations which may serve as starting points for future research. Both limitations and ideas for future research are outlined according to the structure in Section II. Embedding DTs into business processes is an important property in the digital age and a new challenge for successful BPM. Therefore, Section II.1 underlines the need for context-aware BPM methods when exploiting opportunities and overcoming challenges of digitalization. In particular, research paper #1 proposes the 'Context-Aware BPM Method Assessment and Selection Method'. While the method contributes to the knowledge on context-aware BPM methods, further research is still required. First of all, future research should capture the call for more context awareness in BPM method design. Further, the literature review on BPM methods should be updated from time to time and the sample of BPM methods could be broadened by other literature (e.g., BPM handbooks) and methods from other disciplines (e.g., innovation management). Finally, future research might consider to include other assessment dimensions besides the BPM lifecycle and the BPM context framework, or expand the approach to other core elements of BPM (e.g., governance, culture, or strategic alignment).

In response to the call for context-aware BPM method design, Section II.2 investigates the selection and prioritization of suitable DTs for organizations' business processes, i.e., the effective selection of PDPs. Proposing the 'Method for Exploiting the Digitalization Potential of Business Processes', research paper #2 caters for isolated processes and processes whose control flow can be captured in a straightforward manner. As this excludes non-routine processes and process networks, future research might investigate if the method could also use an organization's business process architecture as unit of analysis. Another direction for future research is the investigation of different contexts and the identification how the method's design specification must be tailored to fit these contexts. Of particular interest are changes when switching from exploitation to exploration mode, i.e., when leveraging DTs not only to incrementally improve and streamline, but also to radically re-engineer existing business processes. Based on the method of research paper #2, research paper #3 provides additional frameworks to improve the understanding of DTs. Besides a 'Multi-Layer Taxonomy of DTs', the research paper provides nine 'Archetypes of DTs'. As both frameworks are based on the investigation of 92 DTs from the Gartner Hype Cycle for Emerging Technologies (GHC) between 2009 and 2017, all outcomes should be updated from time to time to ensure that they still apply to the most recent technology developments. Future research should also refine the archetypes' names, which currently refer to the main purpose of the DTs per archetype. But since each archetype covers a broad range of DTs, the names are necessarily imperfect. Finally, there is no higher-order logic according to which the archetypes can be structured. In the future, researchers may set out to identify such a structuring logic, which could then be contrasted to the inductively built archetypes and, in turn, support their proper naming. Completing investigations on the effective selection of PDPs, research paper #4 contextualizes the archetypes with respect to the intra-logistics discipline and presents a 'Framework of DT Affordances in Intra-Logistics'. Just as for the archetypes, future research should bear in mind that further DTs will emerge, whereas the framework should be updated from time to time to ensure that it applies to and covers the most recent DTs. Moreover, future research might deploy the research design to identify affordances related to other corporate functions (e.g., production or sales), which can then be generalized into affordances of DTs for business processes at large.

Finally, Section II.3 investigates the second component of business process digitalization, i.e., the successful implementation of PDPs. Therefore, research paper #5 presents a literature-backed and empirically validated 'Framework of PDP Success'. To fully understand PDP success, it is important to identify interactions among the used success factor categories, the success factors per category, and the success factors of different categories. For a precise measurement of success factors, the dependent variable (i.e., success criteria) must be clear. Future research should therefore examine the measurement of project and process effectiveness and efficiency as well as search for interrelations among the identified success factors. Moreover, future research should investigate the explanatory power of the framework. Among the 29 identified PDP success factors, there is no hierarchical order expressing whether a factors is repeatedly observed or appears in rare occasions. A rare appearance does not connate weak impact and, vice-versa, permanent appearance of a factor does not automatically link to a strong impact on PDP success. Consequently, the explanatory and predictive power of the framework as well as the influence of potential factors that are difficult to observe, are understudied. Both directions depict important gaps and provide opportunities for future research.

In addition to research projects motivated by the individual research papers, this doctoral thesis offers comprehensive starting points and directions for future research. As outlined in Section I, digitalization not only forces organizations to seize the opportunities of emerging DTs, but also to meet related challenges and threats. Against this backdrop, future research might investigate methods and frameworks addressing that other aspect of digitalization. Besides, the further development and evaluation, e.g., the development of an overarching, integrated guideline that systematically leads its users through the introduced artefacts, would be possible.

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V. Appendix

1. Index of Research Papers

Research Paper #1: Context-Aware Business Process Management – Method Assessment and Selection

Vom Brocke J, Denner M-S, Röglinger M, Schmiedel T, Stelzl K, Wehking C: Context-Aware Business Process Management – Method Assessment and Selection. *Submitted working paper*. Earlier version published in *Proceedings of the 16th Conference on Business Process Management (BPM Conference), Sydney, Australia, 2018.*

Research Paper #2: Exploiting the Digitalization Potential of Business Processes

Denner M-S, Püschel LC, Röglinger M (2018): Exploiting the Digitalization Potential of Business Processes. In *Business & Information System Engineering*, 60(4): 331-349.

Research Paper #3: Unblackboxing Digital Technologies – Multilayer Taxonomy and Archetypes

Berger S, Denner M-S, Röglinger M: Unblackboxing Digital Technologies – Multilayer Taxonomy and Archetypes. *Submitted working paper.* Earlier version published in *Proceedings of the 25th European Conference on Information Systems (ECIS), Portsmouth, UK, 2017.*

Research Paper #4: Affordances of Digital Technologies for Intra-Logistics Processes

Denner M-S, Gimpel H, Röglinger M, Schulz L, Schlüchtermann J: Affordances of Digital Technologies for Intra-Logistics Processes. *Submitted working paper*.

Research Paper #5: Success Factors of Process Digitalization Projects – Two Multiple-Case Studies in the German Manufacturing Industry

Denner M-S, Lockl J, Röglinger M: Success Factors of Process Digitalization Projects – Two Multiple-Case Studies in the German Manufacturing Industry. *Submitted working paper.*

2. Individual Contribution to the Included Research Papers

This thesis is cumulative, whereas five research papers comprise the main body of this work. All included papers were written in settings with multiple researchers. Thus, in this section, I will detail the project settings and my individual contribution to each of the five papers.

Research paper #1 (vom Brocke et al.), which is presented in Section II.1, was written with five co-authors – three of whom work at other, international research institutions. A previous version of this paper was presented at the 16th International Conference on Business Process Management by a co-author and myself in Sydney, Australia. All co-authors jointly developed the basic concept for the paper and elaborated the paper's content. Personally, I had a main role in conducting the extensive literature review to identify extant BPM methods, which were then classified according to their actual context awareness. Moreover, I was substantially involved in the development of the underlying classification method ('CAMAS Method') as well as their evaluation with several industry experts. In sum, I had a main role in each part of the project.

Research paper #2 (Denner et al. 2018), which is presented in Section II.2, was developed with two co-authors. As the paper was written in the early stages of my doctoral study and had the purpose of bringing me closer to scientific work, it was my task to drive the whole research project. After the joint development of the paper's main idea, I was primarily responsible for the collection of relevant literature, the formulation of an appropriate research question, the identification of a comprehensive research approach, the development of the results ('Method for Exploiting the Digitalization Potential of Business Processes'), and their following evaluation. Regarding the latter, I conducted expert interviews and three case studies to demonstrate the method's applicability. During the whole research process, the paper benefitted significantly from the feedback of the experienced co-authors. In sum, I was substantially involved in each part of the project.

Research paper #3 (Berger et al.), which is presented in Section II.2, was developed with two co-authors. At the beginning, I had a main role in developing the basic idea of the paper, which was then jointly refined by all co-authors. Again, I was centrally involved in conducting the literature review, which served to collect relevant domain knowledge on DTs and to highlight the extent of the research gap. After the joint development of the 'Multi-Layer Taxonomy of DTs' and the 'Archetypes of DTs', I was primarily responsible for the meaningful elaboration and presentation of our results. Furthermore, I was responsible for the conduction and analysis of the evaluation, e.g., an external Q-Sort. In sum, I was substantially involved in each part of the project.

Research Paper #4 (Denner et al.), which is presented in Section II.2, was written in collaboration with three co-authors. Being the leading author of this paper, I had a main role in conceptualizing and elaborating the paper's content. Besides the analysis of the extensive literature review and the following development of the 'Framework of DT Affordances in Intra-Logistics', I developed the underlying 'Method on the Identification of DT Affordances'. Further, I was closely involved in the evaluation process, i.e., the conduction of interviews with academics and practitioners. In the end, it was my task to consolidate and write down the whole content in a consistent research paper. Although the paper was, to a large extent, my own work, the paper benefitted from the continuous involvement of all co-authors. Throughout, I was substantially involved in each part of the project.

Research paper #5 (Denner et al.), which is presented in Section II.3, was written with two other co-authors. In this project, I took the role of an experienced researcher and supported a younger colleague in his first paper project. Whereas his main contribution was the identification of extant and new success factors/codes of PDPs (literature review and MCS), I was substantially involved in the final elaboration of the results. Therefore, we jointly coded and categorized all identified statements to overarching PDP success factors and built categories with respect to existing IS research. Further, I had a main role in structuring the paper's content and writing it down in a meaningful manner. In sum, I was substantially involved in each part of the project.

3. Research Paper #1: Context-Aware Business Process Management – Method Assessment and Selection

Authors: Vom Brocke J, Denner M-S, Röglinger M, Schmiedel T, Stelzl K, Wehking C

Submitted Working Paper.

Extended Abstract

Context awareness is essential for successful business process management (BPM). So far, research has covered relevant BPM context factors and context-aware process design, but little is known about how to assess and select BPM methods in a context-aware manner. As BPM methods are involved in all stages of the BPM lifecycle, it is important to apply most appropriate methods to efficiently use organizational resources. Against this backdrop, the research question is as follows: *How can BPM methods be assessed and selected in a context-aware manner?*

In response to this question, the research paper presents the Context-Aware BPM Method Assessment and Selection (CAMAS) Method, adopting the Design Science Research paradigm to build and evaluate the proposed artifact (Gregor and Hevner 2013). The CAMAS Method consists of an 'Assessment' and a 'Selection Process', complemented by a 'Classification Framework'. The latter is a theoretically derived classification and facilitates assessing and selecting the applicability of BPM methods along three dimensions that build on the BPM lifecycle (Rosemann and vom Brocke 2015) and the BPM context framework (Vom Brocke et al. 2016). The 'Assessment Process' guides BPM method users and method engineers in assessing in which contexts new developed or existing BPM methods can be applied. The 'Selection Process' primarily guides BPM method users to select the BPM methods most applicable to their specific contexts. Further, it helps to understand the nature of existing BPM methods in a structured and well-founded manner.

The building of the CAMAS Method follows situational method engineering (Ralyté et al. 2003), enhancing existing ideas against the background of context awareness (e.g., Dumas et al. 2018 or vom Brocke et al. 2016). The evaluation of the CAMAS Method is based on a sample of existing BPM methods and an excel prototype representing the basic functionality of the method. To evaluate the 'Selection Process', BPM method users of two different organizations use the excel prototype to selected BPM methods for their specific context. To evaluate the 'Assessment Process', in turn, the excel prototype is applied to 115 existing BPM methods identified in literature.

Overall, the results of the evaluation reveal an overall lack of context-aware BPM methods, as most BPM method engineers have not explicated specific application possibilities for their BPM methods. Thus, the findings of this study call for more context awareness in BPM method design and for a stronger focus on explorative BPM. Besides, the work contributes to the descriptive and prescriptive knowledge on context-aware BPM and helps practitioners select suitable BPM methods in order to efficiently use organizational resources.

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vom Brocke J, Zelt S, Schmiedel T (2016) On the Role of Context in Business Process Management. International Journal of Information Management 36:486–495

4. Research Paper #2: Exploiting the Digitalization Potential of Business Processes

Authors: Denner M-S, Püschel LC, Röglinger M

Published in: *Business & Information System Engineering, 2018, 60(4), 331-349.*

Abstract: Process improvement is the most value-adding activity in the business process management (BPM) lifecycle. Despite mature knowledge, many approaches have been criticized to lack guidance on how to put process improvement into practice. Given the variety of emerging digital technologies, organizations not only face a process improvement black box, but also high uncertainty regarding digital technologies. This paper thus proposes a method that supports organizations in exploiting the digitalization potential of their business processes. To achieve this, action design research and situational method engineering were adopted. Two design cycles involving practitioners (i.e., managers and BPM experts) and end-users (i.e., process owners and participants) were conducted. In the first cycle, the method's alpha version was evaluated by interviewing practitioners from five organizations. In the second cycle, the beta version was evaluated via real-world case studies. In this paper, detailed results of one case study, which was conducted at a semiconductor manufacturer, are included.

Keywords: Business Process Improvement, Business Process Management, Digital Transformation, Digital Technologies, Situational Method Engineering, Action Design Research.

5. Research Paper #3: Unblackboxing Digital Technologies – Multilayer Taxonomy and Archetypes

Authors: Berger S, Denner M-S, Röglinger M

Submitted Working Paper.

Extended Abstract

Digitalization, which is driven by the emergence and adoption of digital technologies (DTs), affects individuals, organizations, and society. Despite their high importance and broad availability, DTs are poorly understood. While there are high-level classifications and comprehensive compilations in the professional literature, the academic literature investigates individual technologies in-depth and discusses theoretical ideas about DTs and related concepts. Yet, a literature-backed and empirically validated understanding of DTs is missing, a circumstance that hampers scientific progress and makes clear-headed decisions in industry difficult. Against this backdrop, the research paper asks the following question: *How can DTs be classified?*

To answer this question, the research paper follows McKelvey's (1982) organizational systematics approach by describing differences and commonalities of DTs and by identifying general classes. As per Nickerson, Varshney, and Muntermann (2013), the authors develop a multilayer taxonomy including characteristics of DTs as a means for classification. The provided taxonomy builds on the latest literature and a sample of 92 real-world DTs compiled from various sources. In the end, it comprises eight dimensions structured along four overarching layers that fit Yoo et al.'s (2010) layered architecture of DTs, i.e., device, network, content, and service. To evaluate the taxonomy, the research paper assess its reliability by classifying the DTs from the sample. On this basis, it calculates object- and dimension-specific hit ratios as well as absolute and relative ratios per characteristic (Moore and Benbasat 1991).

In a second step, the authors inductively inferre DT archetypes, i.e., combinations of DT characteristics typically occurring in practice, based on the classified sample of 92 DTs and hierarchical clustering (Cormack 1971). In the end, the cluster analysis results in nine DT archetypes, i.e., 'Connectivity & Computation', 'Platform Provision', 'Mobile Device', 'Sensor-based Data Collection', 'Actor-based Data Execution', 'Self-dependent Material Agency', 'Analytical Insight Generation', 'Augmented Interaction', and 'Natural Interaction'. The archetypes' reliability and validity is assessed via an internal and external Q-Sort (Nahm et al. 2002). Moreover,

the authors examine the archetypes' year-wise occurrence within the Gartner Hype Cycle for Emerging Technologies (GHC) to assess their robustness over time. Finally, an online questionnaire is send out to industry experts, who confirme the archetypes nomenclature as well as potential use cases.

The main contributions of this research paper, i.e., the taxonomy and the archetypes, extend the common understanding of DTs and serve as basis for future research in this domain. While the taxonomy provides in-depth insights into DTs and enables classifying individual technologies according to the layers of established DT architectures, the archetypes abstract from individual DTs. As such, they provide a sufficiently stable foundation for investigating the affordances of DTs in different contexts as well as the drivers of and barriers to the adoption to DTs.

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6. Research Paper #4: Affordances of Digital Technologies for Intra-Logistics Processes

Authors: Denner M-S, Gimpel H, Röglinger M, Schulz L, Schlüchtermann J

Submitted Working Paper.

Extended Abstract

Digitalization connects the physical with the digital world and enables new ways of automation and data analysis. Thus, embedding digital technologies (DTs) in business processes can generate great value for organizations. Due to its dependence on accurate and up-to-date information, intra-logistics is an exemplary discipline undergoing significant changes. But despite of promising application possibilities linked to digitalization, organizations struggle with identifying which DTs they should adopt to support their intra-logistics processes. Today, many existing contributions deal with single DTs in detail, while others take a more generic perspective and seek to understand how DTs influence the logistics ecosystem. The value of these contributions undisputed, there is no work that answers the following research question: *How can DTs be used in intra-logistics processes?*

In response to this question, the research paper presents a catalogue of ten organisation- and industry-independent Digital Technology Affordances in Intra-Logistics (DTAILs). Each affordance is described in terms of enabling DTs, affected process elements, and related manifestations. As a secondary contribution, the authors compile 46 manifestations that represent specific action possibilities of DTs and thus exemplify the affordances' relevance. Exemplary manifestations of the affordance 'Assistance of Manual Tasks' are 'Job Instructions', 'Loading Guidance', and 'Navigation Support'; exemplary manifestations for the affordance 'Condition Monitoring of Goods and Assets' are 'Predictive Maintenance', and 'Smart Packaging'

The development of the artifact(s) includes two phases. In a first design and development phase, a structured literature review identifies action possibilities enabled by DTs and builds an initial catalogue of DTAILs, while drawing from affordance theory to structure the results (Gibson 1986). The review includes academic literature from both the information systems and the logistics discipline as well as publications from leading logistics, technology and consulting companies. Inspired by Task-Technology-Fit theory (Goodhue and Thompson 1995), the authors set up a 'technology-process-matrix' to support the coding and to structure the findings

(Wolfswinkel et al. 2013). In a second phase, the authors validate, refine, and extend the initial catalogue of DTAILs and manifestations in ten semi-structured interviews with subject matter experts from academia and industry (Myers and Newman, 2007).

Overall, the results of the research paper support organizations in identifying and prioritizing appropriate DTs for their intra-logistics processes and, thus, help managers and/or logisticians to structure their decision-making activities. They also increase existing knowledge on DTs in general and related opportunities in the intra-logistics domain. Finally, the research design can serve as a blueprint for researchers seeking to identify affordances of DTs related to other corporate functions (e.g., production or sales), which can eventually be generalized into affordances of DTs for business processes at large.

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7. Research Paper #5: Success Factors of Process Digitalization Projects – Two Multiple-Case Studies in the German Manufacturing Industry

Authors: Denner M-S, Lockl J, Röglinger M

Submitted Working Paper.

Extended Abstract

Digitalization is driven by the adoption of digital technologies (DTs), changing societal conventions and organizational routines. Novel products emerge, bringing about opportunities in each industrial sector. As things stand, many organizations not only struggle to integrate DTs into their products, but also fail to capitalize on the ability of DTs to improve business processes. With DTs being commonly integrated in business processes through projects, the research paper analyses so called ‘Process Digitalization Projects’ (PDPs), i.e., projects that leverage DTs to improve the effectiveness and efficiency of business processes. Whereas existing literature in business process management and project management has already investigated success factors (SFs) and success criteria of various improvement projects, research on digitalization is less mature. As a holistic view of PDP-related SFs is missing, the research question is as follows: *Which factors drive the success of PDPs?*

To answer this question, the research paper provides the ‘Framework of PDP Success’, which consists of 29 factors structured along six PDP success factor categories, i.e., ‘Strategy’, ‘Culture’, ‘People’, ‘Process’, ‘Project’, and ‘Technology’. The development of the framework follows a multi-staged approach, in which the authors first conduct a structured literature review to identify existing success frameworks/ categories (e.g., Alter 2013). Afterwards, the application of multiple coding (Wolfswinkel et al. 2013) allows to consolidate the preliminary results in an ex-ante model. To validate and refine the ex-ante model, two cross-sectional multiple-case studies (Eisenhardt 2007) in the manufacturing industry complete the literature-based results by empirical data from real-world PDPs. In the end, the analysis of semi-structured interviews (Myers and Newman 2007) on three finished and four running PDPs enables the authors to compile an ex-post model. Compared to the ex-ante model, the ex-post model confirmes the influence of 19 SFs, explores seven new SFs, and refines two factors into three new ones.

From a theoretical perspective, the ‘Framework of PDP Success’ extends the knowledge on digital transformation and process digitalization. Moreover, it provides evidence that SFs included in the literature need to be revised and extended. From a management perspective, the developed artifact supports organizations to systematically control their project activities. Managers, who are responsible for the implementation of PDPs within an organization, for example, can address critical SFs when embedding DTs within their business processes.

References

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