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How to Exploit the Digitalization Potential of Business Processes

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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 do so, 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.

1 Introduction

Process orientation is an accepted paradigm of organizational design (Recker and Mendling 2016). As the related management discipline, Business Process Management (BPM) strives for two overarching objectives, i.e., improving business processes and developing the BPM capability itself (Rosemann and vom Brocke 2015). Process improvement has been a top priority of process decision-makers for a long time (Harmon and Wolf 2016). Due to the high attention from industry, the BPM community has developed mature approaches supporting process discovery, design, analysis, enactment, and improvement (van der Aalst 2013; Vanwersch et al. 2016; Zellner 2011). Nowadays, organizations particularly struggle with capitalizing on digital technologies, which are anticipated to rewrite the rules of competition (Gimpel and Röglinger 2015; Hirt and Willmott 2014). Digital technologies are already changing existing work practices and will do so even more in the future, enabling and forcing organizations to redesign their business processes (Allen 2015; Matt et al. 2015). The problem is that many organizations still lack knowledge on digital technologies as well as on identifying which technologies they should adopt to boost their business processes (HBRAS 2015). A recent McKinsey study, for instance, found that only 7% of 850 C-level executives consider their organization to understand the value of digitalization (Gottlieb and Willmott 2014).

The literature offers numerous approaches to process improvement (Vanwersch et al. 2016; Vergidis et al. 2008). With these approaches focusing on activities before and after improvement, the actual improvement and derivation of improvement ideas happens in a black box (Vanwersch et al. 2016; Zellner 2011). This is why process improvement approaches have long-time been criticized for a lack of guidance on how to put process improvement into practice (Adesola and Baines 2005). In response to this criticism, some researchers investigated how to structure the derivation of improvement ideas, e.g., by compiling process enhancement patterns or redesign best-practices (Mansar and Reijers 2007; Recker and Rosemann 2014). Other authors investigated how to prioritize process improvement projects, e.g., via process assessment heat maps, adopting approaches from multi-criteria decision analysis (MCDA) (e.g., Analytical Hierarchy Process, AHP), or via decision models that valuate improvement projects in terms of their impact on process performance (Darmani and Hanafizadeh 2013; Linhart et al. 2015; Mansar et al. 2009; Ohlsson et al. 2014). Further, Vanwersch et al. (2016) proposed a framework that enables practitioners to generate process improvement ideas by themselves. The value of these advances undisputed, there is to the best of our knowledge no approach that helps derive and prioritize process improvement ideas in line with digital technologies. Given the importance of digital technologies for future work practices, we investigate the following research question: *How can organizations systematically exploit the digitalization potential of their business processes?*

To answer this question, we adopt the action design research (ADR) paradigm and develop a method that aims to assist organizations in systematically exploiting the digitalization potential of business processes. As methods are a valid artefact type of design science research (DSR), this also holds for ADR (March and Smith 1995). According to ADR, we combine the building, intervention, and evaluation of our method in a concerted research effort (Sein et al. 2011). Whereas the initial design specification of our method (alpha version) was built using situational method engineering (SME) as research method, it was further shaped in two design cycles involving development and evaluation. In the first cycle, we interviewed experts from five organizations, a step that allowed us to conceive the beta version of our method based on practitioners' feedback concerning understandability, generality, and real-world fidelity. In the second cycle, we validated our method's beta version with respect to operationality, ease of use, and efficiency via three case studies based on real processes. Consequently, the final result, which we present in this study, is an artefact that not only reflects its theoretical precursors and the intent of researchers, but also the influence of users and the use in context (Sein et al. 2011).

The study is organized as follows: Below, we first provide theoretical background on BPM and process improvement as well as on digitalization and digital technologies. We also propose design principles that guided the construction of our method. We then outline our research method and evaluation strategy. Having introduced the design specification of our method, we report on our evaluation activities. We conclude with pointing to limitations and future research possibilities.

2 Theoretical Background and Design Principles

2.1 Business Process Management and Improvement

BPM is the science and practice of overseeing how work is performed to ensure consistent outcomes and to take advantage of improvement opportunities (Dumas et al. 2013). From a lifecycle perspective, BPM includes the identification, definition, modelling, implementation and execution, monitoring and control as well as improvement of processes (Recker and Mendling 2016). Combining knowledge from information technology and management sciences (van der Aalst 2013), BPM is a prerequisite for successful processes, i.e., for efficient and effective work (de Bruin and Rosemann 2005). Processes split into core, support, and management processes (Armistead et al. 1999). Core processes create value for customers, support processes ensure that core processes function, and management processes help plan, monitor, and control other processes (Harmon 2014). In general, processes are defined as „collection[s] of inter-related events, activities, and decision points that involve a number of actors and objects, and that collectively lead to an outcome that is of value to at least one customer" (Dumas et al. 2013, p. 5). Consequently, business processes can be described using five fundamental perspectives (Zeising et al. 2014). Besides the chronological behavior of the included process tasks (*behavioral perspective*), these perspectives relate to the functional elements of a process (*functional perspective*), the assignment of tasks to human participants (*organizational view*), the implementation of an atomic activity (*operational perspective*) and the information entities handled during individual tasks (*informational perspective*) (Curtis et al. 1992; Mansar and Reijers 2007; Zeising et al. 2014). Beyond, each process can be characterized via different performance dimensions (e.g., costs, flexibility, quality, and time) such as proposed by the Devil's Quadrangle (Leyer et al. 2015; Mansar and Reijers 2007). Against this background, we define the following design principle:

> *(DP.1) Multi-dimensional analysis of business processes: With business processes being multi-dimensional constructs, it is necessary to account for the fundamental perspectives when thinking about analysis and improvement. The same holds true for business process performance, which needs to be operationalized as a multi-dimensional construct as well.*

The BPM discipline disposes of methods, techniques, and tools to support the improvement, enactment, management, and analysis of business processes (Linhart et al. 2015; van der Aalst 2013; Recker and Mendling 2016). Process improvement refers to the "process of assessing, analyzing, and improving the business processes that are important to an organization's success" (Povey 1998, p. 30). Besides a classification into model- and data-based process analysis (van der Aalst 2013) as well as diagrammatic, mathematical, and execution-oriented process models (Vergidis et al. 2008), a fundamental classification is that into continuous process improvement and business process reengineering (Trkman 2010). Similarly, Rosemann (2014) proposes a classification into explorative and exploitative BPM, where the exploitation mode is geared towards continuous process improvement and the exploration mode towards radical process reengineering.

2.2 Digitalization and Digital Technologies

Over the last decades, the world has changed fundamentally (Bhardawaj et al. 2013; Uhl et al. 2016). The digitalization of products and services is a fast-moving, global megatrend that transforms value networks across all industries (Collin 2015). As the impact of digitalization is boosted by the fast emergence of digital technologies (Mattern et al. 2012), digitalization can be defined as the adoption of digital technologies to improve or disrupt business models, business processes as well as products and services (Gartner 2016a). Consequently, organizations across all industries experience rapidly changing customer demands (Priem et al. 2013). The highly dynamic business environment does not only enable organizations to seize digital opportunities, but also forces them to react upon changing business rules (Matt et al. 2015; Turber and Smiela 2014). Research found that various challenges must be tackled when engaging in digital transformation, e.g., dealing with fast-paced technological innovation as well as restructuring business processes, organizational structure, or culture (Ashurst et al. 2008; Markus and Benjamin 1997). Consequently, researchers developed approaches to facilitate digital transformation, e.g., by spotting the correlation between an organization's BPM maturity and its ability to create value via digitalization (Kirchmer et al. 2016), by emphasizing the importance of IT roles in redesign projects (Hansen et al. 2011), or by examining the effects of IS integration on process improvement (Bhatt 2000).

As key drivers of digitalization, digital technologies have become immersed in our daily routines, influencing how we behave in business and private contexts (Aral et al. 2013; McDonald and Russel-Jones 2012). Although an accepted definition of digital technologies is missing, Yoo et al. (2010) state that digital technologies differ from earlier technologies in three characteristics: (1) the re-programmability that separates the functional logic of a device from its physical embodiment, (2) the homogenization of data that allows for storing, transmitting, and processing digital content using the same devices and networks as well as (3) the self-referential nature yielding positive network externalities that further accelerate the creation and availability of digital devices, networks, services, and contents. Further, Yoo et al. (2010) propose an architecture of digital technologies with four layers (i.e., device, service, network, and content) that enables the separation of devices and services due to re-programmability and the separation of network and content due to homogenization of data. The spectrum of digital technologies is broad, ranging from the Internet of Things, over 3D/4D printing and blockchain, to smart advisors or advanced analytics (Gartner 2016b). Due to their novelty and pace of development, there is to the best of our knowledge no classification of digital technologies. What can be found in many sources is a classification called SMAC, including social, mobile, analytics and cloud technologies (Ackx 2014; Evans 2016; Uhl et al. 2016). Social features like wikis or community work spaces mainly change the work among individuals, crossing functional, hierarchical, and organizational boundaries (Ackx 2014). Advances in mobile technology enable applications that provide new ways of communication and information access (Harrison et al. 2013). Advanced analytics support organizations in making sense of and capitalizing on huge amounts of data (Clarke 2016). Cloud computing provides an infrastructure for organizations and individuals to access information and applications from anywhere on demand (Marston et al. 2011). Beyond the SMAC classification, a key lever of digital technologies is seen in in their combination (Cole 2016). For example, ideas of generating new platforms for digital business initiatives by adding personas and context, intelligent automation, smart product integration to the familiar SMAC technologies are gaining ever more importance. As organizations select from a portfolio of digital technologies to transform business models, processes, products and services, knowledge about digital technologies is vital (Evans 2016). Regarding opportunities and threats (e.g., data security, privacy, or technology dependency), organizations face a high level of uncertainty when it comes to identifying which technologies they should adopt (Ackx 2014). Accordingly, we specify the following design principle, which has also been confirmed by the organizations involved in our evaluation:

(DP.2) Reduction of uncertainty about digital technologies: When aiming to exploit the digitalization potential of business processes, it is necessary to successively reduce the involved decision-makers' uncertainty with respect to the opportunities and threats of digital technologies.

3 Research Method

3.1 Action Design Research

To develop our method, we adopted the ADR paradigm, which is closely related to DSR (Sein et al. 2011). DSR, in general, aims to create innovative artefacts (e.g., instantiations, methods, models, and constructs) to improve problem-solving capabilities (Gregor and Hevner 2013; March and Smith 1995). Our artefact is a method that assists in systematically exploiting the digitalization potential of business processes. DSR includes two main activities, i.e., constructing the artefact (building) and determining whether the artefact creates utility (evaluation) (Sonnenberg and vom Brocke 2012). As this design-evaluate pattern ignores the emerging nature of artefacts in organizational contexts, ADR combines building the artefact, intervention in the organization, and evaluation in a concerted research effort. ADR particularly accounts for the reciprocal shaping of artefacts with practitioners (i.e., individuals with first-hand experience) and end-users (i.e., the artefact's target audience). ADR results in artefacts that not only reflect theoretical precursors and the researchers' intent, but also the influence of users and use in organizational contexts (Sein et al. 2011). We now outline how we designed our method, following the four ADR stages (i.e., problem formulation, building, intervention and evaluation, reflection and learning, and formalization of learning) as well as the seven ADR principles.

The first ADR stage refers to formulating the problem in focus. We already provided information about this stage in the introduction, where we outlined our research question. In line with the ADR principle of practice-inspired research, we illustrated that systematically exploiting the digitalization potential of business processes currently receives high attention in industry, boosted by the emergence of digital technologies. As for the ADR principle of theory-ingrained artefacts, our method is informed by existing descriptive and prescriptive knowledge related to BPM, digital technologies, and MCDA (e.g., rating scales and pairwise comparison).

The second ADR stage includes building, intervention, and evaluation (BIE) activities. To develop our method, we followed the IT-dominant BIE form, which required evaluating an alpha version of our method against the assumptions, expectations, and knowledge of practitioners (first design cycle) as well as to evaluate a beta version with end-users in a wider organizational setting (second design cycle). We developed the alpha version of our method in line with SME, an accepted research method for developing methods in the IS context (Henderson-Sellers and Ralyté 2010). Thereby, our method is not only based on existing justificatory knowledge, but also geared towards the design principles we derived from the literature. We evaluated the alpha version in five organizations. To do so, we provided selected practitioners from these organizations (e.g., head of process and change management, head of BPM and organizational development) with an initial description of our method and conducted semi-structured interviews (Myers and Newman 2007). After a careful deliberation of the practitioners' feedback, we further developed our method to obtain the beta version. We evaluated the beta version via case studies with three of the organizations that participated in the first cycle. This time, we applied our method to real business processes and involved these processes' owners and participants as end-users. The real-world feedback and application experience enabled us to further refine our method. As this feedback included only minor adjustments and recommendations for application, we stopped after this design cycle. During the entire ADR process, decisions about the design of our method and intervening in the participating organizations were interwoven with evaluation activities. Due to the intensive collaboration with practitioners and end-users from multiple organizations, we meet the ADR principles of reciprocal shaping and mutually influential roles. Finally, as our ADR project included two design cycles, it also meets the ADR principle of authentic and concurrent evaluation.

The third ADR stage is called reflection and learning, paralleling the first two stages. As we integrated the feedback of practitioners and end-users, we continuously reflected on the design of our method and analyzed the intervention results against the goals of our method. We also gained insights into the contexts in which our method can be applied. Therefore, the refined beta version does not only reflect the preliminary design, but also the organizational shaping and the practitioners' feedback, meeting the ADR principle of guided emergence.

The fourth ADR stage aims at formalizing the learning gained throughout the ADR project. In line with the ADR principle of generalized outcomes, situated learnings must be further developed into general solution concepts, i.e., moving from specific-and-unique to generic-and-abstract (Sein et al. 2011). To do so, we condensed our insights into context and projects types in which our method can be applied. As context and project type define situations, which are a central construct of SME, we integrated our insights into the presentation of our method. We also point to general insights into activities and techniques when introducing our method below.

3.2 Situational Method Engineering

In the literature, there are many definitions of what constitutes a method (Braun et al. 2005). Lorenz (1995), for example, defines a method as a process that is planned and systematic in terms of its means and purpose and that leads to skills in resolving theoretical or practical tasks. Brinkkemper (1996) defines a method as an approach "based on a specific way of thinking, consisting of directions and rules, structured in a systematic way […] with corresponding development products" (p. 276). Generally speaking, a method offers a systematic structure to perform work steps to achieve defined goals (Braun et al. 2005). Further, methods include constitutive attributes and elements that support their application (Braun et al. 2005; Zellner 2011). To ensure that our method follows relevant attributes and covers relevant elements, we compiled a respective list from the literature (Table 1). To do so, we referred to Braun (B) et al. (2005), who derived the most frequent method attributes and elements based on a systematic literature review, as well as to Vanwersch (V) et al. (2016), who identified six methodological decision areas to set up a framework for generating process improvement ideas. Table 1 summarizes all mandatory method components relevant for the development of our method.

Table 1: Mandatory Method Components

	Name	Description	B	V
Attributes	(A.1) Goal orientation	Methods must strive for achieving specific goals	X	X
	(A.2) Systematic approach	Methods must include a systematic procedure model	X	
	(A.3) Principles orientation	Methods must follow general design guidelines and strategies	X	
	(A.4) Repeatability	Methods must be repeatable in different contexts	X	
Elements	(E.1) Activity	Task that creates a distinct (intermediate) output	X	
	(E.2) Technique	Detailed instruction that supports the execution of an activity	X	X
	(E.3) Tool	Tool (e.g., software) that supports the execution of an activity		X
	(E.4) Role	Actor that executes or is involved in the execution of an activity	X	X
	(E.5) Defined output	Defined outcome per activity (e.g., documents)	X	X

As different project situations can occur in the BPM and IS field, the need for situation-specific methods has already been identified years ago (Mirbel and Ralyté 2006). SME thus assists in developing methods suitable for specific situations (Henderson-Sellers and Ralyté 2010). Many construction processes have been proposed to develop situation-specific methods (Gericke et al. 2009). In general, SME splits into method configuration and method composition (Bucher et al. 2007). While method configuration (i.e., extension-based approach) refers to the adaptation of a generic method for a specific situation, method composition (i.e., assembly-based approach) selects and composes method fragments from existing methods against situational needs (Karlsson et al. 2001; Ralyté et al. 2003). As our method closely relates to business process improvement, existing approaches served as foundation for constructing our method. We thus followed the assembly-based approach, involving the following three steps: specification of method requirements, selection of method fragments, and assembly of fragments (Ralyté et al. 2003; Henderson-Sellers and Ralyté 2010). Below, we outline how we applied SME.

The first SME step, i.e., the specification of method requirements, requires specifying the situations in which a method can be used and the requirements that support these situations in light of previously set goals (Hernderson-Sellers and Ralyté 2010). In the context of SME, situations are combinations of a context and a project type (Bucher et al. 2007). The context type refers to organizations contextual factors that influence the content of the future method (Gericke et al. 2009). To define relevant contextual factors, we relied on the BPM context framework by vom Brocke et al. (2016). The project type can be characterized by an initial state before the method was applied and a desired target state after the method was applied (Bucher et al. 2007). We define both situational components of our method in the first part of the design specification section.

The second and the third SME steps, i.e., the selection and assembly of method fragments, are addressed in the third part of the design specification. The assembly-based approach suggests decomposing existing methods into method chunks (i.e., method fragments) and characterizing these fragments by product parts, interfaces, and descriptors. Fragment assembly proposes to determine the similarity between the fragments of different methods, to identify which fragments match the specific situation best as well as to compose the selected fragments to a new method (Henderson-Sellers and Ralyté 2010). In our case, we did not create an entirely new end-to-end method, but enhanced existing business process improvement approaches against the background of digital technologies. We thus referred to the BPM lifecycle by Dumas et al. (2013) as a high-level compilation of activities related to business process improvement, focusing on process discovery, analysis, and redesign. Instead of computing similarities among numerous theoretically useful method fragments, which we do not deem feasible, we conducted an extensive literature review and asked practitioners for their needs. We successively developed method activities, techniques, tools, and roles and compiled the activities into a procedure model. All activities represent method fragments that draw from extant knowledge related to BPM, digital technologies, and MCDA.

4 Design Specification

4.1 Specification of Method Requirements

As outlined above, the first SME step requires specifying method requirements. This step, in turn, requires specifying situations in which the method can be used. As we understand a situation as the combination of a context and a project type, we elaborate on both components below (Bucher et al. 2007).

We define the context type of our method according to the BPM context framework as per vom Brocke et al. (2016), which identifies and discusses relevant BPM context factors. The framework groups context factors in four dimensions, i.e., goal, process, organization, and environment. Each context factor can take one out of several characteristics. As our method addresses the digitalization of business processes, not all context factors are relevant. We only outline relevant factors here. First, our method takes a single-process perspective, abstracting from interactions among processes (Dijkman et al. 2016). As for the goal dimension, our method focuses on exploitation. Thus, it does not aim to radically re-engineer business processes, but to incrementally improve and streamline current work practices by using digital technologies (Rosemann 2014). Considering the process dimension, our method focuses on core and support processes with medium variability. Regarding the organization dimension, our method applies to intra-organizational processes. It does not matter whether a business process is executed in a production or service industry context. As required skills and roles are not necessarily available in small organizations, our method considers processes of medium or large organizations. Regarding the environment dimension, we focus on organizations facing medium or high competition, as such organizations are forced to leverage the potential of digital technologies. The same is true for uncertainty, as many organizations face a medium or high level of uncertainty when reasoning about which digital technologies to adopt (Gottlieb and Willmott 2014; HBRAS 2015).

To define the project type, we characterize the initial state before our method's application as a situation where 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 digital technologies to a higher extent and have enhanced its operational performance and strategic fit (Wu et al. 2015). The project type of our situation refers to the incremental redesign of the process in focus, transforming it from the initial to the target state (Bucher et al. 2007). To structure the redesign, we rely on the initial phases of the BPM lifecycle, i.e., process discovery, analysis, and redesign, as they capture all activities related to process improvement on a high level of abstraction and, thus, fit the purpose of our method (Dumas et al. 2013; Recker and Mendling 2016).

4.2 Method Overview

Before presenting all activities, we provide a high-level end-to-end overview. Our method includes four activities (E.1) each of which includes techniques (E.2), tools (E.3), roles (E.4), and defined output (E.5). Table 2 overviews all elements, whereas Figure 1 offers additional illustrations. From a content perspective, the method's activities relate to a distinct process, digital technologies, or the evaluation of digital technologies' suitability to support the process in focus. First, the process whose digitalization potential shall be exploited is selected and modelled. After that, potentially suitable digital technologies are preselected and assessed from a behavioral process perspective. Then, further evaluation perspectives are included, i.e., additional fundamental process perspectives (e.g., information, product, and customer), goals (e.g., operational performance and strategic fit), and risks relating to the implementation and use of digital technologies (Chapman and Ward 2003; Mansar et al. 2009). Finally, the most suitable digital technologies are determined. Presenting the activities below, we include justificatory knowledge that served as foundation for selecting respective method fragments.

Our method aims to stimulate and structure consensus-oriented discussions among the business-, process-, and IT-related roles involved in process improvement to identify the most suitable digital technologies for the process in focus. Users of our method must be aware that all values determined throughout the method and, consequently, the results are estimations and subjective with respect to the users' knowledge, experiences, and preferences. Drawing from the MCDA literature, our method indicates which rating scales to use to achieve meaningful results. However, it cannot prescribe how to determine the concrete values and how to find consensus. Users have to choose among techniques such as brainstorming, moderated group discussions, or team estimation games (Schwaber 1997; Yoo et al. 2009).

Beyond the constitutive elements, our method addresses the attributes goal orientation (A.1), systematic approach (A.2), principles orientation (A.3), and repeatability (A.4). As for goal orientation, our method strives for exploiting the digitalization potential of a distinct process. To do so, our method assembles four method fragments based on justificatory knowledge. The detailed description of each activity guarantees repeatability in various contexts. Repeatability has also been demonstrated in three case studies of the second design cycle. As for principles orientation, our method is geared towards two design principles derived from the literature on BPM and digital technologies. Accordingly, our method accounts for multiple perspectives on the process and process performance (DP.1). It also strives for successively reducing an organization's uncertainty with respect to digital technologies (DP.2).

Table 2: Overview of the Method's Activities and Elements

Activity (E.1)	Technique (E.2)	Tool (E.3)	Role (E.4)	Output (E.5)
Activity 1: Selection and modelling 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

4.3 Detailed Procedure Model

Activity 1: Selection and Modelling of Business Process

Technique: Activity 1 requires selecting and modelling the as-is process whose digitalization potential shall be exploited, a preparatory task for all other activities included in our method. Process modelling is a standard activity that requires the identification and depiction of relevant sub-processes (SPs). For our purposes, it is sufficient to model the process in focus on the level of sub-processes (i.e., a comparatively high level of abstraction that entails a straightforward control flow) to keep the complexity of the subsequent activities manageable. The users of our method can choose an appropriate level of process modelling as long as the control flow is straightforward. Focusing on sub-processes, activity 1 takes a behavioral process perspective, which offers the most intuitive starting point for process analysis (Mansar and Reijers 2007; Zeising et al. 2014). We complement the behavioral perspective with other fundamental process perspectives in activities 3 and 4. As digital technologies may not only influence single sub-processes, we included a dummy sub-process named 'end-to-end' (E2E) that allows assessing the effects of digital technologies on the control flow (see Activity 1 in Figure 1). If the sub-processes are not equally important for the process in focus (e.g., because of many repetitions, high criticality, or intense customer involvement), it is necessary to assess their relative importance.

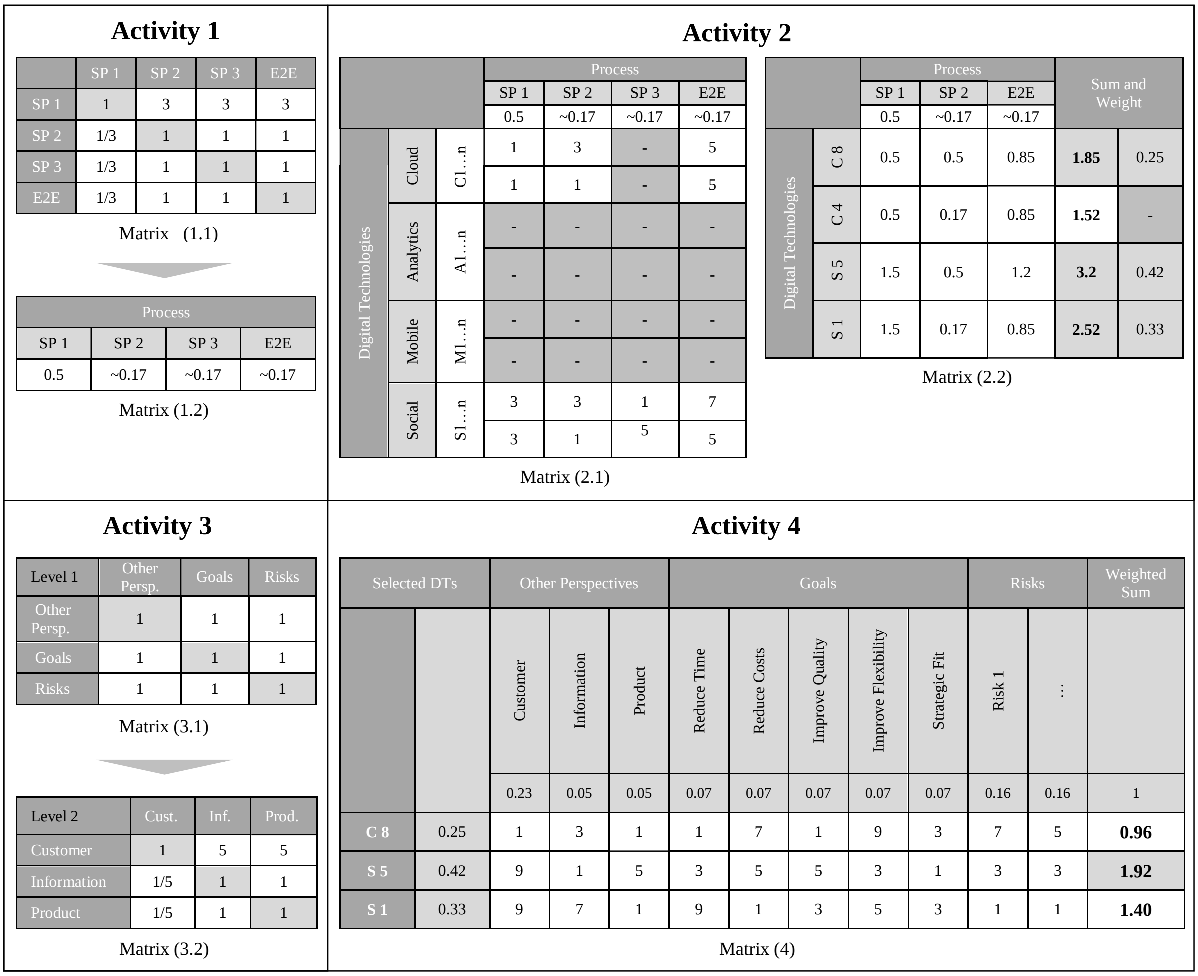


Figure 1: Visualized Procedure Model (with Exemplary Values)

Tool: To model the process in focus, we recommend using established business process modelling languages (e.g., BPMN) and methods (Dumas et al. 2013). To determine weights that capture the sub-processes' relative importance, we adopt the pairwise comparison mechanism known from MCDA

(Saaty 1977). Thus, a matrix with sub-processes on both dimensions must be filled with relative importance values based on a rating scale. As rating scale, we use the basic AHP scale (i.e., 1: equally important, 3: slightly more important, 5: strongly more important, 7: very strongly more important, 9: extremely more important). Generating the standardized matrix and dividing the row totals by the number of sub-processes yields relative importance weights (Saaty 1977). To determine appropriate rating values, method users must choose among techniques such as brainstorming, moderated group discussions, or team estimation games (Schwaber 1997; Yoo et al. 2009). The same holds for the other activities of our method. In Figure 1, activity 1 shows an exemplary matrix for pairwise comparison (1.1) and the weights of different sub-processes (1.2).

Roles: To model the process in focus, activity 1 involves the process owner and process participants. In case the process owner and participants do not have sufficient modelling skills, we recommend involving one of the organization's BPM experts (if available).

Output: The result of activity 1 is a modelled as-is process divided into sub-processes and including an end-to-end perspective. Sub-processes may be weighted according to their relative importance.

Justificatory knowledge and method fragments: One the one hand, we draw from knowledge on business process modelling (Dumas et al. 2013). On the other, we adopt mechanisms from MCDA to support the assessment of sub-processes, digital technologies, evaluation dimensions, and criteria. In particular, we use rating scales (activities 1 to 4) and pairwise comparison (activities 1 and 3). In the literature, both mechanisms are discussed regarding their goodness and application orientation (Eckert and Schaaf 2009). Whereas goodness refers to the quality of measurement scales (e.g., validity, reliability), application orientation refers to their applicability in real-world settings (e.g., time exposure). With our method aiming to assist practitioners in exploiting the digitalization potential of business processes independent from MCDA experts, we focus on the application orientation of MCDA mechanisms. Rating scales achieve excellent results regarding time and applicability. The separate evaluation of alternatives with respect to multiple criteria reduces practitioners' cognitive strain and supports quick assessments. Pairwise comparison is more time-consuming, but appropriate for determining the relative importance of alternatives or decision criteria. Nevertheless, pairwise judgement is highly intuitive and appealing for practitioners. Individuals or groups can apply pairwise comparison efficiently. Further, the calculation of pairwise comparison is fast as practitioners can use standard spreadsheet analysis software (Forman and Gass 2001). As rating scale, we use the basic AHP scale as well as slightly modified variants because the AHP is a well-accepted MCDA approach and has already been successfully used for process decision-making (Mansar et al. 2009). We do not adopt the entire AHP because it requires huge time and economic resources to evaluate real life cases (Polatidis et al. 2006).

Activity 2: Preselection of Suitable Digital Technologies

Technique: Activity 2 requires confronting the modelled process with a longlist of potentially suitable digital technologies. As the complexity of our method strongly increases with the number of sub-processes and digital technologies included, activity 2 first requires eliminating those sub-processes and digital technologies that should not be considered further, yielding a medium list of digital technologies and sub-processes (see Activity 2 in Figure 1). Potential knock-out criteria are that digital technologies do not fit the business process in focus, are too expensive, bear risks that the organization does not feel able to manage, or because the organization already made bad experiences with distinct technologies. Sub-processes may be eliminated as they do not have sufficient digitalization potential, are unimportant for the overall process, or have been redesigned recently. To assess the digitalization potential of the process compared to the status quo, users must assess the extent to which the remaining digital technologies are suitable to support the remaining sub-processes. As it is important that all users have the same expectations towards the possible impact of the remaining digital technologies, we recommend linking each digital technology to one or more organization-specific projects concerning the sub-processes in focus (e.g., based on reference projects). Based on this assessment, activity 2 yields a shortlist of the most suitable digital technologies. Activity 2 also assesses the relative importance of these digital technologies based on their score values.

Tool: To confront the process in focus with digital technologies, a further matrix must be created that includes sub-processes on one dimension and digital technologies on the other. A list of digital technologies may already exist in the organization or needs to be created in a separate workshop. For our purposes, we exemplarily structured digital technologies based on the SMAC classification (Ackx 2014; Evans 2016). Technologies from these groups might be used in combination, a circumstance that must be considered when applying the method. To get an idea of possible digital technologies, we recommend using external insights such as provided by the Gartner Hype Cycle for Emerging Technologies (Gartner 2016b). Reducing the longlists of digital technologies and sub-processes to medium lists does not require a special tool, but depends on organization-specific considerations. For some digital technologies (e.g., mobile enterprise apps or knowledge management systems), there already are methods users can use to complement, support, or affirm the outcome of our method (Hoos et al. 2015; Greco et al. 2013). Note that some of these methods require more information than initially provided from a behavioral process perspective to be applied. The assessment of digital technologies is based on a rating scale. This time we adopt a slightly modified AHP scale, expressing the relative suitability of digital technologies for each sub-process compared to the status quo (i.e., 1: equally suitable, 3: slightly more suitable, 5: strongly more suitable, 7: very strongly more suitable, 9: extremely more suitable). To calculate the suitability of a digital technology across all sub-processes, the respective scores must be weighted according to the sub-processes' relative importance and summed up. The cut-off criterion must be chosen individually. Finally, the shortlisted digital technologies are assigned relative weights according to their score values compared to the scores of other technologies. Activity 2 in Figure 1 visualizes this procedure via two matrices, capturing the longlist (2.1) and the derived medium/shortlist (2.2). As the exemplary scores in (2.1) are multiplied with the weights of the sub-processes (1.2), the weighted scores in (2.2) allow to create the mentioned shortlist and relative weights.

Roles: Assessing the suitability of digital technologies requires knowledge about their characteristics and experience with the process in focus. Therefore, activity 2 must include technology experts (e.g., from the organization's IT department) as well as the process owner and selected process participants.

Output: Activity 2 results in a shortlist of digital technologies that are most suitable to support the sub-processes of the process in focus from a behavioral process perspective. Activity 2 also creates relative weights for these digital technologies necessary to conduct the final assessment in activity 4.

Justificatory knowledge and method fragments: Assessing the suitability of digital technologies for distinct sub-processes is inspired by research on task-technology-fit, a stream arguing that positive performance impacts will result in case a technology offers features and support that fit the requirements of a task (Dale and Ronald 1995). As the assessment of weights and value appraisals is not an easy task as well as prone to subjective influences, we successively reduce complexity via the introduced medium list of digital technologies (Clemen et al. 2000). Considering direct expert estimation to be more accurate and less difficult than alternative methods (Clemen et al. 2000), all required values are assessed via a rating scale, i.e., a slightly modified AHP scale that is appropriate for comparative assessments.

Activity 3: Inclusion of Further Evaluation Perspectives

Technique: So far, our method took a behavioral perspective to determine the suitability of digital technologies for the process in focus and to select a shortlist of suitable technologies. To broaden the scope of our analysis, activity 3 includes further evaluation perspectives, i.e., other fundamental process perspectives, goals, and risks related to the implementation and use of digital technologies. To do so, we consider two hierarchy levels (i.e., factors and criteria), where factors as the first hierarchy level refer to the additional evaluation perspectives and criteria as the second level include various characteristics per factor (see Activity 3 in Figure 1). The factor that relates to other fundamental process perspectives includes customer, information, and product as criteria, inspired by the organizational, informational, and functional process perspectives as introduced in the theoretical background section. These perspectives are particularly influenced by digitalization (Röglinger and Gimpel 2015). The goals factor encompasses criteria that, on the one hand, relate to operational process performance (i.e., quality, costs, time, and flexibility) such as proposed by the Devil's Quadrangle (Mansar and Reijers 2007). On the other, the criteria of the goals factor include the strategic fit of digital technologies with corporate goals and purposes to complement operational performance criteria. According to the practitioners' feedback, the up-to-dateness of the organization's strategy with respect to digitalization at large must be checked to avoid a bias regarding the strategic importance of digital technologies. Considering that organizations face different challenges when engaging in digital transformation and that the adoption of new technologies is beset with risks (Chapman and Ward 2003; Gimpel and Röglinger 2015), the last factor relates to risks of implementing and using digital technologies. In contrast to the other factors, the criteria associated with the risk factor (i.e., individual risks) must be chosen freely to account for the organization's individual context. Whereas our method already catered for non-manageable risks in activity 2, it deals with manageable risks here. Thus, it makes sense to valuate these risks in activity 4. Having defined all criteria, factors and criteria must be weighted in line with their relative importance. Finally, the weights must be aggregated on the level of criteria. To reduce the assessment complexity, we propose an initial configuration, assuming all elements to be equally important. This configuration can be changed in case a distinct factor or criterion is much more or much less important than the others.

Tool: Generating weights that capture the relative importance of factors and criteria is achieved via the pairwise comparison mechanism introduced in activity 1. The weighting happens on two hierarchy levels, which is why four matrices must be used – one to compare the factors on the first hierarchy level and three to compare the criteria of each factor on the second hierarchy level. Activity 3 in Figure 1 visualizes the matrix (3.1) of the first hierarchy level and one matrix (3.2) of the second level. As pairwise comparison requires a rating scale to determine score values for each factor and criterion, we adopt the basic AHP scale analogous to activity 1. The calculation of overall weights on the second hierarchy level requires multiplying the weights of the first level with each corresponding weight of the second level (Saaty 1977; Saaty and Wind 1980).

Roles: Determining the importance of the further evaluation perspectives requires including multiple roles. Activity 3 involves the process owner to cover the perspective of the process in focus as well as members of the senior management and/or of the business development to cover the other perspectives.

Output: Activity 3 results in an assessment of evaluation perspectives that complement the behavioral process perspective used in activities 1 and 2. It also yields a selection of manageable risks that impact the implementation and usage of digital technologies.

Justificatory knowledge and method fragments: Activity 3 draws again from MCDA, i.e., the basic AHP scale. It also adopts the idea of including multiple hierarchy levels when structuring complex decision problems, weighting each level individually, and calculating final assessment weights on the lowest level. To facilitate the applicability of our method, we predefine all factors as well as the criteria for the other fundamental process perspectives and goals. The first hierarchy level draws from Mansar et al. (2009), who propose a strategy for the implementation of business process redesign (BPR). It further builds on the analysis of practitioner guidebooks (e.g., Sharp and McDermott 2009). On the second level, the criteria for other fundamental process perspectives are inspired by Curtis et al. (1992) and Zeising et al. (2014). Goals are defined according to the Devil's Quadrangle (Dumas et al. 2013). Risks must be chosen individually. These risks may include generic risks of BPR projects (Mansar et al. 2009) as well as specific risk factors concerning the implementation of digital technologies (e.g., data privacy and security).

Activity 4: Final Assessment of Digital Technologies

Technique: Activity 4 considers all intermediate results so far, involving the preselected digital technologies and their weights calculated in activity 2 as well as the weighted factors and criteria from activity 3. This multi-dimensional assessment yields a prioritization of digital technologies shortlisted in activity 2. Thus, it is necessary to assess to which extent each shortlisted digital technology supports the factors and criteria compared to the status quo (see Activity 4 in Figure 1). As all assessments involve weights, each digital technology is assessed according to its supporting potential across all weighted evaluation perspectives. If the organization realizes that risks initially deemed as manageable must be classified as non-manageable for distinct digital technologies, it can go back to activity 2 and eliminate the respective technologies from the medium and shortlist. In this case, the specific risks must also be eliminated from the corresponding criteria list in activity 3 and the weights of all criteria must be recalculated. If users are interested in how different assessment values and weights impact the results, we recommend conducting a sensitivity analysis. Sensitivity analyses examine how strongly minor modifications of a distinct input parameter (e.g., weights of sub-processes) influence the overall result, while keeping all other input parameters unchanged. Allocating the uncertainty of the overall results on individual input parameters, sensitivity analyses enable drawing conclusions about whether the results are robust or not (Saltelli et al. 2004). Assuming that method users have carefully determined the suitability of digital technologies in activities 2 and 4, we see most value in analyzing the weights of sub-processes (activity 1) as well as the weights of the further evaluation criteria (activity 3). Sensitivity analysis also help determine with respect to which input parameters subjective bias may be most influential.

Tool: To integrate the different evaluation perspectives, it is necessary to establish a final matrix that includes the preselected digital technologies on one dimension as well as factors and criteria on the other, both complemented by respective weights. The final assessment is performed using a rating scale, i.e., a slightly modified AHP scale analogous to activity 2. The rating scale expresses the extent of support for each criterion compared to the status quo (i.e., 1: equally supportive, 3: slightly more supportive, 5: strongly more supportive, 7: very strongly more supportive, 9: extremely more supportive). In Figure 1, activity 4 shows a matrix (4) filled with exemplary values. As these values are multiplied with the weights of the digital technologies and the weights of the criteria, the summation along the rows leads to an integrated score that represents the final result of our method. As a sensitivity analysis serves as an optional step only, we do not provide a specific tool for checking how changes in the score value and weights affect the final outcomes (Steele et al. 2009).

Roles: Combining and assessing multiple evaluation perspectives requires multiple roles. Thus, activity 4 involves members of the senior management and/or the business development to cover the corporate perspective. It also requires the process owner and selected participants to cover the process perspective.

Output: The overall goal of our method is to support corporate decision-makers in deciding which digital technologies to adopt for a distinct business processes, offering systematic guidance and reducing the selection uncertainty step-by-step. The final result of activity 4 is an integrated score that prioritizes the shortlisted digital technologies. Together with the results of activity 2, this activity helps define concrete ideas with respect to which digital technology to use in which sub-process as well as derive transformation roadmaps. These ideas should then be subject to a detailed assessment and a subsequent business case analysis according to their prioritization.

Justificatory knowledge and method fragments: The rating scale and the related assessment mechanism are similar to activity 2. That is, we use a slightly modified AHP scale to assess the extent to which the pre-selected digital technologies support the criteria of several evaluation perspectives.

5 Evaluation

Our research on developing a method to systematically exploit the digitalization potential of business processes included two design cycles. In both design cycles, we reflected on the initial creation and refinement of our method. As outlined, our method particularly applies to intra-organizational core and support processes with medium variability of medium and large organizations that face medium or high competition. We thus included multiple organizations in the evaluation of our method that strongly differ in terms of their organizational setup as well as in the way how and the motivation why they conduct BPM. Table 3 shows all organizations that participated in the evaluation. As the consulting company (5) primarily advices medium-sized organizations, it was incorporated as a multiplier despite of its small size. In the first design cycle, we evaluated our method's alpha version against the assumptions, expectations, and knowledge of selected practitioners from these organizations. In the second design cycle, we conducted case studies with three out of these organizations to evaluate the beta version, involving the practitioners from the first design cycle as well as process owners and process participants as end-users. Below, we report on the results of both design cycles.

Table 3: Organizations Involved in the First and Second Design Cycle

Organization	Industry	Employees	Revenue [EUR]	Job Title of the Involved Practitioner	DC* 1	DC 2
(1) SERVICE I	Healthcare	2.300 (2015)	192 Mio. (2011)**	Medical Director of Emergency Department	X	X
(2) PRODUCTION I	Flacon production	3.000 (2015)	250 Mio. (2015)	Head of Process and Change Management	X	X
(3) PRODUCTION II	Semiconductor production	800 (2015)	200 Mio. (2015)	Department Head of Semiconductor Production	X	X
(4) SERVICE II	Healthcare	6.200 (2015)	463 Mio. (2015)	Head of BPM and Organizational Development	X	
(5) CONSULTING	Process consulting	40 (2015)	2.5 Mio. (2015)	Chief Executive Officer	X	

* DC: Design cycle ** most recent information available

5.1 Evaluation of the Alpha Version (Design Cycle 1)

Expert Interview Setting

According to ADR, the evaluation of an artefact's alpha version is formative and contributes to its refinement (Sein et al. 2011). Thus, we provided selected practitioners (Table 3) with an initial design specification of our method and conducted semi-structured interviews structured along the method's activities including examples of digital technologies (Myers and Newman 2007). All interviewees were strongly involved in the coordination of business processes and the implementation of improvement projects. Each interview took about one hour and was attended by at least two researchers. After five interviews, we consented that the practitioners' feedback was consistent and that conceptual saturation had been reached (Briggs and Schwabe 2011). Therefore, we did not conduct further interviews.

Considering the evaluation criteria for methods as DSR artefacts, we focused on interviewing the involved practitioners about the method's understandability, generality, and real-world fidelity (March and Smith 1995; Sonnenberg and vom Brocke 2012). All practitioners emphasized the relevance of our research question as, according to their judgement, most organizations face high uncertainty regarding the adoption of digital technologies and lack guidance on how to make related decisions systematically. Thus, the practitioners appreciated the development of a corresponding method. They also acknowledged the understandability and real-world fidelity of our method regarding the intended situation (see specification of method requirements). After careful deliberation, we included most of the practitioners' comments in the beta version. The most considerable changes are listed below.

Changes to the Alpha Version

As for activity 1, not all practitioners considered our focus on sub-processes as sufficient. Consequently, we added the dummy sub-process 'end-to-end' to account for the effects of digital technologies on the process' control flow at large. We also included the option to choose the level of process modelling as long as the control flow remains straightforward in order not to restrict our method's applicability. As two practitioners pointed to potential difficulties in the modelling process, we involved the BPM expert as additional role in this activity. In activity 2, all practitioners agreed to assess the suitability of digital technologies with respect to sub-processes including the 'end-to-end' dummy sub-process. Four practitioners emphasized the importance of preselecting digital technologies according to their suitability, but indicated that the applicability of such an assessment varies with the respective participants' expertise. As outlined above, this problem relates to the missing knowledge of many organizations on digital technologies. Consequently, we compiled a list of digital technologies with definitions and exemplary use cases according to the SMAC classification as an input for evaluating the beta version. This list of digital technologies is preliminary and requires future research as, for example, it does not consider combinations of technologies. Moreover, all practitioners assessed the presented rating scale, which is based on the AHP scale introduced by Saaty (1977), as understandable and applicable, highlighting the fact that it features a well-defined semantics for each scale element. As four practitioners considered the assessment by individual persons as difficult, we involved business-, process-, and IT-related roles as well as suggested to use our method as a structured guidance to support discussions among these roles. In fact, our method must not be reduced to the mere calculation of scores for digital technologies. This applies to activities 3 and 4, too. Regarding activity 3, all practitioners approved the importance of involving further evaluation perspectives. Although the practitioners agreed with the predefined factors and criteria, four of them emphasized the importance of a strategic component. This is why we added the sub-criterion 'strategic fit' to complement criteria related to operational performance. All practitioners confirmed that risks vary strongly between organizations and must be chosen individually. We therefore compiled an initial catalogue of risk factors as input for the evaluation of the beta version. As two practitioners criticized activity 3 as too detailed due to the number of pair-wise comparisons to be made, we proposed an initial configuration that only needs to be adapted in case a distinct factor or criterion is much more or much less important than others. Regarding activity 4, all practitioners appreciated the integration of several perspectives. As one practitioner was interested in the impact of the different weights and assessment values on the final result, we included the use of sensitivity analysis as an optional tool.

Beyond feedback regarding our method's activities, we also identified a complementary application field. Instead of applying the method to an individual process and its sub-processes as unit of analysis, it can also be applied on the level of an organization's business process architecture (Dijkman et al. 2016). In this case, the method's output would be a list of the most suitable digital technologies across all processes. This application field is favorable if an organization first needs to preselect suitable digital technologies on a strategic level. Using an individual process as unit of analysis is favorable in case an organization has already strategically preselected digital technologies and if there are sufficiently many technologies that can be used per process. Although the second application field is appealing, we stuck with the individual process as unit of analysis. Designing and evaluating a modified variant of our method is subject to further research.

5.2 Evaluation of the Beta Version (Design Cycle 2)

Case Study Setting

In line with ADR, the evaluation of the beta version is summative, assessing the artefact's value and utility outcomes (Sein et al. 2011). Therefore, we conducted case studies within three of the organizations that also participated in the first design cycle, applying our method to business processes selected by the practitioners. This time, a team of process owners and process participants was involved, representing the required end-users. Each case study took between two and three hours and was attended by at least two researchers. To conduct the case studies efficiently, the process owners already preselected the process in focus and prepared a medium list of digital technologies and risks based on our input. In the case studies, we focused on activities 2 to 4 to validate the quantitative parts of our method. Applying our method to two bid proposal management processes (PRODUCTION I and PRODUCTION II) and a patient admission process (SERVICE I), we validated our method's operationality, ease of use, and efficiency (March and Smith 1995; Sonnenberg and vom Brocke 2012). As our method worked well in these settings, the end-users' feedback satisfied the evaluation criteria and entailed only minor adjustments of the method. Instead, we identified recommendations for the application of our method in industry settings, which we summarize below. To strengthen the traceability of our method, we also share insights into the case study conducted at PRODUCTION II.

During all case studies, the participants were very interested and underscored the need for methodological support when exploiting the digitalization potential of business processes. The involved practitioners and end-users rated our method as demanding, but applicable and sufficiently operational in industry settings with respect to the intended situation. Further, they appreciated the group discussion as well as the interactive approach to sense-making about process digitalization. As the results confirmed the applicability of our method, we stopped the evaluation process after the second design cycle. Further cycles are needed if the method is adapted with respect to the needs of other contexts.

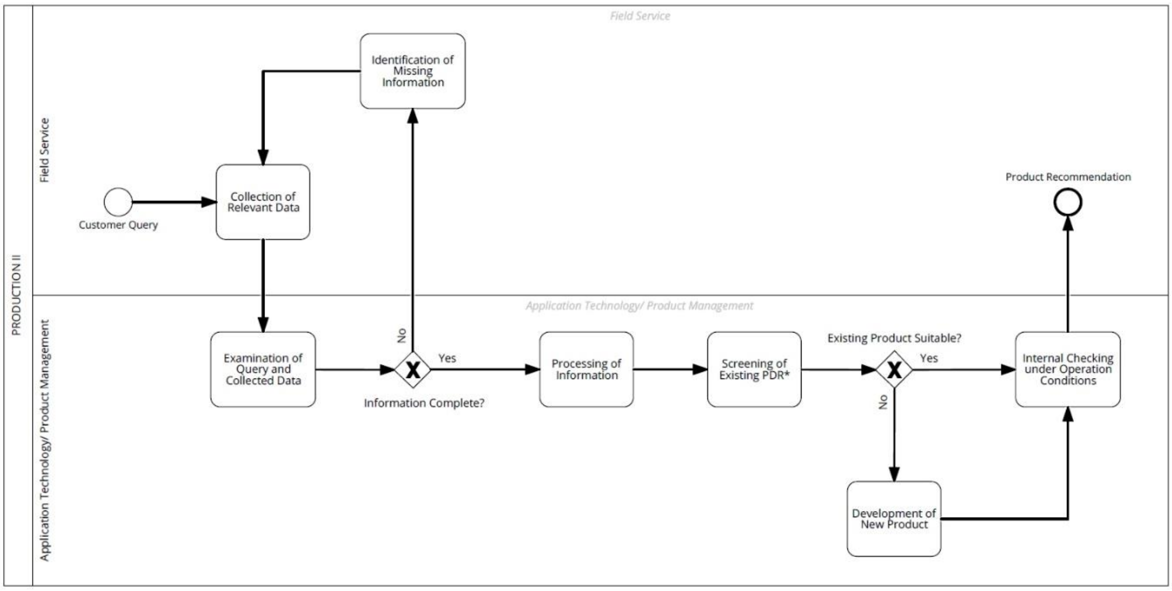
Recommendations for Application

Across all case studies, we identified the necessity to achieve a shared understanding of the process in focus among all participants. Thus, for activity 1, we recommend choosing a modeling level that is understandable and clearly expresses the content of each sub-process. Regarding activity 2, all participants must share the same understanding of the digital technologies under consideration. Providing the participants with an exemplary list of digital technologies, we identified gaps regarding their knowledge about digital technologies. Consequently, we recommend discussing digital technologies and potential combinations in a separate workshop, defining all technologies relevant for the organization independent from the business process in focus. In order to ensure that all participants share the same understanding of the impact that these technologies may have on the process, every technology should further be linked to a specific subject or project concerning the process in focus. Concerning the assessment of digital technologies, participants must be encouraged to not mix up single sub-processes and the end-to-end perspective. Otherwise, the assessment is biased. As for activity 3, the complexity of the hierarchical pairwise comparison tends to interrupt the actual assessment. Thus, we recommend performing a separate workshop to define the relative importance of the involved factors. As for activity 4, some participants had difficulties in assessing the effects of digital technologies on different risks. As a high rating equals a positive influence (e.g., on data security), the formulation of all risk-related criteria in activity 3 should have the same polarity.

Beyond the recommendations for single activities, we derived general advice for applying our method. One of these recommendations is to conduct separate workshops, e.g., for the selection of digital technologies or for the definition and weighting of factors and criteria, respectively. Different workshops do not only relieve the participants' cognitive strain, but also allow to reduce the time needed for applying our method. For example, our method already grants the degree of freedom to execute activities 2 and 3 parallelly. As our method seems to be quite complex at first glance, we recommend involving a moderator. Additionally, we recommend intensively studying our method as a whole before performing the single activities to ensure high end-to-end efficiency. A useful means for doing so is a kick-off workshop where the moderator introduces the entire method. Such a workshop should particularly point to the fact that the values determined in each activity of our methods are estimations and subjective with respect to the involved users' knowledge, experience, and preferences. For each activity, a group size of four to five participants shaped up as appropriate in the case studies we conducted.

Application of our method at PRODUCTION II

When preparing the case study at PRODUCTION II, we asked our interview partner from the first design cycle, i.e., the technical director of the composites department, to preselect a process whose digitalization potential should be exploited. With PRODUCTION II striving for high quality within short lead times, for processing customer queries quickly as well as for responding flexibly to changing customer needs, the technical director selected the bid proposal management process to be analyzed.



* PRD: Product Requirement Document (i.e., a product catalogue or specification book)

Figure 2: Bid Proposal Management Process at PRODUCTION II

The technical director provided us with initial information about the bid proposal management process, which we transferred into the process model in Figure 2. The process starts with an incoming customer query, received by the field service. After collecting information concerning the customer's needs, the field service forwards this information to the product management, which checks the received information for completeness. If information is missing, the field service contacts the customer again. As soon as all relevant information has been collected, the product management processes the information and screens the product requirement document (PRD) for existing products that meet the customer's needs. Depending on whether a suitable product exists, a new product must be developed, before checking the product under operating conditions. As soon as the product has passed this internal test, the field service recommends it to the customer.

In line with activity 1 of our method, the technical director and the involved end-users of the bid proposal management process (i.e., two process participants and two members of the IT department) agreed on dividing the process into sub-processes. As our method takes process models with a straightforward control flow as input, we skipped the decision gateways shown in Figure 2. The sub-processes shown in Figure 3 capture the activities included in Figure 2, whereas the activities 'Processing of Information', 'Screening of Existing PRD' and 'Internal Checking under Operation Conditions' were summarized as a single sub-process called 'Aggregation of all Data'. Afterwards, all case study participants assessed the relative importance of all sub-processes including the dummy sub-processes 'E2E'. The results are shown in Figure 3.

Activity 1

	SP 1	SP 2	SP 3	SP 4	SP 5	E2E
SP 1	1	1/5	1/3	1/9	1	1/5
SP 2	5	1	5	1	5	1
SP 3	3	1/5	1	1/5	5	1/3
SP 4	9	1	5	1	9	1
SP 5	1	1/5	1/5	1/9	1	1/5
E2E	5	1	3	1	5	1

Matrix (1.1)

Bid Proposal Management Process (PRODUCTION II)					
Customer Query (SP 1)	Collection of Relevant Data (SP2)	Examination of Query and Data (SP 3)	Aggregation of all Data (SP 4)	Product Recommendation (SP 5)	E2E
0.04	0.26	0.10	0.32	0.04	0.24

Matrix (1.2)

Figure 3: Results of Activity 1 (Case Study at PRODUCTION II)

The technical director also selected digital technologies whose potential for the bid proposal management process he intended to analyze. He selected Social Customer Relationship Management (CRM), mobile and smart devices (MD, SD), big data analytics (BDA), speech-to-text translation (STT), smart advisors (SA), and cloud services (C). As for social CRM, PRODUCTION II expected to engage customers in collaborative conversations to provide mutually beneficial value in a trusted and transparent business environment. Mobile and smart devices were expected to enhance internal communication in terms of exchanging digital notes and invoices or by establishing multi-party location-independent conferencing. Big data analytics was expected to transform raw data into meaningful business information and to enable the linkage of structured and unstructured data (e.g., engineering drawings). In addition to big data analytics, speech-to-text translation and cloud services were expected to further facilitate data processing, aggregation, and storage. Finally, PRODUCTION II aimed to validate the potential of smart advisors to guide both customers and internal salesforce through the bid proposal management process.

The technical director and the involved end-users agreed that no dependencies among these digital technologies are considered when reflecting on their implementation at PRODUCTION II. The main reason for this decision was that the participants did not see any technical or predecessor-successor relationships regarding their specific context that would have implied scheduling decisions.

In activity 2, the participants valued suitability of the preselected digital technologies regarding the sub-processes identified in activity 1. Afterwards, we aggregated the resulting values in line with the weights from activity 1. As PRODUCTION II decided on a cut-off criterion of three, the three technologies with the highest scores across all sub-processes were chosen for further evaluation. Figure 4 summarizes the intermediate result of activity 2. The values illustrate the central idea of our method: whereas cloud services (C), for example, did not have any positive impact on the 'customer query' sub-process (SP 1), it was assessed to have great potential to enhance the 'data aggregation' sub-process (SP 4). As the 'data aggregation' sub-process is weighted much higher than the 'customer query' sub-process, this effect is further intensified, leading to a good assessment of cloud services for the overall process.

Activity 2

		Bid Proposal Management Process						Sum and Weight	
		SP 1	SP 2	SP 3	SP 4	SP 5	E2E		
		0.04	0.26	0.10	0.32	0.04	0.24		
Preselected Digital Technologies	C	0.04	0.79	0.69	2.85	0.12	1.69	**6.18**	**0.38**
	SA	0.04	1.32	0.29	1.59	0.12	1.20	**4.56**	**0.28**
	STT	0.20	0.26	0.10	0.32	0.04	0.24	1.16	-
	BDA	0.04	1.32	0.29	0.95	0.04	1.20	3.85	-
	SD	0.20	0.79	0.49	0.95	0.04	1.20	3.68	-
	MD	0.20	0.79	0.10	0.32	0.20	1.20	2.81	-
	CRM	0.20	1.85	0.49	0.95	0.27	1.69	**5.45**	**0.34**

Matrix (2.2)

Figure 4: Results of Activity 2 (Case Study at PRODUCTION II)

Regarding activity 3, relevant risks had to be chosen. Based on a catalog of potentially relevant risks elaborated before the case study, the technical director and the other end-users considered employee acceptance, data security, and applicability (i.e., technical feasibility) to sufficiently represent the risks associated with the implementation of digital technologies at PRODUCTION II. They did not see any need to weigh the further evaluation perspectives included in our method (e.g., other process perspectives, goals, risks) differently. They thus adopted the initial configuration, assuming equally important evaluation factors and criteria.

Activity 4 combined all intermediate results so far. Having discussed and weighted all values that express the extent to which the selected digital technologies support the other evaluation perspectives, we provided the participants of PRODUCTION II with the final result of the case study as shown in Figure 5. Concerning the digitalization potential of PRODUCTION II's bid proposal management process, the implementation of cloud services was assessed to have the highest utility, followed by smart advisors, and social CRM.

Activity 4

Selected DTs		Other Perspectives			Goals					Risks			Weighted Sum
		Customer	Information	Product	Reduce Time	Reduce Costs	Improve Quality	Improve Flexibility	Strategic Fit	Employee Acceptance	Data Security	Applicability	
		0.111	0.111	0.111	0.067	0.067	0.067	0.067	0.067	0.111	0.111	0.111	1
C	0.38	1	9	3	7	5	3	7	7	7	1	7	**1.924**
SA	0.28	3	7	1	5	3	3	5	7	5	5	7	**1.308**
CRM	0.34	3	9	1	5	3	5	3	5	5	1	3	**1.295**

Matrix (4)

Figure 5: Results of Activity 4 (Case Study at PRODUCTION II)

6 Conclusion and Outlook

In this study, we investigated how organizations can systematically exploit the digitalization potential of their business processes. Combining ADR as research paradigm with SME as research method, we proposed a method that assists organizations in determining which digital technologies are most suitable for a distinct business process. Our method applies to intra-organizational core and support processes with medium variability of medium and large organizations facing medium or high competition. Drawing from knowledge related to BPM, digital technologies, and MCDA, our method includes four activities: (1) selecting and modelling the business process in focus, (2) preselecting and assessing the suitability of digital technologies from a behavioral process perspective, (3) including further evaluation perspectives (i.e., other fundamental process perspectives, goals, and risks), and (4) determining the most suitable digital technologies. In line with the specific requirements of the organizations involved in our evaluation and the scarce knowledge about digital technologies typically available in many organizations, our method strives for successively reducing organizations' selection uncertainty with respect to digital technologies and aims to stimulate structured, consensus-oriented discussions among the involved business and IT roles. We evaluated our method in two design cycles. To evaluate our method's alpha version, we interviewed experts (e.g., head of process and change management, head of BPM and organizational development) from five organizations. To evaluate our beta version, we conducted case studies including real business processes and process participants with three organizations. Our method contributes to the prescriptive body of knowledge related to business process improvement. It is the first approach to account for digital technologies in the improvement of business processes.

Both design cycles revealed limitations of our method. Some limitations have already been incorporated in the beta version of our method, others stimulate future research. As for its design specification, our method caters for isolated processes and processes whose control flow can be captured in a straightforward manner. This makes it hard to apply our method to nonroutine processes and excludes process networks. Our method also emphasizes the behavioral process perspective, i.e., the tasks included, while considering other relevant process perspectives (e.g., information, customer, and product) for assessment purposes. While this design decision aims to keep our method's complexity manageable for end-users, future research should explore how to overcome this and the other limitations. Another direction for future research is the investigation of different contexts such as inspired by the BPM context framework and the identification how our method's design specification must be tailored to fit these contexts.

In particular, we expect substantial changes when switching from exploitation to exploration mode, i.e., when leveraging digital technologies not only to incrementally improve and streamline, but also to radically re-engineer existing business processes. While both modes have their merits, an investigation of the exploration mode seems very promising due to the disruptive character attributed to digital technologies. We expect that methods with an explorative focus should think in terms of business models and value propositions to open new revenue pools. The behavioral process perspective including the control flow, as taken by out method, is more suitable for exploitative methods. In our opinion, future research could explore two further topics. First, while evaluating our method, we recognized that our method could also use an organization's business process architecture and individual processes as unit of analysis instead of individual processes and their sub-processes. This would enable a more strategic assessment of digital technologies. Second, we only evaluated our method with respect to digital technologies. Rooted in the vague definition of digital technologies, we cannot exclude that our method can also be applied to exploit businesses processes regarding the potential of non-digital technologies.

As for applicability and usefulness, we applied our method to real business processes in three case studies. While these cases corroborated our method's usefulness for process owners and participants, we do not have substantial experience that would allow for applying our method in other contexts. Future research should thus focus on more case studies and on setting up a knowledge base. To facilitate future evaluation activities, we recommend developing an IT-based decision support tool using our method's design specification as blueprint. As we experienced a substantial lack of knowledge in industry regarding the existence and opportunities of digital technologies, a circumstance that is in line with the absence of an accepted definition of digital technologies, we also recommend research on the definition and classification of digital technologies. This would, on the one hand, facilitate the selection of digital technologies in activity 2 and, on the other, allow for tying the method closer to digital technologies.

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