Design of Robotic Process Automation and Process Mining for Optimisation of Processes and Process Management

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List of Abbreviations

6S	Six Sigma
AI	Artificial Intelligence
API	Application Programming Interface
AR	Action Research
BPI	Business Process Improvement
BPM	Business Process Management
BPR	Business Process Reengineering
CAD	Computer-Aided Design
CAIE	Computers & Industrial Engineering
cf.	Compare
CI	Continuous Improvement
CPM	Corporate Performance Management
CRISP-DM	Cross-Industry Process for Data Mining
CSF	Critical Success Factor
CTQ	Critical to Quality
DFSS	Design for Six Sigma
DM	Data Mining
DMAIC	Define, Measure, Analyse, Improve, Control
DoE	Design of Experiments
DSR	Design Science Research
ECIS	European Conference on Information Systems
EPC	Event-driven Process Chains
ERP	Enterprise Resource Planning
EU	European Union
FSF	Future Skills Framework
FTE	Full Time Equivalent
GUI	Graphical User Interface
H	Hypothesis
HF	Hypothesis Formation
HICSS	Hawaii International Conference on System Sciences
HT	Hypothesis Testing
HTML	Hypertext Markup Language
ID	Identification Number
IEEE	Institute of Electrical and Electronics Engineers
IS	Information Systems
ITIL	Information Technology Infrastructure Library
JOBR	Journal of Business Research
JQ	JourQual (ranking)
KDD	Knowledge Discovery in Databases
LDA	Latent Dirichlet Allocation
LSA	Latent Semantic Analysis
LSS	Lean Six Sigma
MES	Manufacturing Execution System
ML	Machine Learning
n.R.	Not Ranked
NLP	Natural Language Processing
NLTK	Natural Language Toolkit

NMDS	Nursing Minimum Data Set
OM	Operations Management
OZG	Onlinezugangsgesetz
P	Publication
PDCA	Plan-Do-Check-Act
PEPA	Prozesseignung und -Priorisierung für Automatisierung
PM	Process Mining
RO	Research Objective
RPA	Robotic Process Automation
RQ	Research Question
TBD	To be defined
TF-IDF	Term Frequency - Inverse Document Frequency
TQM	Total Quality Management
UK	United Kingdom (of Great Britain and Northern Ireland)
URL	Uniform Resource Locator
USA	United States of America
VHB	Verband der Hochschullehrer für Betriebswirtschaft
VPN	Virtual Private Network
WFH	Work From Home
WHO	World Health Organization
WSD	Word-sense Disambiguation

PART A

„*Improvement begins with I.* "

Arnold H. Glasow

„*Heavy investments in information technology have delivered disappointing results - largely because companies tend to use technology to mechanize old ways of doing business. They leave the existing processes intact and use computers simply to speed them up.* "

Michael Hammer (1990)

1 Exposition

1.1 Motivation and Goals

„*We see more and more claims emerging in the literature which stress the importance of extending BPM with more innovation-oriented concepts. A key idea of explorative BPM is to ensure that organizations systematically integrate emerging opportunities, such as those brought about by digital technologies or changing customer needs, in order to offer new value propositions*.“

Grisold et al. (2021a)

„*In the context of BPM, digital technologies can help make processes more responsive and potentially more predictive regarding changing external conditions. Therefore, BPM research should build on existing initiatives regarding the exploration of the opportunities offered by digital technologies*.“

Röglinger et al. (2022)

The digital transformation places new demands on the business process management (BPM) of established structures (Beverungen et al. 2021; Reijers 2021; vom Brocke and Schmiedel 2015). In addition to the classic expectation of maintaining and optimising the existing process landscape, they are expected to simultaneously test new technologies and drive the development of innovative solutions (Beverungen et al. 2021; Dumas et al. 2018; van Looy 2021). Rising costs, pressure to save money, rapid changes in technology, and higher user demands are pushing companies to recognize, implement, and take advantage of the new optimisation approaches (Beverungen et al. 2021; Rosemann and vom Brocke 2015). To this end, BPM consistently seeks, selects, and implements the new technologies and methods that are most likely to add value to the business (Beverungen et al. 2021; Rosemann and vom Brocke 2015).

The technologies frequently discussed in the current academic discourse on BPM are Robotic Process Automation (RPA) for process automation and Process Mining (PM) for process discovery, conformance testing, and improvement. RPA includes the development and use of software robots to automate rule-based and repetitive tasks performed by humans within workflows and process-related applications and operations (Dumas et al. 2018; Grisold et al. 2020a; Mendling et al. 2020). PM refers to a method of reconstructing and evaluating business processes using existing data. PM uses existing data from operational information technology (IT) systems to reconstruct and analyse business processes (Grisold et al. 2020a; Reijers 2021; vom Brocke and Schmiedel 2015).

This method focuses on implicit process knowledge present in the data to define, assemble, and visualize process steps. These both technologies are also referred to as digital process innovations (Wiesböck and Hess 2020).

While traditional BPM is mostly dominated and driven by legacy IT systems, a wave of innovation in operational process execution is simultaneously beginning through technologies such as RPA and PM (Grisold et al. 2021b; Mendling et al. 2018). These technologies make process optimisation tools directly accessible to end users and are quite versatile overall; some of them support automation of work processes, others provide new opportunities for process insights and analysis, but overall, they are not part of the previous IT architecture around BPM (Dumas et al. 2018; Mendling et al. 2020).

The basic scientific consensus is that there is a general dynamic of technological advancement in the way business processes are defined and lived - a new digital technology penetration that will open new perspectives for both - process owners and process executors (vom Brocke and Schmiedel 2015). As the importance of these new technologies increases, so does the need to be able to deploy them practically in a more targeted way (Grisold et al. 2021b; Reijers 2021). The literature suggests that it is critical to the profitable deployment of these technologies that such IT-enabled innovations are increasingly implemented by non-IT specialists with end-user-centric approaches and easy-to-use IT (Dumas et al. 2018; Martin et al. 2021; Reijers 2021; vom Brocke et al. 2021). To make the motivation and objective of this work comprehensible, it draws on the established literature on the benefits of using digital technologies in the context of BPM, especially in the context of process optimisation.

In this context, the literature assumes that BPM restructures processes and pursues the inherent goal of optimising the entire corporate structure (Dumas et al. 2018; Rosemann and vom Brocke 2015). Under certain circumstances, RPA and PM can extend the conventional solution approach and the process models of BPM (Mendling et al. 2018). It turns out that BPM, at its core, forms a blueprint in which all processes are optimally integrated, improving the company's output through a new optimised value chain (Grisold et al. 2021b; Mendling et al. 2018; vom Brocke and Schmiedel 2015). As a building block of this optimised chain, both PM and RPA should be incorporated - PM being used to systematically analyse and evaluate business process data and RPA automating individual tasks (Grisold et al. 2020; Leno et al. 2020). Figure 1-1 schematically shows the interaction of these two technologies within and with BPM and how they complement each other in a common workflow. Both PM and RPA are understood in the literature as a component of BPM to be integrated in the future and therefore understood in combination as a tool that would have to be used to implement BPM (Dumas et al. 2018; Reijers 2021).

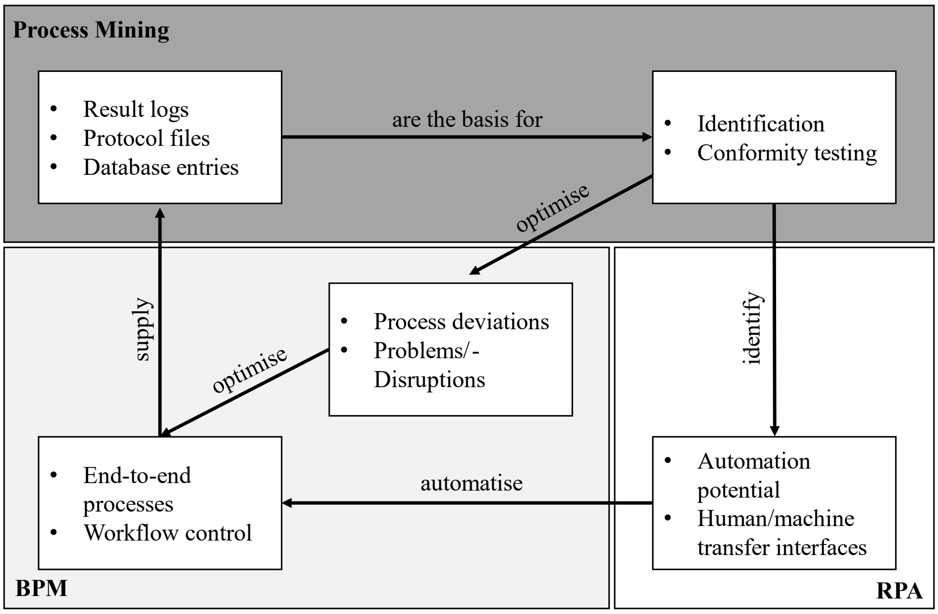

Figure 1-1: The interaction of BPM, RPA, and PM according to Hierzer (2017)

A central argument of this work is that these digital process innovations (RPA and PM) studied have an immediate, identifiable, measurable, and traceable impact on process optimisation and process performance (Dumas et al. 2018; Grisold et al. 2021b; Mendling et al. 2018). This is in line with the literature in this research area but does not yet consider the possible design implications for optimal integration into BPM (Grisold et al. 2021b; Mendling et al. 2020; vom Brocke et al. 2021). Therefore, the ability of the approaches of RPA and PM to integrate within traditional BPM and the resulting potential optimisation approaches for BPM are currently considered an intrinsic research gap (Grisold et al. 2021b; Röglinger et al. 2022; Syed et al. 2020; van der Aalst et al. 2003).

Following on from this, however, it is first necessary to empirically record the actual possibilities for improving process performance to determine the actual impact and potential of these technologies, also about the lack of a design perspective (Grisold et al. 2021b; Plattfaut and Borghoff 2022; Recker 2021; vom Brocke et al. 2021). Therefore, this dissertation pursues several empirical qualitative and quantitative approaches - both behavioural and design-oriented - to answer this current research gap.

„The authors are convinced, however, that without a thorough and complete understanding of a research domain, a researcher may ask the wrong questions or formulate a meaningless hypothesis. No matter what research methods are applied, incorrect or irrelevant questions can only lead researchers to inappropriate conclusions."

Nunamaker et al. (1990).

„Perhaps 'grand' theory requires multiple studies - an accumulation of both theory-building and theory-testing empirical studies."

Eisenhardt (1989)

To this end, the dissertation first formulates hypotheses that are as reliable as possible according to the principles of Nunamaker et al. (1990), but also considering the definitions of Kaplan and Maxwell (2005) and Eisenhardt (1989). These state that evidence-based, valid, and validated knowledge must first be obtained and substantiated to form useful, rigorous hypotheses with greater explanatory power. This helps the dissertation to subsequently conduct practical hypothesis tests and generate results on the optimisation, performance, integration, and value of RPA and PM in the BPM context.

1.2 Problem Statement, Theoretical Reference, and Research Questions

The way information systems (IS) are changing businesses, and BPM in particular, is fundamental. The impact of IS on BPM and related functions has led to a huge degree of digitalisation over the last decade, meaning that many processes that were analogue ten years ago are now fully digital (Dumas et al. 2018; Reijers 2021). This increase in technologization, especially through information-based processes, leads to a high demand for continuous improvement of business processes through rationalisation and optimisation of resources (Dumas et al. 2018; Mendling et al. 2018).

However, while BPM has traditionally focused on standardisation, automation, and continuous process improvement, modern organisations also demand flexibility, agility, and above all the technology-driven and technology-based innovations in process design and implementation (Dumas et al. 2018). Rosemann (2014) has described this change in BPM by calling the combination of the traditional focus (as exploitative BPM) and the focus on process innovation (as explorative BPM) „*organisational ambidextry*". Confirming this, Recker (2015) calls this the shift of BPM from an „*automation logic*" to an „*innovation logic*".

This thesis takes this as its starting point and traces the seven central paradoxes formulated by Beverungen et al. (2021) in his widely acclaimed research note on future research in this field, especially paradox 1 „*We need to develop new technologies and organizational ideas to achieve both of these conflicting objectives at the same time. An important aspect can be to re-define traditional roles of process managers and process participants*“ and paradox 2 „*Companies are, therefore, challenged to manage some parts of a process for efficiency, while other parts of a process must be managed for business value. The BPM discipline must develop theories and artifacts that allow managers to reconcile both objectives, based on applying methods on a higher level of abstraction*“ are significant for the understanding, derivation and design of the problem and research objectives of this thesis. Against this background, Plattfaut and Borghoff outline the necessary research agenda for RPA in their 2022 paper. This thesis and the contributions therein address or at least pick up on eleven of the fifteen research gaps mentioned there. In particular, the aggregated research gap that states that „[...] *it is necessary for future research to further investigate designing and understanding robot-human collaboration*“ is an important reference point for the research efforts presented here.

This thesis therefore takes the implications for future research in this area as an opportunity to review the results from Table 1-1 and Table 1-2 and to formulate an associated research need into a research objective. Table 1-2 shows the differences between BPM, RPA and PM. It is apparent that the specific prescriptive design knowledge of the two technologies in interaction with BPM has received little attention in the IS research community. Although a variety of research needs in this area have been addressed and identified, there is no clear and concrete research on how RPA and PM should be designed to best integrate and add value to different process optimisation approaches and BPM.

Table 1-1: Overview of the differences between BPM, RPA, and PM according to Santos et al. (2020)

Domain	BPM	RPA/PM
Application	Creation of a new application (Mendling et al. 2018; Syed et al. 2020)	Use of existing applications (Aguirre and Rodriguez 2017; Syed et al. 2020; vom Brocke et al. 2021)
Business goal	Process re-engineering (Dumas et al. 2018; Lacity and Willcocks 2016; van der Aalst et al. 2016)	Automation of existing processes (Aguirre and Rodriguez 2017; Grisold et al. 2020a; Martin et al. 2021; Willcocks et al. 2017)
Development responsibility	Development by programmers (Asatiani et al. 2020; Rosemann 2014)	Development by the business unit (Syed et al. 2020; van der Aalst 2012; vom Brocke et al. 2021; Willcocks et al. 2015)

Development times	Long development times (Asatiani et al. 2020; van den Bergh 2014)	Fast development times no complex integration required (Martin et al. 2021; Syed et al. 2020; Willcocks et al. 2015)
Integration method	Interacts with business logic and data acces layers (Grisold et al. 2021b; Syed et al. 2020)	Interacts with systems through the presentation layer (Martin et al. 2021; Syed et al. 2020; Willcocks et al. 2017)
Process suitability	Best suited for process requiring IT expertise on high-valued IT investments (Trkman 2010; vom Brocke and Schmiedel 2015)	Suitable for processes that require business and process expertise (Aguirre and Rodriguez 2017; vom Brocke et al. 2021)
Programming requirements	Requires programming skills (Asatiani et al. 2020; Müller et al. 2016; Trkman 2010; van der Aalst et al. 2003)	Does not require programming skills (Aguirre and Rodriguez 2017; Willcocks et al. 2015)

Therefore, the goal is to broaden the understanding of the impact of digital process technologies on BPM and their implications, as well as the related design knowledge. To this end, this thesis will further explore the influences of RPA and PM on process performance as well as the prescriptive knowledge for the design of the technologies used in the context of BPM. Different theoretical approaches provide the theoretical basis for investigating the prescriptive design knowledge of RPA and PM on e.g. process performance (Dumas et al. 2018; Grisold et al. 2021b; van Looy 2021; van Looy and Shafagatova 2016). This thesis presented here considers different domains (e.g., public sector, manufacturing, healthcare), actor groups (e.g., IT professionals, users, vendors), work practices, specific application systems (e.g., *UiPath*, *DISCO*, *ProM*) and various forms of documentation and distribution of knowledge about the development and use of these technologies.

„*That is, researchers use multiple sources of evidence to build construct measures, which define the construct and distinguish it from other constructs. In effect, the researcher is attempting to establish construct validity.* "

Eisenhardt (1989)

According to Recker (2021), who in turn refers to Eisenhardt (1989), the diversity of areas and perspectives of inquiry allows for a deeper understanding of a particular phenomenon, as one can look beneath the surface of a situation and provide a rich context for understanding the phenomena under investigation.

As mentioned above, current academic discourse shows that BPM and RPA as well as PM as technologies are not mutually exclusive but are often used simultaneously to combine the advantages of each method (Grisold et al. 2020; Leno et al. 2020; Mendling et al. 2018; Plattfaut 2019; Plattfaut and Borghoff 2022). The literature therefore often calls for examining the use of RPA and PM as supporters, promoters, and drivers of BPM success (Flechsig et al. 2019; Grisold et al. 2021b; Plattfaut and Borghoff 2022; Reijers 2021). Thereby, the question for this work is, how BPM can be optimised with and through RPA and PM, and how these technologies can be integrated into BPM to achieve a higher level of process optimisation. To this end, this thesis follows the common research opinion and defines RPA and PM as a method and BPM as a concept (Dumas et al. 2018; vom Brocke and Schmiedel 2015; Willcocks et al. 2017). In the field of RPA and PM and their impact on process performance, numerous studies and scientific works have been conducted in recent years. This has resulted in numerous scientific mapping studies and reviews to date, excerpts of which are presented in Table 1-2. These topics form the basis and frame of reference for the research objectives and the resulting research questions of this thesis.

Table 1-2: Excerpt on the relevant literature

		Asset Redeployment	Faster Scalability	FTE Reduction	Improved Customer Experience	Increased Accuracy	Increased Efficiency	Increased Job Satisfaction	Proposed Design Optimisation
Topic	Article	Core Findings							
RPA	Engel et al. (2022)		x				x		
PM	Graafmans et al. (2021)			x			x	x	
RPA/PM	Leno et al. (2020)	x				x	x		
RPA	Hofmann et al. (2020)		x	x	x	x	x		
RPA	Syed et al. (2020)	x	x	x	x	x	x	x	
RPA/PM	Geyer-Klingeberg et al. (2018)	x	x			x	x		
RPA	Mendling et al. (2018d)	x			x	x	x	x	

They all examined the impact of the technologies on process performance but contained gaps in the design optimisation of the technology itself and the associated BPM. Thus, this work contributes to theory and research in this area by adding new insights and perspectives to the above studies. It should be emphasized that RPA and PM are each a relatively new construct and the impact on the process and BPM performance, as well as the supporting knowledge for them, has not yet been explored (Mendling et al. 2018; Reijers 2021; van Looy 2021). However, there is also still limited understanding of how these technologies create measurable value for processes and overall BPM. The questions derived from the previous research can be summarised as follows: Understanding the benefits that RPA and PM solutions can have for organisations in terms of optimisation potential for processes and BPM, and the resulting design knowledge.

„*Here, we argue, is an opportunity for IS research to make significant contributions by engaging the complementary research cycle between design-science and behavioral-science to address fundamental problems faced in the productive application of information technology. Technology and behavior are not dichotomous in an information system.*“

Hevner et al. (2004)

„*Although many IS design theory components have been addressed, others might be improved or strengthened by behavioural science elements, particularly to formulate and evaluate the theoretical insights derived from IT artefact development and use.*“

Beck et al. (2013)

This thesis follows Hevner et al. (2004), Gregor and Hevner (2013), and Beck et al. (2013) in their view that a multi-perspective approach of behavioural and design-oriented research seems appropriate to derive technology impacts as well as evidence for technology design. Following the summary of the academic discourse given here, the main objective of this thesis can be summarised as the overarching primary research object (RO).

RO: *Generate prescriptive knowledge for the design of Robotic Process Automation and Process Mining for improving process management*

This research objective is divided into six research questions (RQ), which are organised into two overarching domains. The first area addresses hypothesis formation (HF) and the second area addresses hypothesis testing (HT) in the field. Table 1-3 below summarizes the six research questions and indicates which research method was used to answer each question. The columns *Primary data* and *Quantity* indicate which types of data were mainly used to answer the RQ and in what quantity or duration they were collected. In the contributions on which this thesis is based, over 135 hours of interviews were conducted and over 128,000 textual data were collected and analysed. In addition, this Table assigns each research question to the HF (hypothesis formation) and HT (hypothesis testing) domain of this thesis to provide an overview.

Table 1-3: Overview of the research questions

#	RQ	Method	Primary data	Quantity	Area
RQ1	What are the drivers and barriers for the adoption of RPA and PM?	Grounded Theory	Interviews	~ 16 h.	HF
RQ2	What are the main positive and negative topics in the life cycle of RPA technology?	Sentiment Analysis	Newspaper articles	~ 95,000	HF
RQ3	What conclusions can be drawn from job advertisements regarding the dissemination, use and implementation of RPA and PM?	Text Mining	Job advertisements	~ 33,000	HF
RQ4	What are the drivers, barriers and impacts when using RPA and PM in practice and what optimisation opportunities can be derived from this?	Case Study Research	Interviews	~ 91 h.	HT
RQ5	How can process management be optimised through RPA and PM?	Design Science Research	Interviews	~ 18 h.	HT
RQ6	How can - firstly - process management and - secondly - processes be optimised through RPA and PM?	Action Research	Interviews	~ 10 h.	HT

The aforementioned research questions will be explained in detail in the following section.

RQ1: Grounded Theory: What are the drivers and barriers for the adoption of RPA and PM?

The origin of RQ1 lies in the fact that scientific studies were mainly conducted with conventional companies. These studies then showed how innovative process technologies can be implemented in a practicable way.

With this research question, this thesis aims to create a detailed and theory-building understanding of the drivers and barriers to the adoption of innovative process technologies - RPA and PM - in an industry-specific scenario. In addition to the general drivers and barriers, particular attention will be paid to the impact of innovative process technologies on the modernisation of existing processes, with a focus on the impact on process performance and adaptability.

RQ2 sentiment analysis: What are the main positive and negative topics in the life cycle of RPA technology?

For new technologies and technology introductions, hype cycle concepts are typically used to illustrate what phases of public attention a new technology goes through during its introduction and how this relates to its technology lifecycle. RQ2 contextualizes this fact. In this work, RQ2 is used to capture the current phase of RPA technology and the impact on RPA, its past, and future application. To this end, a quantitative analysis is used to determine how the flow of news about RPA has changed between the years 2015 and 2020. In addition, a sentiment analysis based on the automated evaluation will be used to determine which more positive or more negative themes have emerged in the adoption and application of RPA from 2015 to 2020.

RQ3 text mining: What conclusions can be drawn from job advertisements regarding the dissemination, use, and implementation of RPA and PM?

In RQ3, the thesis deepens the results of RQ1 and RQ2 through additional quantitative surveys. Job advertisements are examined regarding their formulated requirements for digitisation efforts, goals, and focal points in various work areas. The employee qualifications and competencies needed in the future and present, as well as the urgent employer requirements in the BPM digitisation environment, are identified. This is followed by the synthesis of RQ1-3, from which the hypotheses are formed. These hypotheses will be completed by the conclusion of RQ3. In RQ4 they are explicitly tested in the field, practice-oriented as well as end-user-centred. The generated hypothesis will be shown in the results section of this thesis.

RQ4 Case Study Research: What are the drivers, barriers, and impacts when using RPA and PM in practice, and what optimisation opportunities can be derived from this?

Within RQ4, various application areas (e.g., public sector, manufacturing, healthcare, retail) are examined as case studies. The focus is on the measurable impact of the realisation, development, and deployment of RPA and PM on processes and BPM. The findings from RQ4 serve to highlight initial fundamental differences between formed hypotheses and real requirements to enable a deeper understanding of these.

RQ5 Design Science Research: How can process management be optimised through RPA and PM?

In RQ5, the findings from RQ4 are taken up. For this purpose, targeted design science investigations are carried out to optimise the application and design of RPA and PM for

BPM. In particular, the integration capability issues, and the resulting design approaches and artifacts will be elaborated with this research question.

RQ6 Action Research: How can - firstly - process management and - secondly - processes be optimised through RPA and PM?

The last research question, RQ6, summarises the findings of RQ4-5 and relates them to action research. For this purpose, solutions were designed with practice, prototypes were implemented and used against the background of the findings of the previously formulated hypotheses. This should lead to a deeper understanding of the formulated research objective.

1.3 Thesis Structure and Publications

Due to its cumulative nature, this thesis is naturally divided into two parts - *Part A* and *Part B*, as shown in Figure 1-2, which is separated into these two parts. The numbers on the top of Figure 1-2 lead to the chapters of this thesis.

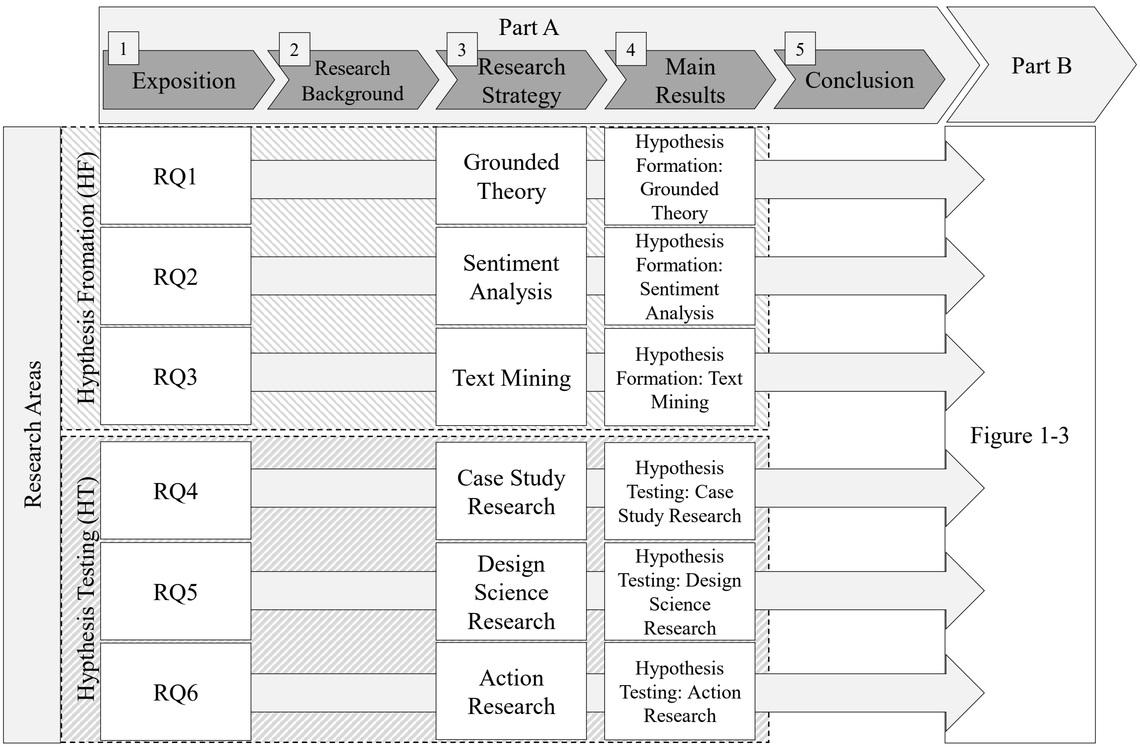

Figure 1-2: Structure of Part A of the thesis

In the following, the structure of this thesis as well as the main contents of each chapter of this thesis will be explained. *Part A* organises and summarizes the research findings, which are presented in *Part B*, providing a framework structure. This thesis starts with *Part A*, which consists of the first five chapters (Chapter 1-5), and follows with *Part B* which consists of the 15 research articles that respond to the research questions formulated in *Part A*. In the following both Parts - *Part A* and *Part B* - will be structured in detail with their corresponding chapters and sections.

Part A

Part A of this thesis starts with the first chapter (Chapter 1), which describes the initial situation and motivates the topic of optimisation potentials and design knowledge of BPM with RPA and PM by pointing out the problem and research gap. Subsequently, the objective of the thesis is summarized and the research questions that are to be answered within the scope of the thesis are presented. Finally, the structure of this thesis is explained and the thematical focus is placed in the overall context.

In Chapter 2, the theoretical foundations of BPM (Section 2.1) are presented. To this end, the term BPM is first defined. Section 2.1 also elaborates and presents the following thematic focuses: Selected relevant phase models of process management (Section 2.1.1); the definition of process performance management (Section 2.1.2), the connection of IS and technology with actual BPM (Section 2.1.3).

Section 2.2 provides an overview of process optimisation. For this purpose, relevant existing optimisation concepts (Section 2.2.1), as well as the objective function of optimisation based on process metrics, are presented in more detail (Section 2.2.2). In addition, the essential technologies of RPA (Section 2.3) and PM (Section 2.4) are discussed against the theoretical background of scientific and practice-oriented research.

Section 3 describes the research design by first distinguishing and elaborating on design-oriented business informatics from behaviourist business informatics, and then dividing the structure of the thesis into the individual research methods for the formulated research questions. This is followed by the analysis of the guiding and main research methods of this thesis in section 3.2 which is divided into the hypothesis formation (HF) and hypothesis testing (HT) part. HF includes the research methods grounded theory (Section 3.2.1), sentiment analysis (Section 3.2.2) and text mining (Section 3.2.3). The HT part follows in the form of the research methods case study research (Section 3.2.4), design science research (Section 3.2.5), and action research (Section 3.2.6).

Chapter 4 concludes the main findings and results of the previous work. To this end, following the research questions and the outline of Chapter 3, Section 4.1 to Section 4.3 first show the hypothesis formation (HF). Section 4.5 to Section 4.7 further show the hypothesis testing (HT) and are derived accordingly from the results presented. To this end, the respective sections derive the conclusions from the individual research contributions. Based on this, an overarching synopsis of the results is presented in a classifying manner in Section 4.7.

The Part A of the thesis ends with Chapter 5, which presents the implications for theory and practice and assigns the results to the respective research questions and identified fields of action (Section 5.1). This is followed by a presentation and justification of the research limitations of this work (Section 5.2). The outlook in Section 5.3 identifies further research needs.

Part B

As mentioned earlier, *Part B* contains the 15 publications (P1-15, shown in Table 1-3) on which the cumulative dissertation is based on. The publications (P1-15) are not presented in chronological order of appearance, but rather according to their respective contribution to the content framework of the underlying research questions and the resulting research framework, as shown in the order framework in Figure 1-3.

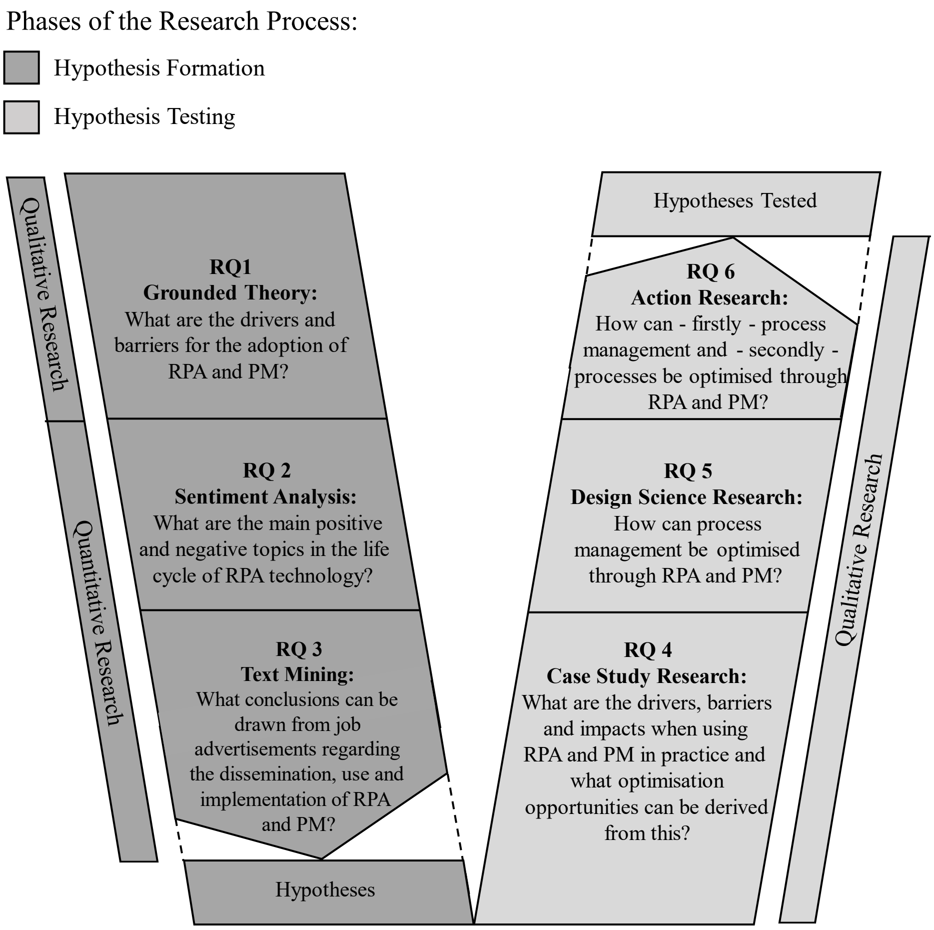

Figure 1-3: Framework of Part B of the thesis

The articles were published on the one hand in relevant academics (peer-reviewed) journals, such as Journal of Business Research (JBR), Computers and Industrial Engineering (CAIE), and Journal of Organizational Computing and Electronic Commerce (JOCEC). On the other hand, these publications were published in the proceedings of scientific conferences, such as the proceedings of the European Conference on Information Systems (ECIS) and the Hawaii International Conference on System Sciences (HICSS). The scientific publications used in this thesis were written and published between 2019 and 2022.

Table 1-4 gives an overview of the 15 publications (P#) relevant to this thesis. The table shows the publications sorted according to the coverage of the particular research questions (RQ). The content of the table consists of the citation (title) (including co-authors), the classification of each publication according to the JOURQUAL3 (JQ) ranking of the *Verband der Hochschullehrer für Betriebswirtschaft e.V.* and the type of publication (type). In addition, the status of the publication is indicated in relation to contributions already published or still in the review process (status). Publications 11 and 13 were written in German for the journal *HMD Praxis der Wirtschaftsinformatik*, all other publications were written in English. Broken down by the respective JQ ranking, four of the accepted publications are rated „B", three are rated „C", two are rated „D" and five are not ranked (n.R.). One publication is still in the review process at the time of dissertation completion and are declared as *„to be defined*" (TBD). For the present compilation of the complete work, all publications were converted into the same format. The existing original format of the tables and figures in the publications has been slightly modified to allow integration into the overall text. The included references to tables, figures, and chapter numbers have been modified to reflect the existing outline of this thesis. All citations in *Part A* and *Part B* of the thesis have been standardized to conform to the citation style of the *MIS Quarterly Referencing Guide* in Version 2021.

Table 1-4: Overview of the scientific publications of this thesis

P#	RQ	Titel	JQ	Type	Status
1	RQ 1	Plattfaut, R.; Koch, J. (2021): Preserving the legacy - Why do professional soccer clubs (not) adopt innovative process technologies? A grounded theory study. In: *Journal of Business Research* 136, S. 237-250. DOI: 10.1016/j.jbusres.2021.07.024.	B	Journal	Published
2	RQ 1	Koch, J.; Vollenberg, C.; Plattfaut, R.; Coners, A. (2022): The Fear of Losing Control - What Prevents the Automation of Buisness Processes in Sensitive Areas. In: *Proceedings of the 55th Hawaii International Conference on System Sciences*.	C	Conference Proceedings	Published
3	RQ 2	Kregel, I.; Koch, J.; Plattfaut, R. (2021): Beyond the Hype: Robotic Process Automation's Public Perception Over Time. In: *Journal of Organizational Computing and Electronic Commerce* 31 (2), S. 130-150. DOI: 10.1080/10919392.2021.1911586.	C	Journal	Published
4	RQ 3	Koch, J.; Plattfaut, R.; Kregel, I. (2021): Looking for Talent in Times of Crisis - The Impact of the Covid-19 Pandemic on Public Sector Job Openings. In: *International Journal of Information Management Data Insights* 1 (2), S. 100014. DOI: 10.1016/j.jjimei.2021.100014.	n.R.	Journal	Published

5	RQ 3	Kregel, I.; Koch, J.; Coners, A. (2019): Digitalisation in the Public Sector: A Job Mining Perspective. In: *Proceedings of the 26th Annual European Operations Management Association Conference*.	n.R.	Conference Proceedings	Published
6	RQ 4	Plattfaut, R.; Borghoff, V.; Godefroid, M.; Koch, J.; Trampler, M.; Coners, A. (2022): Critical Success Factors for Robotic Process Automation - Analyzing Multiple Case Studies. In: Computers in Industry.	C	Journal	Accepted with minor revision
7	RQ 4	Koch, J.; Vollenberg, C.; Matthies B.; Coners, A. (2022): Robotic Process Flexibilization in the Term of Crisis: A Case Study of Robotic Process Automation in a Public Health Department. In: *Proceedings of the 30th European Conference on Information Systems*.	B	Conference Proceedings	Accepted with minor revision
8	RQ 4	Koch, Ja.; Koch, Ju.; Vollenberg, C.; Bade F. M.; Coners, A. (2022): The Dark Side of Process Mining. How Identifiable Are Users Despite Technologically Anonymized Data? A Case Study from the Health Sector. In: *20th International Conference on Business Process Management*.	TBD	Conference Proceedings	Under Review
9	RQ 4	Koch, J.; Koch, L.; Vollenberg, C.; Plattfaut, R; Coners, A., (2021): 'From Nurse to Nerd!' How to Accelerate eHealth Using No-Code Approaches, In: *Proceedings of the 28th Annual European Operations Management Association Conference*.	n.R.	Conference Proceedings	Published
10	RQ 4	Koch, J.; Trampler, M.; Kregel, I.; Coners, A. (2020): 'Mirror, Mirror, on the Wall': Robotic Process Automation Using a Digital Twin. In: *Proceedings of the 28th European Conference on Information Systems*.	B	Conference Proceedings	Published
11	RQ 4	Koch, J. (2020): Click Here, Click There! Analysis of the Differences in Process Remodeling Using Robotic Process Automation: A Comparative Case Study Between the Public Sector and Industry, In: *Proceedings of the 27th Annual European Operations Management Association*.	n.R.	Conference Proceedings	Published
12	RQ 5	Kregel, I.; Stemann, D.; Koch, J.; Coners, A. (2021): Process Mining for Six Sigma: Utilising Digital Traces. In: *Computers & Industrial Engineering* 153, S. 107083. DOI: 10.1016/j.cie.2020.107083.	B	Journal	Published
13	RQ 5	Plattfaut, R.; Koch, J. ; Trampler, M.; Coners, A. (2020): PEPA: Entwicklung eines Scoring-Modells zur Priorisierung von Prozessen für eine Automatisierung. In: *HMD* 57 (6), S. 1111-1129. DOI: 10.1365/s40702-020-00670-3.	D	Journal	Published

14	RQ 6	Koch, Ju.; Koch, Ja.; Vollenberg, C.; Coners, A. (2022): Don´t Believe Your Eyes - The Problem of Process Mining in Auditing. In: *29th Annual European Operations Management Association Conference*.	n.R.	Conference Proceedings	Accepted
15	RQ 6	Vollenberg, C.; Koch, J.; Trampler, M. Bade, F. M.; Coners, A.; Plattfaut, R. (2021): Die Entwicklungsbeschleunigung von Robotic Process Automation Lösungen - Fallstudie einer deutschen Gesundheitsbehörde. In: *HMD* 58 (5), S. 1244-1263. DOI: 10.1365/s40702-021-00764-6.	D	Journal	Published

2 Research Background

2.1 Business Process Management

The term process management, which is referred to in this thesis as business process management and abbreviated to BPM, is defined differently in the literature. Interpretations range from an operational view of processes in the sense of optimising process time, costs, and quality to achieve higher customer satisfaction to the approach of process-oriented corporate management (Dumas et al. 2018; vom Brocke and Rosemann 2015). Based on the above, a comprehensive definition of BPM was taken up by Antonucci et al. (2009) as part of the Association of Business Process Management Professionals as follows:

„*Business process management (BPM) is a disciplined approach to identify, design, execute, document, measure, monitor, and control both automated and non-automated business processes to achieve consistent, targeted results aligned with an organization's strategic goals. BPM involves the deliberate, collaborative and increasingly technology-aided definition, improvement, innovation, and management of end-to-end business processes that drive business results, create value, and enable an organization to meet its business objectives with more agility. BPM enables an enterprise to align its business processes to its business strategy, leading to effective overall company performance through improvements of specific work activities either within a specific department, across the enterprise, or between organizations*".

For this thesis, it is relevant to know the antecedents and current manifestations of the BPM research field, which remain to the areas of business administration and IS. The promise of coordinating aspects of business activities into business processes triggered several research initiatives to formally define BPM.

As a result, BPM is viewed as a holistic management approach and can be defined as a time-logical sequence of activities performed to achieve business objectives on a process-oriented business object (Rosemann and vom Brocke 2015; Trkman 2010; van der Aalst et al. 2003). However, BPM can also be defined as the ability of an organisation to change organisational business processes. Methods, techniques, and tools are included in BPM to support the design, configuration, implementation, evaluation, and analysis of operational business processes, which applies accordingly to innovative process technologies such as RPA and PM (Heckl et al. 2010; Mendling et al. 2018; van der Aalst et al. 2003).

As mentioned before, BPM focuses on modelling and improving business processes, which is also included in the lifecycle of a workflow. Dumas et al. (2018) argue that BPM approaches are integrated into the workflow lifecycle. They describe the workflow lifecycle in the sense that the development of a workflow application starts with the modelling and analysis of the processes

It can be deduced that BPM helps organisations to continuously improve their business processes and provide effective services or products through innovation by focusing on a process-oriented business structure (Rosemann and vom Brocke 2015). Due to the various definitions mentioned above, it is necessary to clarify the definition used in this thesis. Therefore, in the context of this work, the following definition is used:

BPM is an integrated concept that encompasses planning, organizational and controlling measures that enable processes to be managed in line with the needs of customers and other stakeholders. The measures aim to improve work processes in terms of customer satisfaction, quality, time, and costs. BPM refers to management approaches or methods for aligning business processes to improve the effectiveness of the company.

Over time, BPM has developed into a generally accepted management tool in today's corporate practice. This development is also attributable to the fact that companies are increasingly exposed to rising cost pressure due to external environmental and market factors (Daniel et al. 2012; Dumas et al. 2018). Strategic decisions, such as the ever-closer interlocking and cooperation with customers and suppliers, also against the background of increasing interlocking with IS, also require a process-oriented company organisation (vom Brocke and Mendling 2018). While many disciplines have influenced the development of BPM, the biggest drivers for the further development and relevance of BPM are IT-based innovations and the associated dynamic development of computer and communication technology since the 1950's (Grisold et al. 2021b; Mendling et al. 2018). As a result, business processes have become more complex and are now largely networked with IS (Mendling et al. 2018; Mendling et al. 2020).

Many companies see the continuous improvement of their business processes through the integrative use of IS as a decisive competitive factor (vom Brocke and Schmiedel 2015). Academia is now making an extensive contribution to this (Asatiani et al. 2020; Di Francescomarino et al. 2019). Therefore, there is almost an unmanageable number of publications dealing with the integration of corporate functions along the value chain via various information technology systems and related topics (Cognini et al. 2018; Grisold et al. 2021b; Mendling et al. 2020; van Looy 2021). Derived from the general tasks of management, BPM encompasses the planning, management, and control of these organisational processes according to the specifications of the business strategy and under the conditions and involvement of the information system (Grisold et al. 2021b; vom Brocke and Rosemann 2015). The business strategy defines the necessary business processes based on the strategic goals (Gadatsch 2010). It is the basis for identifying and aligning the business processes. Customers and stakeholders place demands on an organisation that is implemented in the business processes, so IT strategy and customer requirements must be well aligned (Asatiani et al. 2019; Mendling et al. 2020).

However, the literature describes on the one hand that a too one-sided orientation towards information technology innovations leads to a rather short-term operational orientation so that longer-term success potentials and core competencies cannot be developed and expanded (Röglinger et al. 2022; van Looy 2021). On the other hand, it is described that a too one-sided orientation towards the business strategy without taking current technologies into account can also lead to not achieving the operational goals (Grisold et al. 2021b; Mendling et al. 2020).

Accordingly, today's BPM must be oriented towards the requirements of customers, IS, the company's performance, and the performance of competitors (Lehnert et al. 2016; Mendling et al. 2020). From the point of view of established research, this should involve an orientation to the market (Gadatsch 2010). The customer-oriented use of information technology in BPM thus creates added value that can be consistently divided into the dimensions of quality, service, costs, flexibility, and time (Dumas et al. 2018). The goals for the use of technology in BPM can be composed to several of these dimensions (Grisold et al. 2021b; Mendling et al. 2020). The literature emphasises the importance that these goals are operationally measurable and can be applied to concrete processes (Grisold et al. 2021b; Rosemann and vom Brocke 2015). It is assumed that the prerequisite for this is precise knowledge of the integration performance of possible technology use (Grisold et al. 2021b; Mendling et al. 2018; van Looy 2021).

2.1.1 Phase Models for Process Management

Numerous contributions to the introduction of BPM can be found in the scientific literature (Dumas et al. 2018; Gadatsch 2010; Koch 2015). These proposals are mostly formulated as process models which follow different phase models (Dumas et al. 2018). These models assign different structured sections to corresponding methods and techniques (Becker et al. 2005).

In this chapter, the process models of Becker et al. (2005), Jeston and Nelis (2014), and Dumas et al. (2018) are discussed. These three models show the steps to depict a design or implementation process of BPM, which puts the tasks and activities that arise into a meaningful and logical order (Becker et al. 2005). Of importance for the explanations of the problem definition of this thesis are the corresponding model designs, which specify, implement, and determine the use of information technology in addition to defined activities, phases, and methods (Poeppelbuss et al. 2011). Thereby it is shown, which results must be achieved, and which conditions must be given (van der Aalst et al. 2012). This description of the methods, techniques and the associated prerequisites can in turn serve as a basis for understanding the integration of such information technologies (RPA and PM) in BPM.

2.1.1.1 Procedure model for process-oriented reorganisation

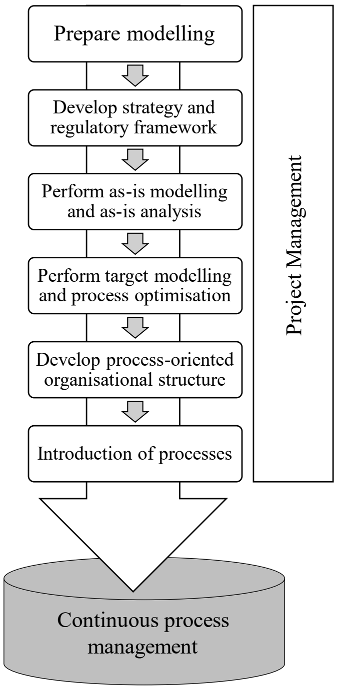

Figure 2-1: Procedure model for process-oriented reorganisation according to Becker et al. (2005)

As shown in Figure 2-1, Becker et al. (2005) present a procedure model that includes seven phases. These seven phases will be explained further in the following:

Phase 1 - Modelling preparation

In modelling preparation, design recommendations for information modelling are developed. This is an essential task to ensure the success of process modelling (Dumas et al. 2018). Thus, the appropriate modelling standard is available to ensure the achievement of the set goals (Becker et al. 2005; Dumas et al. 2018).

Phase 2 - Development of the strategy and regulatory framework

In the strategy and regulatory framework development, the processes and process objectives are structured. The goal is to schematically represent the essential elements and their relationship to each other to ensure transparency in the further course of the project (Becker et al. 2005).

Phase 3 - Actual modelling

The as-is modelling and analysis serve to identify potentials for improvement and is thus the basis for the to-be modelling or target modelling, as weak points are identified in this phase (Becker et al. 2005).

Phase 4 - Target modelling

Building on the as-is modelling, this phase involves target modelling, i.e., the target state of the company's process landscape (Dumas et al. 2018). On the one hand, the target modelling forms the basis for the alignment of the company's organisational structure and, on the other hand, the basis for internal benchmarking or workflow management (Becker et al. 2005).

Phase 5 - Development of a process-oriented organisational plan

The process-oriented organisational plan is designed according to the target processes. As already mentioned, the dimensions for determining the organisational structure are time, cost, and quality (Becker et al. 2005).

Phase 6- Introduction of the new organisational plan

When the new organisational plan is introduced, the concept (target model, process-oriented organisational plan) is introduced as part of the new organisational plan. For this purpose, an implementation strategy is defined that includes the sequence and timing of the introduction of the new processes (Dumas et al. 2018). Change management techniques are used to ensure success and sustainability (Becker et al. 2005).

Phase 7 - Continuous BPM

After the introduction of a process-oriented organisational structure, it is necessary to establish a continuous BPM (Dumas et al. 2018). This can also be done through mechanisms of knowledge management and knowledge provision as well as through feedback mechanisms (Becker et al. 2005).

2.1.1.2 The 7FE Project Framework

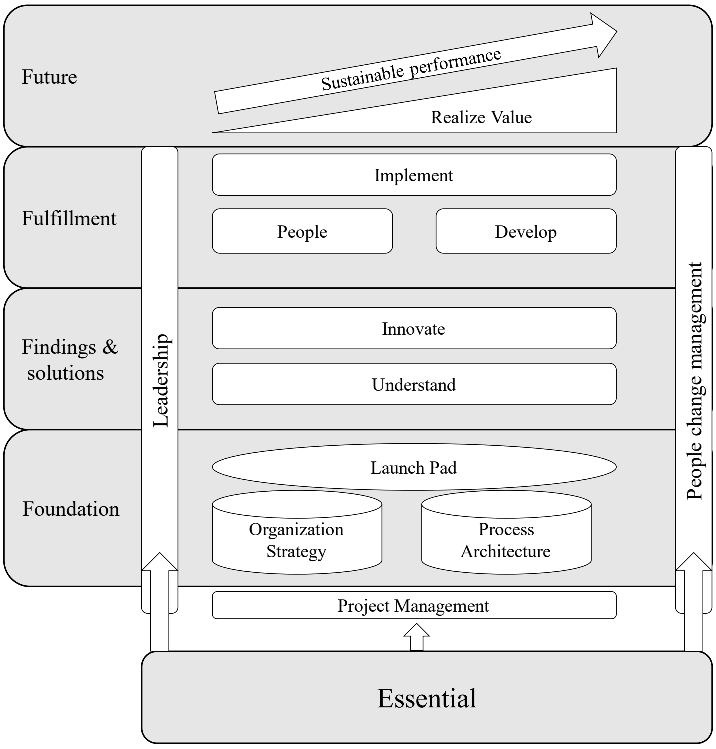

Figure 2-2: The 7FE Project Framework according to Jeston (2014)

Jestons so-called 7FE framework, shown in Figure 2-2, consists of a total of ten business processes in four process groups (Future, Fulfilment, Finding and Solutions, Foundation). The framework comprises three overarching core principles: Leadership, Project Management and People Development (Jeston 2014). To put them in the context of this thesis, the core principles are the starting point of any BPM activity. They state that insights and solutions are the result of analyses of the existing process. These must take place in order to understand, improve and maintain existing processes. Jeston also explicitly points out that this is necessary to innovate processes with the help of technology (Jeston 2014). In the following, each phase will be explained in detail:

Phase 1 - Organisational Strategy Phase

The company's strategy sets the determination, direction, and capability. It is important that the BPM team knows and understands these, so there must be thorough alignment. Processes are a means to achieve business goals (Jeston 2014).

Phase 2 - Process Architecture Phase

Process architecture is a tool to provide and ensure process guidelines, process models, rules, and principles for implementing BPM (Gadatsch 2010; Jeston 2014). This phase focuses on the organisational aspect of the project (Gadatsch 2010; Jeston 2014). Whether it is carried out depends on the maturity of the organisation (Jeston 2014).

Phase 3 - Start-up phase

In this phase the selection of the business process, objectives, scope, and infrastructure (members, stakeholders, structure, and technologies to be used...) takes place (Jeston 2014).

Phase 4 - Understanding phase

All process variables are collected in this phase to be able to compare them later - in particular, IS are to be used. In addition, the existing process situation is captured and understood. The result is a process model with the relevant metrics, documentation of the performance status, a root cause analysis, and an overview of possible quick wins (Jeston 2014).

Phase 5 - Innovation Phase

In this phase, new efficient and effective process opportunities are identified by interviewing internal and external stakeholders and conducting process simulations. In addition, resource costs are determined, capacity planning is carried out, a feasibility analysis is performed, and automation options are considered (Jeston 2014).

Phase 6 - Staff Phase

The main task of this phase is to ensure that the activities and actions of the staff members who are to carry out the process are consistent with the decided organisational and process objectives. During this, employee objectives and job descriptions, including the profile of skills and abilities, are developed (Jeston 2014).

Phase 7 - Development Phase

The development phase takes place in parallel with the staffing phase when all preparations have been completed. The goal is to create the necessary infrastructure for future operations (Jeston 2014).

Phase 8 - Introduction phase

The introduction of the new process flows, new role descriptions, performance management, performance measurement, and intensive training is based on an introduction plan that is sensitively adapted to the needs. In addition, there is a plan for discontinuation of the measures and the occurrence of unforeseen circumstances. The results are trained and motivated employees and new or improved processes that function satisfactorily (Jeston 2014).

Phase 9 - Value Creation Phase

The value creation phase does not run as a separate phase but is already considered in the previous phases. Benefits, already outlined in the project plan must be identified. Various tools for benefit management are used to evaluate the benefits achieved in a structured manner and to communicate them in a targeted manner (Gadatsch 2010; Jeston 2014). Benefit management is always aligned with stakeholder expectations. The results are also used for knowledge storage and lessons learned (Jeston 2014).

Phase 10 - Sustainability phase

In the sustainability phase, all stakeholders in the organisation must recognize that a process has a life cycle and must be continuously improved. The transition from project to operations is necessary to ensure the mobility of the process and guarantee the sustainability of the improvements. Performance metrics are introduced for monitoring and control. Quality assurance loops are also established. This final phase of the process project is the first phase in which BPM is introduced as a day-to-day business activity. The deliverables of this phase are mechanisms for managing business processes, identifying, and exploiting improvement opportunities, and improving processes. In addition, the organisational and business results of the project are evaluated and secured for follow-up projects (Jeston 2014).

2.1.1.3 The BPM Lifecycle

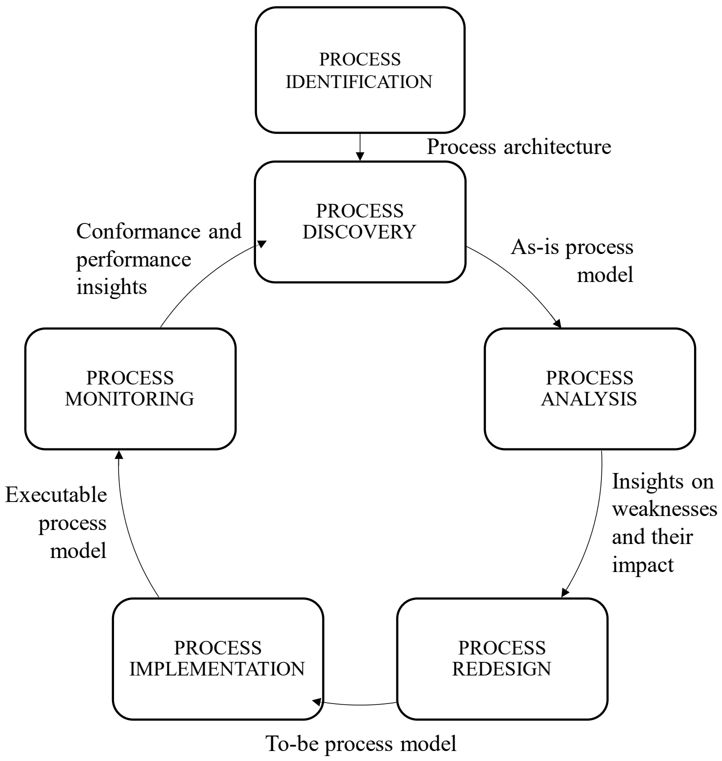

Figure 2-3: The BPM Lifecycle according to Dumas et al. (2018)

Figure 2-3 shows the widely used BPM lifecycle model according to Dumas et al. (2018). This describes the phases of managing business processes and illustrates how a BPM project or initiative can be organised to lead to process improvement through the six main steps of process identification, process discovery, process analysis, process redesign, process implementation, and process monitoring and control.

However, it is important to note against the backdrop of this work that the six phases are rarely executed in practice in exactly this idealistic, sequential manner. For example, an organisation may decide to only document the processes without considering a redesign. Nevertheless, the BPM lifecycle is often used to illustrate how BPM-related activities convey to each other and how they holistically contribute to BPM. The following section gives a further description of each phase of the BPM lifecycle:

Phase 1 - Process Identification

Process identification addresses the establishment of the BPM initiative, including a detailed description of the organisation's key processes and an assessment of their current state (vom Brocke and Mendling 2018). The main output of this phase is a „*process architecture*“ that identifies the organisation's key processes, describes the relationships between the processes, and defines criteria for prioritizing the processes (vom Brocke and Mendling 2018; Dumas et al. 2018).

Phase 2 - Process Discovery

Process discovery shifts the focus of the cycle from the organisation's overall portfolio and management to a specific process. The process discovery phase provides detailed descriptions of a business process in its current state. This description is referred to as the as-is process model (Dumas et al. 2018).

Phase 3 - Process Analysis

During the process analysis phase, analytical tools (vom Brocke and Mendling 2018) and techniques are used to identify weaknesses in the as-is process and the impact of each weakness (Dumas et al. 2018).

Phase 4 - Process Redesign

Process redesign addresses the key weaknesses (vom Brocke and Mendling 2018) in the process and provides a revised design for the process, referred to as a target design in the form of a process model. This model is then used as the basis for process implementation (Dumas et al. 2018).

Phase 5 - Process Implementation

Process implementation typically includes the introduction of IS and measures to facilitate organisational change. This phase has the goal of adapting the organisation's processes to the designed process model (Dumas et al. 2018).

Phase 6 - Process Monitoring and Control

Once the redesigned process is implemented, the process monitoring and control phase continuously collects and analyses execution data to verify conformance to performance and compliance objectives. Deviations from these goals and changes in the business environment or business objectives trigger a new iteration of the BPM lifecycle (Dumas et al. 2018).

2.1.2 Process Performance Measurement

In the context of this thesis and the research questions raised in Chapter 1, it is considered useful to place process performance measurement and optimisation in its theoretical context. Business process performance measurement - often referred to in the literature as process performance measurement - involves the definition, collection, visualisation, and analysis of a set of indicators that evaluate performance-related data of one or more business processes (Gleich 2021; van der Aalst et al. 2012c). These indicators, typically referred to as Process Indicators (Section 2.2.2), are quantifiable metrics that enable an evaluation of the efficiency and effectiveness of business processes and can be measured directly against the data generated in the process flow (van Looy and Shafagatova 2016).

Table 2-1: Performance perspectives according to Kaplan and Norton (2005)

KPI area	Business goals
Customer-related performance	Customer satisfaction Customer-oriented solutions Market orientation, development, and growth
Financial performance	Revenue growth Net profits Return on assets
Learning and growth-related performance	Satisfied employees Knowledge base Investment in R&D and innovation
Internal business processes related performance	Efficient and effective business processes Cost of producing Quality of internal outputs

As academia, as well as companies, strive to focus on the topic of performance measurement as comprehensively as possible, this field is discussed frequently in the literature as well as in practice. Since process-oriented performance measurement in the context of this thesis is a multidisciplinary topic that is the focus of research in management as well as in business informatics and especially in BPM, various models, systems, and methods for performance measurement are presented. Various performance measurement models, systems, and frameworks have been developed by researchers and practitioners (Folan and Browne 2005; Kaplan and Norton 2005; Nudurupati et al. 2011)

While measurement models were initially limited to financial performance, the challenges of rapidly growing technological penetration required a more balanced and integrated approach from the 1990s onwards, leading to multidimensional models. The best-known multidimensional performance measurement model is the Balanced Scorecard (BSC) developed by Kaplan and Norton, shown in Table 2-1, which takes a four-dimensional approach to business performance: the financial perspective, the customer perspective, the internal business process perspective, and the learning and growth perspective (Baum et al. 2013; Dumas et al. 2018).

The BSC helps to translate an organisation's strategy into operational performance indicators - often called key performance indicators or metrics - and goals with targets for each of these performance perspectives. The BSC is one of the most established approaches to process-oriented performance measurement (Horváth et al. 2015). In this context, academic research also suggests a close relationship between business process performance and organisational performance, either in terms of a causal relationship or more often as different indicators co-existing, as in the BSC.

The established performance measurement models usually offer little guidance for the selection and operationalisation of performance indicators for IT support of business processes. This is because, especially against the background of the research objective of this thesis, they essentially limit themselves to defining performance perspectives without, however, offering concrete indicators (Baum et al. 2013; Niven 2002).

In this regard, extensive research has been conducted in the past for both performance models and performance measurement of business processes. The research concludes that performance indicators are considered organisation-dependent, as many measurement models such as the BSC require a strategic orientation. The academic discourse states that although the selection of appropriate performance indicators is challenging for innovative technologies in the process environment, it is also important for performance measurement (Niven 2002).

However, considering the procedural models presented in Section 2.1.1, performance measurement can also focus on a single business process, in particular regarding this work and the research questions raised. Dumas et al. (2013) thereby position time, cost, quality, and flexibility as typical performance perspectives for business process performance measurement, as discussed in section 2.1.1.3. The following perspectives can be used for performance measurement: Financial perspective, Customer perspective, Employee perspective, Societal perspective, and Innovation perspective (Kaplan et al. 1997; Schreyer 2007).

Based on the approach presented in this thesis, there is a need to measure the use and design capabilities of RPA and PM technologies with a variety of performance metrics, i.e., from quantitative to qualitative and from financial to non-financial indicators. Therefore, the prevailing performance perspectives with associated indicators in the academic literature can be considered as a conceptual framework derived from the current process literature and theoretically validated by established measurement approaches.

Accordingly, the research conducted here also uses the conceptual framework to empirically validate the research questions by involving subject matter experts and case studies to refine the suitability and lack of concreteness of the indicators. In this context, the relationships between the actual performance of technologies and the expected performance of technologies, as well as the impact of specific strategic or environmental design principles, are explored through the selection of appropriate performance indicators. The results then offer the possibility, following the existing literature, to complement and enrich the measurement of the performance of the technologies RPA and PM in the context of BPM (Asatiani et al. 2020; Ivančić et al. 2019; Leno et al. 2020; Syed et al. 2020; van Looy and Shafagatova 2016).

2.1.3 Link to Information and Communication Technology

The basic scientific consensus is that information technology has a significant influence on BPM, as it not only supports the flow of business processes, but also makes important contributions to their organisational design (Garcia et al. 2019; Grisold et al. 2020a; Plattfaut and Koch 2021; vom Brocke et al. 2021; Willcocks et al. 2017). If one follows the St. Gallen Management Model, which is shown in Figure 2-4, the organisation of companies is based on a layer model divided into three levels (Rüegg-Stürm 2003). On the first level, the corporate strategy is defined first, i.e., it is considered what the company wants to achieve and what products or services it wants to offer. The second level is about how these goals are to be achieved, whereby the business processes play a central role. Suitable processes must be defined that enable and support the implementation of the goals. At the third level, resources take into account. These can be people, machines, or IS involved in the processes, but also knowledge and information needed to fulfil the tasks within the processes.

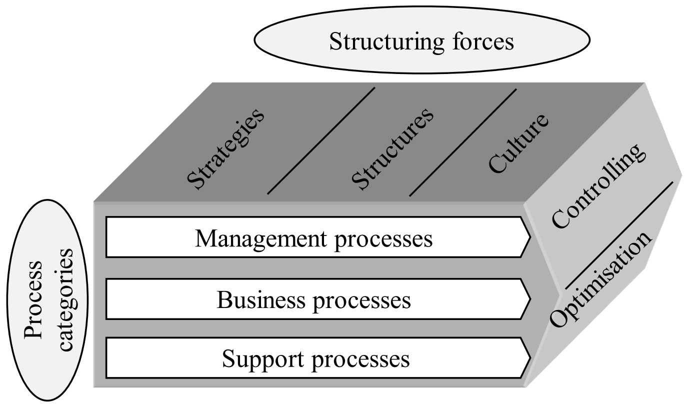

Figure 2-4: The three levels of organisation according to Rüegg-Stürm (2003)

Each of these levels is strongly influenced by the other levels. Strategy, processes, and resources must be well aligned to support each other in the best way. Among the resources mentioned, IS occupy a special position because they usually map the business processes directly in the software and must therefore also be adapted when processes change.

Allweyer describes that a precise knowledge of the procedures of the business processes to be supported is a prerequisite for being able to map them optimally in an information system (Rosemann and vom Brocke 2015). Against the background of this thesis, it is important to explain that information technology and thus also RPA and PM in BPM only have a quasi-instrumental character. BPM is primarily an organisational and only secondarily a technological task. The consideration of business processes thus represents an important link between BPM and information technology issues (vom Brocke and Rosemann 2015). In function-oriented companies, special IS are used to optimally support BPM (Rosemann and vom Brocke 2015; vom Brocke and Mendling 2018). For example, to better understand process data, companies have been successfully using Business Intelligence (BI) methods for years (Mendling et al. 2018; van der Aalst et al. 2016). Furthermore, IS in BPM enable the process-related comparison of performance data. According to scientific studies, increasing efficiency is just as much an inherent and prioritised task of corporate IT in connection with BPM as reducing errors in daily business (Mendling et al. 2018; Tiwari et al. 2008). Finally, the claim is formulated in the literature that BPM often aims to digitalise and automate business processes across the board through the exclusive use of IT (Dumas et al. 2018; Grisold et al. 2020a; Grisold et al. 2021b; Syed et al. 2020).

2.2 Process Optimisation

Process optimisation is one of the most important components of BPM and the methods listed in this section contribute significantly to achieving the goals of BPM described in Section 2.1. According to the literature, the methods of the approaches to process optimisation presented here must be integrated into BPM and used systematically and continuously (Dumas et al. 2018; van der Aalst et al. 2016). IS can and should make an important contribution to optimising business processes. Various concepts for process optimisation exist in the literature, some of which contradict each other and are intensively discussed both in science and in practice. Two views of process optimisation are frequently used (Dumas et al. 2018):

> *First, revolutionary process optimisation: Here business processes are radically improved. The benchmark is the target process and not the actual state.*
>
> *Secondly, evolutionary process optimisation: Here, process optimisation is seen as part of BPM. Here, the processes are improved in small steps.*

For revolutionary process optimisation, Business Process Reengineering (BPR) is considered the best-known method. Its main features are a fundamental rethinking of business processes, the radical redesign of essential business processes (Beverungen et al. 2021; Rosemann and vom Brocke 2015; vom Brocke et al. 2018).

Evolutionary process improvement, on the other hand, starts with existing business processes and is carried out as a continuous task. This approach is characterised by iterative improvements or its repetitive nature, close involvement of employees and low risk (vom Brocke and Rosemann 2015).

2.2.1 Optimisation Concepts

Table 2-2: Process optimisation concepts

Feature	Revolution	Evolution
Method examples	BPR	Kaizen, Six Sigma
Extent of change	As a project Top-down	Continuous bottom-up
Frequency of application	Episodic	Continuous
Impact of change	Whole processes, cross-process	Primary process steps
Involved	Top-down (management)	Hybrid (management and employees)
Object	New process	Existing process
Process understanding	Core processes	All business and core processes
Risk	High	Moderate
Steps in the process organisation	Project organisation, vision, recognise business processes, new design	Motivation of employees, incentive system for employees, improvements only in small steps
Target	Quantum leaps in time, cost, quality	Change of all processes, further development of employees
Trigger	Radical need for change	Need for adaptation

The general optimisation concepts, as shown systematically in Table 2-2, are presented in the following section, and structured regarding revolutionary and evolutionary optimisation approaches (Dumas et al. 2018; Gadatsch 2010; Hammer and Champy 2009; Weske 2007). Regardless of which concept is pursued, process optimisation usually consists of the phases of preparation, preliminary investigation, as-is analysis and target conception, implementation, and evaluation (vom Brocke and Mendling 2018; Weske 2007). As described above, a distinction must be made between a radical and revolutionary redesign of a business process, shown here based on the example of BPR, and a more continuous evolutionary business process optimisation of existing processes, shown here with the methods of Kaizen and Six Sigma (vom Brocke and Mendling 2018).

In BPR, an optimal solution is sought independently of an existing process design, which leads to a radical redesign of business processes and follows the revolutionary process optimisation approach. The previous structures are considered non-existent, and the processes are completely re-modelled. Hammer and Champy are considered the founders of this radical form of business process analysis (Hammer and Champy 1993). The result of BPR should be fundamental, radical as well as dramatic improvements in the performance variables transparency, controllability, stability, robustness, reusability, traceability, ease of application, complexity reduction (Dumas et al. 2018; Hammer and Champy 2009). This can ultimately improve time, quality, costs, and customer satisfaction (Baier et al. 2022; Gadatsch 2010). Section 2.2.1.1 will discuss the concept of BPR in detail.

Evolutionary process optimisation, on the other hand, is a step-by-step process improvement method, i.e., it is carried out continuously. It is applied to existing processes and implemented with the involvement of all employees in day-to-day business. Primarily, individual process steps are improved (Rosemann and vom Brocke 2015; Trkman 2010). However, it is also possible to improve the entire process. The most relevant evolutionary methods are Kaizen and Six Sigma, as mentioned above, and will be explained in detail in Section 2.2.1.2 and Section 2.2.1.3.

2.2.1.1 Business Process Reengineering

Business Process Reengineering (BPR) has attracted attention from both industry and the academic community as it has greatly changed BPM practice in organisations by countering the functional hierarchical approach with a process-oriented, collaborative approach (Dumas et al. 2018; Hammer 2015; van der Aalst et al. 2016). There is a consensus in the academic community that BPR, while fundamentally viable, is problematic because of its radical approach. Since many projects could not be successfully implemented, the attractiveness of softer instruments, some of which also allow for a bottom-up approach, has gained in importance (Dumas et al. 2018; Hammer and Champy 2009).

The term business process reengineering was coined by Henry Johansson in 1993 and defined by Hammer and Champy (1993) as: „*Fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in key performance indicators such as cost, quality, service and cycle time"*. In contrast to the classic business process optimisation, where only individual business processes are made more efficient, here a fundamental rethinking of the company and its business processes took place. BPR is essentially based on the following four basic statements:

First, BPR is oriented towards crucial business processes (Hammer and Champy 2009). Second, the business processes must be oriented towards the customers (Hammer 2015). Third, the company must focus on its core competencies. Fourth, the possibilities of current information technology must be used intensively (Rosemann and vom Brocke 2015).

The approach of Davenport and Short (1990) follows on from this and takes up in their theory five steps for the use and implementation of BPR, which are described further in the following:

Phase 1 - Vision and goal setting

The first phase serves to lay the foundations for the BPR project and process. This involves the company's staff and the department's team. Those involved need to be trained to manage the development and change process.

Phase 2 Identify the processes to be revised

Here, the most important processes to be optimised through business process reengineering are identified.

Phase 3 - Understanding and measuring the existing process

In the third phase of BPR, the focus is on the current state of the processes. On this basis, the possible potentials towards a target state are identified.

Phase 4 - Use of information technology as a change enabler

In the fourth phase, new information system-based methods and behaviours are introduced into the company. In this way, those involved, e.g., employees or the team concerned, learn to use the new information technologies, and thus help to shape the BPR.

Phase 5 - Design and evaluation of the process prototype

In the final fifth phase, the restructuring is designed, implemented, and evaluated. The stakeholders work based on the restructured business processes. Evaluation loops are carried out to make any necessary adjustments.

Against the background of this thesis, it is important to note that BPR specifically envisages that information technology can only be used profitably if the critical business processes have been analysed and defined beforehand. At the same time, Davenport shows how the use of IT has a significant positive impact on process change. During BPR, numerous terms such as „*business process automation*“ have therefore become established (Dumas et al. 2018; van der Aalst et al. 2016). The concept predicts the complete redesign of processes intending to overcome function-oriented organisational forms and the consistent implementation of process-oriented organisational and operational systems, including IT-supported implementation, and assigns a key role to IS (van der Aalst et al. 2003, 2020b).

2.2.1.2 Kaizen - Continuous Improvement Process

Kaizen means „*improvement*“ translated from Japanese and belong to the evolutionary process optimisation approaches. In the literature, the term „*continuous improvement process*“ is often used synonymously. In this approach, employees are encouraged to make suggestions for improvement, which are immediately reviewed and implemented if successful (Bessant et al. 2001; Bhuiyan and Baghel 2005). The characteristics of Kaizen include, on the one hand, team, and employee orientation. On the other hand, are optimisation in small steps that can be implemented quickly and require the support of all employees. The basic idea is the daily implementation of improvements (Imai 1986; Soković et al. 2009).

Against the background of this thesis, it is important to note that Kaizen does not make any statements about aspects such as the role of IS, so it cannot replace BPM, but it can very well complement it (Dumas et al. 2018). Compared to the revolutionary method of BPR discussed before, the optimisation approach of Kaizen has the advantage that a higher level of acceptance and identification can be achieved through the intensive involvement of employees and the possibility of co-design, which strengthens the success of implementation (Hammer 2015; Jeston 2014). In the relevant literature, improvements in this context are related to all company processes „*from the product idea to production to sales, taking into account and supporting the customer*“. To successfully implement Kaizen in a company, not only a clear commitment by management is required, but also continuous training of all employees to make them recognise the potential for improvement and motivate them to implement new impulses for process improvement (Gadatsch 2010; vom Brocke and Mendling 2018; Weske 2007).

In Kaizen, standards and established processes must be questioned again and again at all levels of the company. This applies to individual workplaces, teamwork as well as to higher-level corporate processes, and existing IS. A variety of different instruments and concepts have been developed in the scientific community for the concrete implementation of Kaizen. In scientific publications, reference is often made to Deming's PDCA cycle in the form illustrated in Figure 2-5.

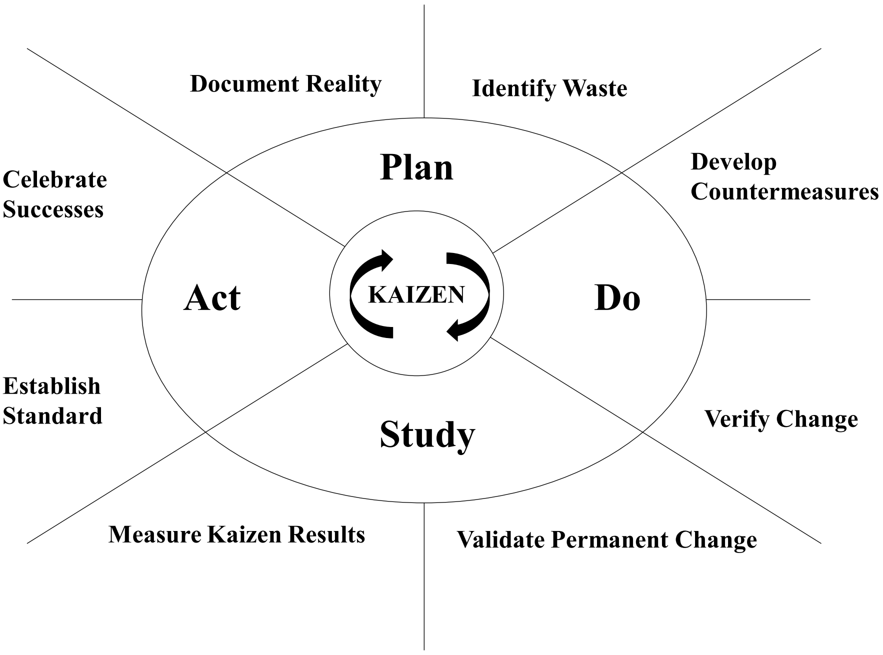

Figure 2-5: Kaizen - Continuous Improvement Model according to Deming (2018)

In the planning phase, the actual process of the individual work procedures is first analysed to develop an improvement plan. In the second phase, the employees concerned are familiarised with the plan and the planned improvements are implemented accordingly (George et al. 2007; Pyzdek and Keller 2014). Subsequently, in phases three and four, it is critically reviewed whether the planned improvement has occurred or not (George et al. 2007; Koch 2015). If the improvement has occurred, an attempt must be made to establish the improved workflow as a new standard in the company. If no improvement has occurred, the previous phases are gone through again.

According to the definition of Kaizen and with this to meet the requirement of continuous process improvement, the cycle must logically be triggered again at regular intervals even after the new work process has been successfully established. The types of practical elements and tools that can be used to implement Kaizen range from Kanban project management and the concept of just-in-time production to quality controls, small group work, and comprehensive productivity control.

In academic research, however, there seems to be no consensus on which methods can be clearly and inconsistently assigned to Kaizen. However, regardless of which tools or concepts are used, the identification of error causes and sources is the starting point of all activities in the Kaizen concept (Imai 1986). In the context of this work, it is important that in the Kaizen concept, employees are sensitised to repeatedly question their work processes independently from the customer's point of view (Koch 2015). To this end, all conceivable IS, or information technologies such as RPA or PM, among others, should be used to investigate problems that arise and actively make suggestions for improvement

(Grisold et al. 2021b; Kane et al. 2019; van Looy 2021). Managers, in turn, must take up these suggestions and initiate the improvement process.

2.2.1.3 Six Sigma

The main objective of Six Sigma is formulated as follows: „*To meet the customer's requirements completely and profitably*“ (George et al. 2007; Hoerl 2001). This means that critical processes (from the customer's point of view) must be identified and continuously improved to recognize and meet customer requirements. In its ideal form, Six Sigma is an integral part of the corporate culture and a common language. Six Sigma process improvement follows a structured approach in which root causes are identified through statistical analysis (Linderman et al. 2003). These root causes are then worked on. According to relevant literature, the standardized approach guarantees successful implementation as well as monitoring and ensuring sustainability.

The process optimisation method has its origins in quality management. The aim is to systematically identify and sustainably eliminate sources of error in products, services, and processes (Koch 2015; Niñerola et al. 2021). Statistical methods are used to operationalize quality. The strictly quantitative and systematic approach distinguishes Six Sigma from the other methods of process optimisation already presented in this thesis. More objective assessments of process quality are the maxim here. Quality is not considered from a technical point of view, but always from the customer's perspective (George et al. 2007; Muraliraj et al. 2018). The value of a service is to be increased for both internal and external customer groups.

In addition to quantitative measurements, this approach focuses on a strong analytical approach to solve even complex problems. To improve processes in the direction of Six Sigma quality in practical application, the phases „*Define*“, „*Measure*“, „*Analyse*“, „I*mprove*“ and „*Control*“ give a systematic approach and include statistical procedures and tests (de Mast and Lokkerbol 2012; George et al. 2007; Shafer and Moeller 2012). This method is based on the PDCA cycle described above and is also abbreviated as the DMAIC cycle, which is shown in Figure 2-6 for illustration.

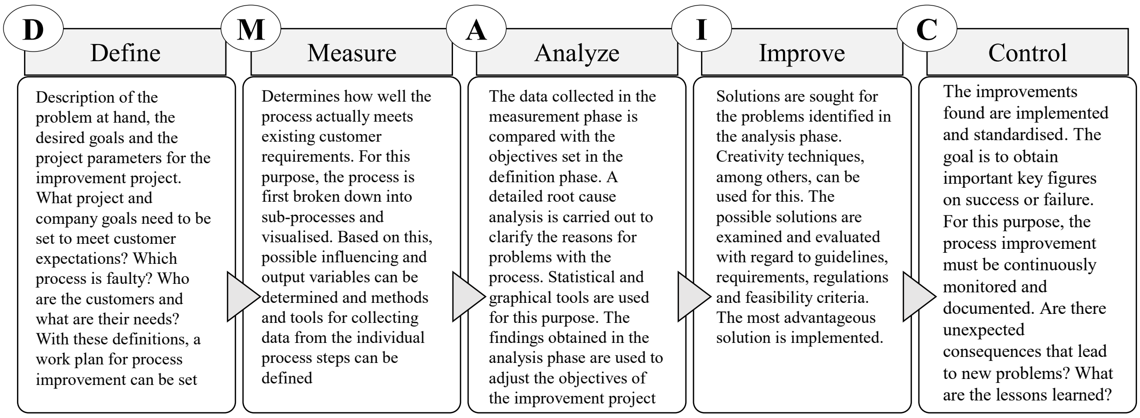

Figure 2-6: DMAIC-Methodology according to George et al. (2007) and Koch (2015)

In the Define and Measure Phase, the current process and the problem, as well as the targets are defined and documented. These phases also include the determination of the process performance (Pande 2000; Uluskan 2016). The Analyze Phase involves the analysis of the process in more detail using statistical measures, performance indicator as well as statistical tests (Uluskan 2016). After the identification of the verified reasons for the problems, possible solutions will be elaborated. Finally, the solution is introduced, and the process is monitored to ensure lasting improvement and sustainability (Koch 2015).

The basic evaluation of the Six Sigma method is judged very differently in the literature. Pande states that Six Sigma claims to reduce costs and at the same time increase customer satisfaction (Niñerola et al. 2021; Schroeder et al. 2008; Uluskan 2016). However, it must be noted that the strict enforcement of cost reductions has a direct positive impact on customer satisfaction, as the Six Sigma approach suggests customer orientation, but projects neglect exactly this in practical application (Koch 2015; Lande et al. 2016).

2.2.2 Target Function of Optimisation: Process Indicators

„*Indicators are figures that provide information about quantifiable facts in a condensed form in retrospect or determine them in a forward-looking manner. Individual isolated indicators are limited in their informative value. A combination of several indicators leads to a system of indicators in which the individual indicators are in a factually meaningful relationship to each other, complement or explain each other and are oriented towards a common overriding goal. When defining indicators, it should be noted that several variables can have a balancing effect.*“

Alpar et al. (1998)

Since the beginning of industrialisation, companies have been interested in key figures for the concise representation of quantifiable facts, especially in business IS. The relevant scientific literature defines key figures in a broad sense as absolute and relative rational numbers. They are used as a measure to characterize individual, quantifiable facts of a scientific, technical, social, or economic nature in virtually all areas of daily life.

Table 2-3: Reasons for process measurement according to Jung (2006) and van Looy and Shafagatova (2016)

Reason	Explanation
Definition of improvement potentials	Existing weak points can be uncovered, and possible solutions can be worked out
Evaluation of process changes	Checking whether the measures taken are successful and whether the intended goals can be achieved
Improvement of the basis for decision making	The data obtained improves the basis for decision-making
Motivation	Comparison of actual and target values provides feedback on success or failure and thus has a motivating effect
Participation in external and internal competition	Measurement enables positioning of processes in external and internal competition
Process evaluation	The current state of the process is quantified, and the target/actual comparison can be performed continuously

According to Horváth et al. (2015), true ratios must indicate the effectiveness or efficiency of a process in achieving a target value or plan. The original purpose of performance indicators was to represent a real problem abstractly in terms of numbers, but this has expanded considerably over time, as Table 2-3 shows. For a company, this means that it needs key figures to be able to separate the essential from the non-essential in its operations, to obtain a qualified selection of data, and to better understand the interdependencies (Baum et al. 2013; Horváth et al. 2015). Only the relation provides a meaningful key figure, which recognizes fundamental cause-effect relationships and can think and act purposefully as a control instrument. In addition to a control and monitoring function, key figures serve to operationalize goals, identify anomalies and changes, and define critical values as target values for individual areas (Gadatsch 2010; Krallmann et al. 2013). Used correctly, key figures support management at all levels of a company in the sense that they enable consistent monitoring and control of the strategic and operational goals set. In addition, the use of key figures can also improve the quality and speed of communication between all those involved, as the dynamics of a company can be presented, and even complex processes and issues can be made easy to understand (Alpar et al. 1998).

After the identification, modelling, and implementation phases, BPM requires tools for continuous measurement and analysis of process performance (Dumas et al. 2018). Such monitoring serves not only to record the status but also to identify deviations from targets so that necessary countermeasures can be initiated. With the measurement and evaluation of processes, the prerequisites for continuous process optimisation are created - accordingly, process performance indicators are the target function of process optimisation (Rosemann and vom Brocke 2015; vom Brocke and Rosemann 2015b).

In the previous chapter the prerequisites, and reasons for measuring processes were presented. Under the objective function of process optimisation presented here, the measurement of processes or process performance is understood in such a way that a reference to the process objectives is established via key figures (Dumas et al. 2018). Therefore, process-specific key figures are required for the measurement, which directly depicts the facts in processes and enables the process participants to adapt their activities regarding the changes. These described requirements correspond to process key figures, which are defined by Dumas et al. (2018) as follows: „*Each of the four performance dimensions [time, cost, quality, and flexibility] can be refined into a number of process performance measures (also called key performance indicators or KPIs). A process performance measure is a quantity that can be unambiguously determined for a given business process - assuming of course that the data to calculate this performance measure is available.*“

It should be noted that companies often have a primarily financial performance measurement. However, this is only suitable for business processes and BPM to a limited extent (Horváth et al. 2015; Niven 2002; Trkman 2010). To measure business processes comprehensively, performance measurement in the literature is based on the four dimensions of time, cost (Horváth et al. 2015; Dumas et al. 2018), quality (Dumas et al. 2018; Trkman 2010), and flexibility (Dumas et al. 2018; vom Brocke and Mendling 2018), which avoids one-sided financial management focused on short-term optimisation and promotes an orientation towards customer needs, considering future oriented and multidimensional KPI's (Dumas et al. 2018; Trkman 2010).

Measuring the success of business processes thus goes far beyond the financial evaluation of results by ensuring performance transparency in addition to financial transparency. By including the non-financial dimensions of quality, flexibility, and time the causes and drivers of the financial outcome measures are also captured (Dumas et al. 2018; vom Brocke and Mendling 2018; Rosemann and vom Brocke 2015). Process goals in these dimensions can be contradictory, e.g., there is often a conflict of goals between high process quality and fast availability (Horváth et al. 2015). In many cases, process-related goals are also not focused on maximisation or minimisation (Horváth et al. 2015; Trkman 2010). Thus, minimizing the resources used can lead to less quality and with this quality problem (Dumas et al. 2018; Rosemann and vom Brocke 2015).

The benefit of such performance measurement for the research questions posed in this thesis lies in the systematic identification of these conflicting goals. While one can focus on individual metrics, a plausible overall picture must emerge that relates to the particular business process to contextualize technology use through RPA or PM.

Therefore, both absolute and relative, quantitative, and qualitative, and input- and output- or impact-oriented metrics are relevant for performance measurement in this thesis. This has the advantage for the research questions that can be used for benchmarking purposes (vom Brocke and Mendling 2018). The quantitative indicators primarily used in the research presented here, which are based on clearly measurable factors, are easier to measure and transfer to business practice than qualitative indicators (Horváth et al. 2015; Dumas et al. 2018; Trkman 2010). For this purpose, the basic data required for the determination of the performance indicator must be available in Empire in a system-related manner, which has been done here. Suitable survey methods such as expert interviews, explicit surveys, and analyses of process protocols were used to this end.

2.3 Robotic Process Automation

The technology of Robotic Process Automation (RPA) takes place in this Chapter. As RPA is the main part of the thesis the main facts about this technology are explained in the following.

‘‘*RPA tools perform [if, then, else] statements on structured data, typically using a combination of user interface interactions, or by connecting to APIs to drive client servers, mainframes or HTML code. An RPA tool operates by mapping a process in the RPA tool language for the software robot to follow, with runtime allocated to execute the script by a control dashboard.*’’

Tornbohm and Dunie (2017)

Many automated systems have the following in common: they eliminate the human factor and improve precision, quality, and accuracy (Fung 2014; Güner et al. 2020). The first idea of how to automate processes using software dates to 1935, when computer scientist Alan Turing described how a systematic algorithm could make processes more effective

(Doguc 2022). More recently, a new type of automation has been introduced: virtual robots. These robots are used primarily in the service industry (Aguirre and Rodriguez 2017; D'Onofrio and Meinhardt 2020). Here, they assist humans with structured and rule-based processes, i.e., work that is normally considered routine, such as checking credit applications in financial institutions. When virtual robots take over a task previously performed by humans, using software that mimics the steps of a structured process, it is called robotic process automation (RPA) (Lacity et al. 2015). RPA is about using software to automate business processes. This software is often referred to as virtual or software robots. According to Lacity and Willcocks, RPA has three special characteristics compared to other automation tools that are mostly used in the BPM context (Lacity et al. 2015; Lacity and Willcocks 2016).

First, RPA is easy to configure and its implementation does not require programming skills. Second, RPA software is non-invasive, meaning that RPA software sits on top of existing systems and accesses the systems just as a human would. Third, in terms of governance, RPA is enterprise-ready, meaning IT requirements such as security, scalability, and auditability are easily met.

Thus, RPA can improve the capabilities of humans in performing cognitively demanding and unstructured tasks and, accordingly, create more value-added contributions to the optimisation of existing process structures. Furthermore, according to the literature RPA can be easily scaled up or down as needed and makes processes far more efficient and with a much lower error rate. As a result, cognitive capacity is freed up and people can spend their time on more cognitively demanding tasks. In addition, RPA can enable workers to take on tasks that are more demanding, more fulfilling, and better suited to their strengths. There are several software tools and providers available in the RPA space; in these development environments, the user runs, configures, tests, and manages the various processes and RPA-Bots.

As with any automation, RPA means replacing processes that were previously performed by humans, but this time by configuring robotic software to perform the tasks and between different systems. To do this, RPA provides the tools to automate rule-based, logical processes for users that involve well-defined and structured data with a deterministic set of output values. Moreover, the tasks are often repetitive and highly manual. RPA applications have been widely studied in business process research over the years, among others in the financial industry (Asatiani and Penttinen 2016), the public sector (Houy et al. 2019), and health care (Ratia et al. 2018). Most of these processes are back-office or support processes for services where the customer is not directly involved. In this context, the scientific debate has also shown that the most important measures for the success of

RPA are cost reduction (Ivančić et al. 2019; Willcocks et al. 2015), increase in process speed (Plattfaut 2019; Syed et al. 2020), error reduction (Penttinen et al. 2018; Plattfaut 2019), and increase in compliance (Enriquez et al. 2020; Willcocks et al. 2017).

There are two main differences between the implementation of RPA and the classic business automation attached to BPM. First, RPA programming can be learned in a few weeks; thus, extensive programming experience is not required (Asatiani et al. 2020; Flechsig et al. 2019; Mendling et al. 2018). This results in a cost-effective form of automation with a quick opportunity to achieve a high return on investment (Agostinelli et al. 2020; van der Aalst et al. 2018a). Second, RPA automates a process with an „*outside-in*“ approach, meaning it controls the computer at the user interface level, which does not interfere with the underlying computer systems (Flechsig et al. 2019; König et al. 2020; Mendling et al. 2018). These key differences provide a significant advantage over traditional BPM-based business automation, which follows an „*inside-out*“ approach (Agostinelli et al. 2020; König et al. 2020; van der Aalst et al. 2018a).

On the research side, many studies have examined the implementation of RPA in the most sub-domain business contexts and application domains (Ivančić et al. 2019; Syed et al. 2020). However, the focus has been on the measurable process performance achieved by RPA and the impact of RPA implementation on workplace design, but the necessary and sufficient integration performance has not been considered or design principles derived (König et al. 2020; Leno et al. 2021; van der Aalst et al. 2018a).

2.4 Process Mining

As Process Mining (PM) is the focus of this thesis, the background of this technology needs to be discussed in detail. Therefore, this section discusses the technology of PM in detail.

> „*Process mining aims to discover, monitor, and improve real processes by extracting knowledge from event logs readily available in today's information systems. Over the last decade there has been a spectacular growth of event data and process mining techniques have matured significantly. As a result, management trends related to process improvement and compliance can now benefit from process*“
>
> van der Aalst (2012)

In the idealised concept of process modelling, a model is created by the management level of an organisation, and this same model is then implemented by the people involved according to the model. In the real world, unfortunately, this is often not the case for various reasons (Leno et al. 2021; Martin et al. 2021). It often happens that there is no model for a process because it was simply created from given requirements and optimised through practical execution (Garcia et al. 2019). If there is a model for a process, it may not be formal, or there may be a good formal model but the execution of the process deviates from the specification (Leno et al. 2021; vom Brocke et al. 2021). These deviations may be an optimisation of the people executing the process or simply an arbitrary action that degrades the process. The goal of PM is to improve the above problems (Garcia et al. 2019; Martin et al. 2021).

On the one hand, it should allow the creation of models from the log data of the instantiation of the processes. On the other hand, PM also provides the ability to evaluate the execution of the processes by running the event logs against the model to prove conformance. Moreover, with the help of the data, it is now also possible to improve the given process model (Garcia et al. 2019; Leno et al. 2021).

PM thus stands for the analysis of processes based on execution logs, commonly titled event logs. The idea of using PM in the context of BPM was already introduced in the 1990s. PM provides information about end-to-end processes in organisations, which is why PM methods are now used in most phases of the BPM lifecycle, not only in the design phase, but also in the implementation, monitoring, and adaptation phases. An obvious example is the use of PM in the diagnosis phase (Leno et al. 2021). In the diagnostic phase, PM is used to identify opportunities for process improvement and to provide ideas for redesign. PM determines knowledge from event logs and graphically represents a business process in a process model. The process model identified reflects reality by describing the dependencies between activities performed by a user (vom Brocke et al. 2021). A technique designed to create visibility for the enterprise level (Garcia et al. 2019; Martin et al. 2021).

PM is still a very young but already well-established research discipline (vom Brocke et al. 2021). The development of PM in recent years, reinforced by the great interest of the research community, has led to a variety of PM techniques and tools (Leno et al. 2021). PM can be classified between computational intelligence and data mining on the technical side and process modelling and analysis, which originated in business, on the other side. Thus, according to the literature, PM also serves as an interface between traditional BPM and data mining (Martin et al. 2021).

However, if one follows the current research, PM is not to be considered as a type of data mining, but rather as an extension of it. PM is mainly applied to find process weaknesses and their causes. Process weaknesses can be categorized into process inefficiencies such as bottlenecks, rework, and changes, and deviations from a target process such as compliance violations. The technology can also be used to continuously measure the results of process improvement initiatives such as fundamental re-engineering and incremental improvement (Martin et al. 2021).

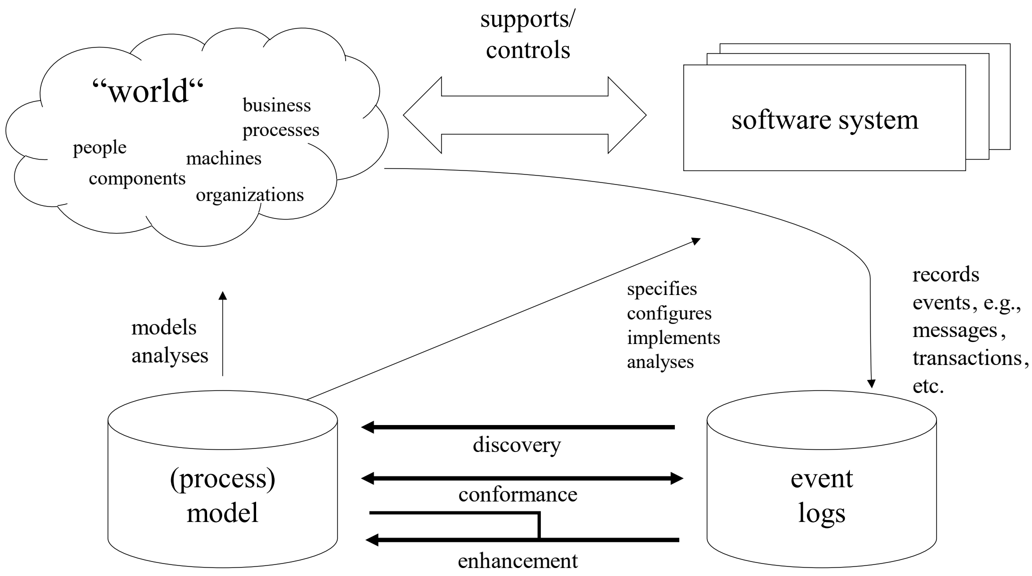

Figure 2-7: Types of Process Mining according to van der Aalst et al. (2012a)

In general, PM can be divided into three main application areas, which are also shown in Figure 2-7. According to the „*Process Mining Manifesto*" the basic applications of PM are process discovery, process conformance, and process enhancement (van der Aalst et al. 2012a)

In the PM application area of *Discovery*, event logs are used as input to build a process model from the information they contain. In the PM application area *Conformance*, the event logs are used to check the conformance of the actual process with the target process, e.g., to identify process deviations (Leno et al. 2021; van der Aalst et al. 2012a). The PM application area of *Enhancement* also uses event logs and existing process models as input. However, here optimisations are made as part of the process improvement process so that they can subsequently be reviewed and improved if necessary (van der Aalst et al. 2012a; vom Brocke et al. 2021). The three PM Application Areas are discussed in more detail below (Martin et al. 2021; van der Aalst et al. 2012a).

Process Discovery

Process discovery is one of the most difficult tasks in PM. Based on an event log, a process model is created to represent the behaviour observed in the event log. Process discovery deals with the control flow perspective, i.e., it focuses on the arrangement of activities (van der Aalst et al. 2012a). By definition, a process discovery algorithm is a function that maps an event log to a process model such that the model represents the behaviour observed in the event log (Leno et al. 2021; Martin et al. 2021). The definition basically leaves open which notation should be chosen for the visualisation but contrary to the widely used graphical specification languages like event driven process chains (EPC) the PM application systems mostly use Petri nets for visualisation.

Process Conformance

In process discovery, a process model was generated from an event log; process conformance, on the other hand, takes an event log and a process model as parameters and provides, as a result, a metric describing the overlap between the event log and the existing process model (Garcia et al. 2019; vom Brocke et al. 2021). The goal of process conformance is to identify both similarities and differences between modelled and observed behaviour (van der Aalst 2016). Analysis of the event log and process model provides global conformance metrics and local diagnostics. Once the inconsistencies are identified, they need to be looked at from two angles (van der Aalst 2016, 2018a).

- First, the process model is wrong and does not reflect reality. In this case, the process model should be improved (Leno et al. 2021; vom Brocke et al. 2021).
- Second, the cases deviate from the process model. Consequently, methods should be developed that lead to better control of the process and prevent deviant actions (van der Aalst et al. 2012a; vom Brocke et al. 2021). Such deviations should be allowed in the future and included in the model (Martin et al. 2021; van der Aalst 2016).

Process Enhancement

While process discovery deals solely with the control flow perspective, process enhancement attempts to use additional information from event logs to provide further perspectives on the underlying process (Garcia et al. 2019; Martin et al. 2021). This area of process enhancement is referred to as an extension (van der Aalst et al. 2012a; vom Brocke et al. 2021).

3 Research Strategy

3.1 Research Paradigms

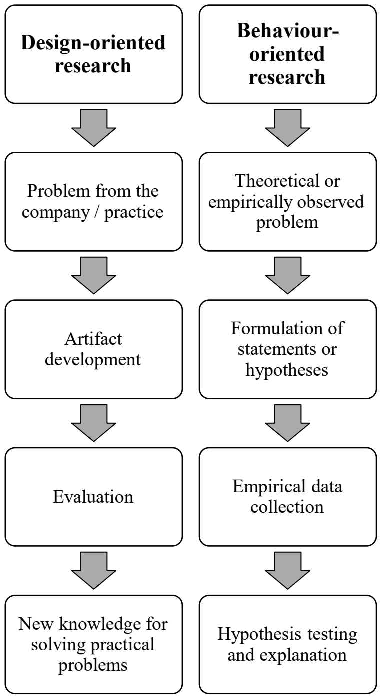

Figure 3-1: Differences between the two research paradigms according to Lehner and Zelewski (2007)

Business informatics sees itself as a „*real world*" science since phenomena of reality are studied (Recker 2021). Business informatics is also a formal science (Recker 2021; Wilde and Hess 2007), since the prediction, explanation, description and especially the design of IS requires the development and application of formal description procedures and theories (Becker et al. 2003; Hogrebe et al. 2010). Furthermore, business informatics is also a kind of engineering science since the design of IS or information services in particular requires a design systematics (Hogrebe et al. 2010; Wilde and Hess 2007). Within the scientific positioning of business informatics, deduction and induction are the two fundamental mechanisms of scientific knowledge (Becker et al. 2003; Recker 2021).

Deduction describes the process of deriving or logically inferring knowledge from certain observations or premises (Recker 2021; Wilde and Hess 2007). Deduction is classically associated with the direction from the general to the particular or from theory to empiricism (Recker 2021). Induction describes that a general statement is to be made with the help of an individual case. Thus, an attempt is made to derive conclusions for the general from an observed event (Wilde and Hess 2007).

The definition of the research goals considered in this thesis and the associated research approaches are based in the scientific discipline of business informatics as it is understood in particular in the German-speaking and Scandinavian regions (Österle et al. 2011; Peffers et al. 2012a; Recker 2021). In contrast to the more behaviour-oriented business informatics research from the North American region, a design-oriented research approach is used here.

Table 3-1: Research method spectrum of this thesis

Behaviour-oriented		Design-oriented	
Grounded Theory	RQ1	Design Science Research	RQ5
sentiment analysis	RQ2	Action research	RQ6
text mining	RQ3		
Case studies	RQ4		

The central object of consideration in this thesis are IS - their characteristics as socio-technical systems result from their components of people, tasks, and technology (Hevner et al. 2004). This thesis is based on both behavioural and design-oriented research approaches and thus belongs to the core paradigm of business informatics research, but also appropriates from IS research. Figure 3-1 shows a comparison in the progression of the two research paradigms while Table 3-1 gives an overview of the research methods in the research paradigms with the assignment to their respective use in this thesis.

To ensure an intersubjectively comprehensible approach to answering the research questions posed in Section 1.2, there are different research designs and research methods that can guide the research process, depending on the scientific discipline. To describe the research methodological design of this dissertation, the chapter is divided into two parts. Based on the research guiding questions from the first chapter and the presentation of the research goals pursued there, the first part in Section 3.1 explains the basics of design-oriented research and behaviour-oriented research - as a starting point for the methodological approach of this dissertation. Building on the research paradigms, the second part of this chapter in Section 3.2 explicates the methodological framework in the form of research methods used in this dissertation.

In design-oriented research, research goals can be divided into knowledge and design goals (Gregor and Hevner 2013; Hevner et al. 2004; vom Brocke and Maedche 2019). In this context, knowledge goals generate a comprehensive understanding in an application area, identify problems relevant to practice and derive research gaps from this (Beck et al. 2013; Peffers et al. 2012a). Design goals, on the other hand, pursue the development of solution-oriented artefacts of a real problem (Peffers et al. 2012a; vom Brocke and Maedche 2019). Derived from the identified research objective, the following sections present the research methods pursued, which are assigned to the research questions investigated and discussed.

3.1.1 Design-oriented Approaches

„*Design-oriented IS research is not a non-judgmental scientific discipline, rather it is normative, in a sense that the construction of artifacts is guided by the desire to yield a specific benefit and to satisfy certain objectives.*"

Österle et al. (2011)

The origins of design science research lie in engineering and differ from natural sciences. While behavioural science research, as part of natural sciences, describes the behaviour of objects and phenomena in the real world and analyses their interactions with each other, artificially created things - so-called artefacts - form the central research object of design-oriented research (Peffers et al. 2007). The design of artificial artefacts pursues the goal of solving real-world problems through new ideas, practices, technical capabilities, or products. Against the background of this work, the design-oriented approach in combination with behavioural science methods and tools promises a complementary research design for the set research objective and the research questions deduced. The behavioural science methods and tools used help to understand and analyse the problem, while the design-oriented approach generates a solution. In contrast to empirical and social science research (Hevner et al. 2004; Peffers et al. 2007), there is currently no generally accepted approach for a stringent implementation of design-oriented research (Hevner et al. 2004; Recker 2021).

3.1.2 Behaviouristic-oriented Approaches

Behavioural IS research, on the other hand, predominantly uses the methods of empirical social research (Nunamaker Jr et al. 1990; Österle et al. 2011). Theories and models are developed to explain or predict organisational and psychological phenomena in connection with the development and use of IS (Eisenhardt 1989; Gregor 2006). The focus is not on the innovative design of IS, but on the question of which influencing factors, character traits or experiences in dealing with technology cause a user to accept an information system or a business solution (Eisenhardt 1989; Nunamaker Jr et al. 1990; Recker 2015). The result of behavioural research is, therefore, usually a model that explains or predicts certain aspects of human behaviour or perception and their influence on IS and business solutions (Österle et al. 2011; Recker 2015). With the help of this approach, it is possible to analyse the needs of digital users. Behavioural research contributes to gaining intersubjectively comprehensible insights into the use and acceptance of IS and business solutions by users (Gregor 2006; Nunamaker Jr et al. 1990; Recker 2015).

3.2 Research Methods

This section summarises the research methods used in this dissertation project and the underlying publications. The attached Table 3-2 provides a clear overview. As explained in Chapter 1 and illustrated in particular in Figure 1-1, the research questions provide the frame of reference for the use of the associated research methods - these are also listed here in the appropriate order. Each research method was identified, selected, and used to answer the RQ1-6 derived from the research objective (Section 1.2) in terms of best possible stringency. A corresponding overview of the research methods used in relation to the frames of reference used in the thesis follows. In the following, the research methods Grounded Theory, Sentiment Analysis, Text Mining, Case Study Research, Design Science Research and Action Research are presented.

Table 3-2: Overview of the research methods used

RQ	Publication	Method	Section	Primary data	Secondary data	Area
RQ1	P1; P2	Grounded Theory	3.2.1	Interviews	Literature review; RPA development documents; RPA test logs	HF
RQ2	P3	Sentiment Analysis	3.2.2	Newspaper articles	Literature review	HF
RQ3	P4; P5	Text Mining	3.2.3	Job advertisements	Literature review	HF
RQ4	P6; P7; P8; P9; P10; P11	Case Study Research	3.2.4	Interviews	Literature review; RPA development documents; RPA test logs; PM event logs; PM execution logs; PM error logs	HT
RQ5	P12; P13	Design Science Research	3.2.5	Interviews	Literature review; RPA development documents; RPA test logs; PM event logs; PM execution logs; PM error logs	HT
RQ6	P14; P15	Action Research	3.2.6	Interviews	Literature review; RPA development documents; RPA test logs; PM event logs;	HT

					PM execution logs; PM error logs	

3.2.1 Grounded Theory

„*Grounded theory is not just a coding technique, but offers a comprehensive method of theory generation. In fact, one of the attractions of grounded theory for information systems researchers is the promise that it will help us to develop new theories of information systems phenomena - theories that are firmly grounded in empirical phenomena.*“

Urquhart et al. (2010).

If one follows what mentioned at the beginning, Grounded Theory research should be the first method used in a research process, since the goal is to develop new theories (Eisenhardt 1989; Glaser and Strauss 2017). Grounded Theory is a qualitative methodology used in the collection and analysis of data. Social scientists Barney Glaser and Anselm Strauss (2017) developed and implemented Grounded Theory to help sociologists systematically collect and analyse data in the process of theory development. Theory development in grounded theory research goes beyond the descriptive phase of qualitative research and interprets comprehensive data sources and extracts concepts to explain phenomena.

For research question RQ1, it is significant that data from many different perspectives are collected during theory building to find connections within a phenomenon. The result is an explanatory theory that expands the knowledge base of a phenomenon by uncovering fundamental features and structures (Glaser and Strauss 2017; Urquhart et al. 2010). The methodology aims to analyse patterns and connections of a core or central process that transcends time and place (Chun Tie et al. 2019). The juxtaposition of concepts creates the possibility of grouping different data sources under one representation, making Grounded Theory methodology a combination of data collection, analysis, and theory building (Chun Tie et al. 2019; Glaser and Strauss 2017).

In P1, a Grounded Theory study was conducted with reference to RQ1 to identify the drivers and barriers to the adoption and use of innovative process technologies as summarised in Figure 3-2. P1 relies quite rigorously on extensive data and derivative contributions to theories of technology adoption in using this methodology, six interviews served as the primary data source, using observations and literature as a means of triangulating the study (Charmaz 2014; Chun Tie et al. 2019). The interview data was collected using an interview protocol and heuristically coded independently by the authors using software specifically designed for Grounded Theory.

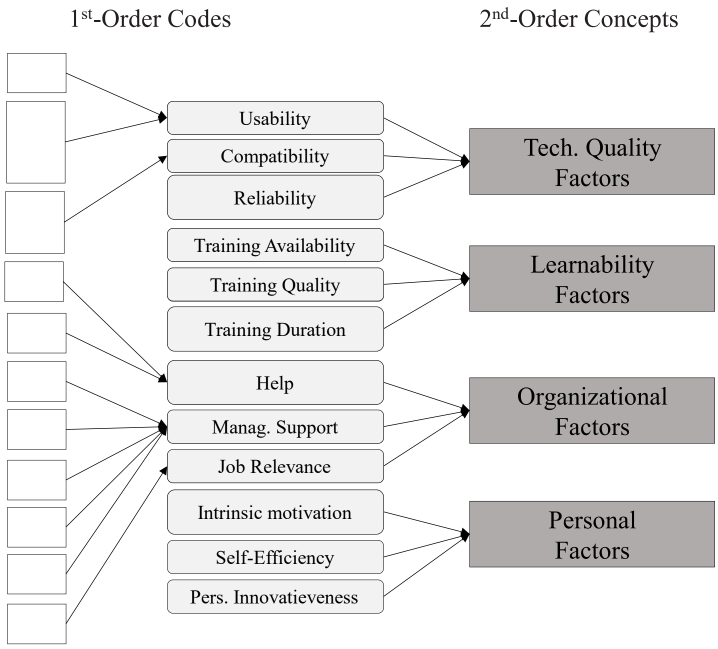

Figure 3-2: Constructs that emerged in P3 through the application of Grounded Theory

P2 explores the potential barriers and drivers of end-user adoption of RPA technology in particularly sensitive process areas. For this purpose, the grounded theory method was used within a health authority to determine which factors influence the intention to use and the benefits of such solutions. Figure 3-3 shows the research process of the grounded theory method used in P2.

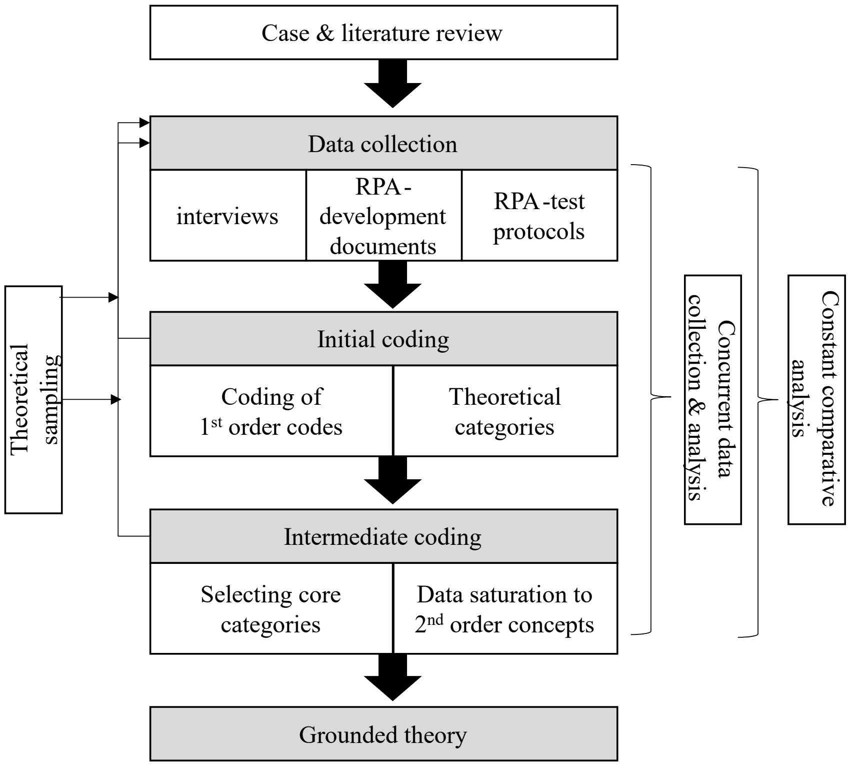

Figure 3-3: Research process of the grounded theory method used in P2.

3.2.2 Sentiment Analysis

> „*Since early 2000, sentiment analysis has grown to be one of the most active research areas in natural language processing. It is also widely studied in data mining, Web mining, and text mining. In fact, it has spread from computer science to management sciences and social sciences due to its importance to business and society as a whole.*"
>
> Liu (2010)

The field of sentiment analysis has recently received much attention from researchers. In addition to the term sentiment analysis, other terms have emerged in the scientific community to describe slightly different tasks, e.g., opinion mining, sentiment mining, subjectivity analysis, affect analysis, emotion analysis, review mining, etc (Chintalapudi et al. 2021; Ravi and Ravi 2015).

Much of the early research on textual information processing still focused on information extraction and retrieval, e.g., information retrieval, text classification or text clustering. Vinodhini and Chandrasekaran (2012) cite three factors that have led to a huge increase in sentiment analysis research activities in recent years:

1) The rise of machine learning methods in natural language processing and information retrieval
2) The availability of datasets on which machine learning algorithms can be trained, due to the development of the internet
3) The realisation of the commercial and intelligence applications that this field offers

Especially with the increasing spread of internet-based platforms and social media, the sentiment analysis has arisen out of this necessity (Liu 2010; Vinodhini and Chandrasekaran 2012)

Vinodhini and Chandrasekaran (2012) explain that sentiment analysis is concerned with the computational treatment of opinions, sentiments, and subjectivity in texts. In natural language processing, sentiment analysis includes various aspects that deal with how information about emotions, attitudes, perspectives, and social identities are conveyed in language (Pang and Lee 2008; Ravi and Ravi 2015). The procedure of an opinion mining analysis is like that of text mining, which is basically divided into data acquisition, pre-processing and knowledge acquisition (Liu and Zhang 2012). As with web mining, data collection is done using web crawlers, hypertext (HTML) parsers or special application programming interface (API) provided by individual websites as an interface. As with text mining, continuous texts are also analysed in opinion mining (Liu 2010; Zhang et al. 2018). This means that, again, unstructured texts serve as the data source. In sentiment analysis, the knowledge acquisition part represents the classification of opinion orientation (Pang and Lee 2008; Schumaker et al. 2012).

In P2, a sentiment analysis of the public perception of RPA in the light of different theories and a comparison with other technologies was exercised and this is how RQ2 was addressed. The applied methodology allows for a deeper understanding of the public perception of RPA in relation to this thesis and the related research question, which allows for a deconstruction and conclusion on possible success and failure factors of RPA projects. Building on these observations, P2 aims to use sentiment analysis to develop such a deeper understanding of public perceptions of RPA and to pursue the research goals. To this end, P2 analyses how public perceptions of RPA evolve over time in a descriptive manner. For this purpose, the methodology of sentiment analysis was applied to several published news articles on the topic of RPA. It was thus possible, against the background of this thesis, to assess the quantity of news articles over time, the sentiment of these news articles in terms of polarity, the sentiment of these news articles in terms of subjectivity or objectivity and the predominant themes using topic modelling. Secondly, in P2, the results of this descriptive analysis were classified and compared with existing theories of the technology life cycle, with previous analyses of the life cycles of other technologies and with academic literature on RPA.

3.2.3 Text Mining

„*The benefit of text mining comes with the large amount of valuable information latent in texts which is not available in classical structured data formats for various reasons: text has always been the default way of storing information for hundreds of years, and mainly time, personal and cost contraints prohibit us from bringing texts into well structured formats*"

Feinerer et al. (2008)

In contrast to data mining, text mining deals with the analysis of unstructured texts. A fundamental problem in the automated analysis of text lies in its unstructured nature (Allahyari et al. 2017; Feinerer et al. 2008). To be able to process such data, it is necessary to prepare the data material. The goal is to convert the data into a clearly structured schema that remains the same across all data sets. For the procedure of a text mining analysis, the following steps according to Aggarwal and Zhai (2012) , Feldman and Sanger (2008) , and Manning et al. (2009) are shown in Figure 3-4.

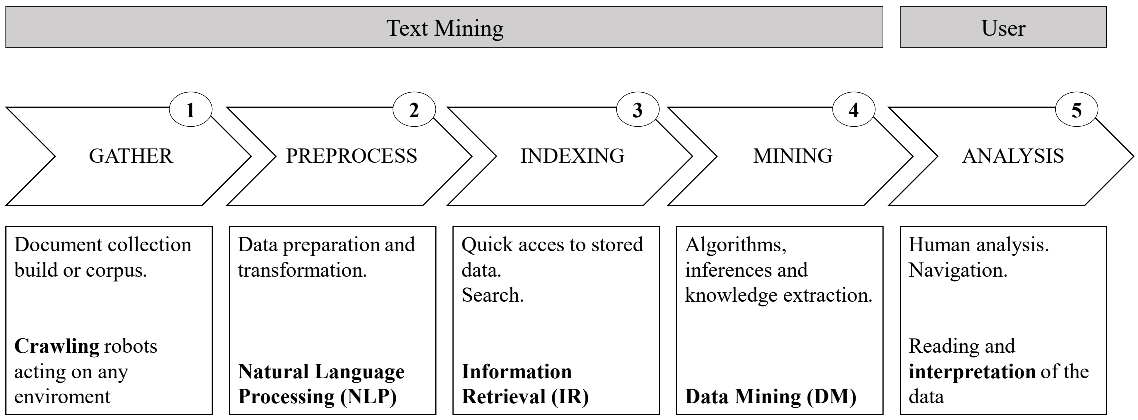

Figure 3-4: Steps of text mining Process

The first step is to set a goal whose achievement is measurable (Feinerer et al. 2008; Feldman and Sanger 2008). The second step is to identify a set of relevant documents based on the objective (Feinerer et al. 2008; Feldman and Sanger 2008). Once a set of documents is available, they must be converted into a structured form in step three. To do this, various features are extracted from the text and all documents are brought into a uniform form. The methods most used here are tokenisation, part-of-speech tagging and lemmatisation (Feinerer et al. 2008; Feldman and Sanger 2008). Tokenisation attempts to recognise words from a continuous text. Part-of-speech tagging is the assignment of words and punctuation marks in a text to word types (Feinerer et al. 2008; Manning et al. 2009). For this purpose, both the definition of the word and the context are considered. Lemmatisation attempts to convert all words into their basic grammatical form. After this pre-processing, the actual analysis can take place in step four. The methods used here correspond largely to those of data mining (Feinerer et al. 2008; Manning et al. 2009). In step five, the results obtained through the analysis are interpreted and evaluated for their validity (Feldman and Sanger 2008; Manning et al. 2009).

For P3, this thesis summarise a snapshot of current digitisation-related job advertisements and the drain contained IT-related skills and abilities in Germany by applying text mining algorithms and statistical analysis to 800 job advertisements crawled on the internet. Regularly crawling the job posting website for several months to obtain all job postings that match the search term *digi**. These search results therefore contain words like digital, digitise and digitisation in different meanings and contexts. In P4, this thesis investigate the extent to which the Covid-19 pandemic has affected the supply of jobs in the public sector in Germany and target IT resources and IT-relevant skills and competencies. The use of text mining methods, especially topic modelling, as shown for P3 in Figure 3-5, makes it possible to answer RQ3 against the background of the stacked research objectives.

The collection of raw data in P3-4 on job vacancies was followed by several steps of data processing and qualitative iteration of data cleaning, in which this thesis discussed, categorised, and clustered the data characteristics. In P3, this thesis first reviewed the raw crawled job ad texts to discuss the overall data set and identify typical recurring content. From this, four main categories were formed for coding all the crawled job advertisements.

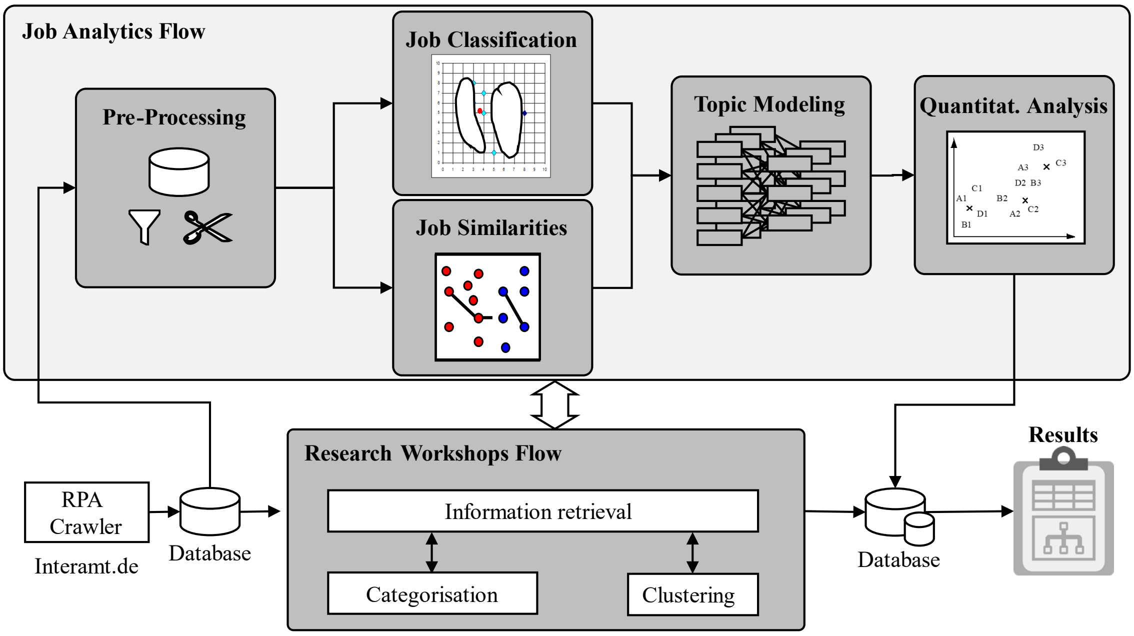

Figure 3-5: P3 research process and procedure

In the research process of P3-4, analysis was required to extract structured information from partially structured or unstructured job advertisements. This included correcting missing values, normalising, and discretising job ads, and pre-processing the text to remove and replace embedded characters that could affect the content of the analysis (Feinerer et al. 2008; Feldman and Sanger 2008). Elimination of irrelevant stop words was also done as part of the pre-processing (Feinerer et al. 2008; Feldman and Sanger 2008). Our goal was to reduce the text corpus by terms that occur frequently but do not contribute to the meaningfulness. In the German job advertisements, these are mainly articles, pronouns, and some adjectives. For this processing step, an extensive stop word list was created that covers about 40-50% of the entire text content.

In P3, algorithms for categorisation were applied in each case. The research design considered k-nearest neighbours' algorithm and Naive-Bayes, which have been intensively discussed in the literature (Islam et al. 2007; Rosa and Ebecken 2003). Both variants were investigated for their suitability for job classification. The probabilistic classifiers group terms of equal frequency together, as queries otherwise only provide general results. By grouping, the classifier has an average frequency of occurrence and can thus be considered a suitable attribute for the individual class descriptions.

Topic modelling was also used in P3-P4, a method that has become increasingly popular in research in recent years (Allahyari et al. 2017; Jelodar et al. 2019). Topic modelling describes a group of statistical procedures that allow inferences to be made about the thematic structure of the individual job ad in the ad collection (Debortoli et al. 2016). The algorithms also determine the thematic relevance of the respective job ads (Jelodar et al.

2019; Murawski and Bick 2017). In contrast to keyword tools, the topic modelling used does not only reveal keywords and topics that appear in the job ads. Rather, it reveals the semantic relevance and context of the words and phrases (Murawski and Bick 2017; Schmiedel et al. 2019).

In this step, P3-P4 apply the Latent Dirichlet Allocation (LDA) topic modelling technique to domain-centred job data along with other feature engineering methods to define the features of a job advertisement and a desired job profile. The LDA algorithm was chosen because it can generate higher dimensional topics than other common algorithms (Blei 2012; Jelodar et al. 2019; Wallach et al. 2009). To this end, text mining algorithms are used to analyse various HR needs - via job advertisements - for their relevant content contribution to the concept of digitisation through a constructive mechanism (Debortoli et al. 2016; Wallach et al. 2009). This has likewise enabled to gain in-depth understanding of the benefit intentions, the skill and competence profile of the users of PM and RPA technology.

3.2.4 Case Study Research

„*Interpretive research can help IS researchers to understand human thought and action in social and organizational contexts; it has the potential to produce deep insights into information systems phenomena including the management of information systems and information systems development*“

Klein and Myers (1999)

„*The strengths of qualitative methods relate primarily to the understanding of a system's specific context of development and use, the ways developers and users perceive the system, and the processes by which the system is accepted, rejected, or adapted to a particular setting. We believe that these are crucial issues for the development, implementation, and evaluation of computer information systems.*

Kaplan and Maxwell (2005)

In terms of questions, Yin (2018) states that research that addresses „*how*“ and „*why*“ is explanatory and that case studies, as opposed to quantitative methods, are the preferred strategy for asking such questions. The relevant literature confirms that the decision to focus on qualitative case studies stems from the fact that this design is chosen precisely because research is interested in insights, discoveries, and interpretations rather than hypothesis testing (Kaplan and Maxwell 2005; Myers and Avison 2002; Pereira et al. 2013; Yin 2018). Moreover, case studies are chosen when the researcher has little control over events and when the focus of the research is on a contemporary phenomenon in a real-world context (Yin 2018). Case study research copes with the technically different situation where there are many more variables of interest than data points, and usually relies on multiple sources of evidence, bringing the data together in a triangulating way (Myers and Avison 2002).

In summary, the literature usually cites three reasons why case study research is a useful research strategy for business informatics. First, the case study allows the researcher to study invasive species in a natural setting. Secondly, the case study enables the researcher to learn about the state of the art. Thirdly, the case study enables the researcher to develop theories based on practical experience (Flick et al. 2004; Pereira et al. 2013; Yin 2018). According to Yin (2018) and Flick et al. (2004) there are three basic types of case studies, depending on their purpose:

1. Intrinsic case study: In this type of study, the case is chosen because of its uniqueness or exceptionality. The aim is to better understand a particular case rather than to understand or test a theory or develop a new theoretical explanation.

2. Instrumental case study: In this type of case study, the case is of secondary importance. The aim is to help the researcher better understand an external theoretical question or problem.

3. Collective case study: The study of several instrumental case studies is the main feature of this type.

The case studies conducted in P6 and P8-P11 belonged to the „*Intrinsic case studies*“ as the aim was to better understand the intrinsic aspects of an individual case, i.e., the main characteristics of the case according to the literature or the actions taken. The case study conducted in P7 belongs to the „*instrumental case studies*“ as it was used to better understand an underlying theory. Table 3-3 shows which case studies were used in this thesis and how exactly they are composed in terms of content. The table is broken down by the publication number (see Section 1.2 in chapter 1), the number of case studies and case study partners investigated, the number of data collected (mainly interviews), the type of case study according to the previous explanations and the case design.

Table 3-3: Overview of the case study research included in this thesis

Publication	Number of case studies	Quantity of surveys	Case Type	Case Design
P6	3	19	Intrinsic	Multiple Case
P7	1	30	Instrumental	Single Case
P8	1	18	Intrinsic	Single Case

P9	5	5	Intrinsic	Multiple Case
P10	1	41	Intrinsic	Single Case
P11	11	36	Intrinsic	Multiple Case

Recker (2021) compares the single case design with the multiple case design depending on the research objective. According to this, a single case study is suitable if:

– Firstly, it is an informative case, i.e., a situation that was not previously accessible to scientific investigation; this was the case in P8 and P10. In P10, case study research was used to investigate the transformation and adaptation of specific planning tools from the ideas of a digital twin to realise an integrated business process in a specific public administration environment. P8 analysed the real-world utility of data anonymisation techniques for PM and the assessment of their suitability for privacy protection in the specific context of healthcare.

– Secondly, it is a critical case to test a well-formulated theory, which applies to P7. In P7 a case study was used to show how the concept of „*flexibility by design*“ theory can be influenced by RPA and how exactly flexibility in process execution can be achieved with it.

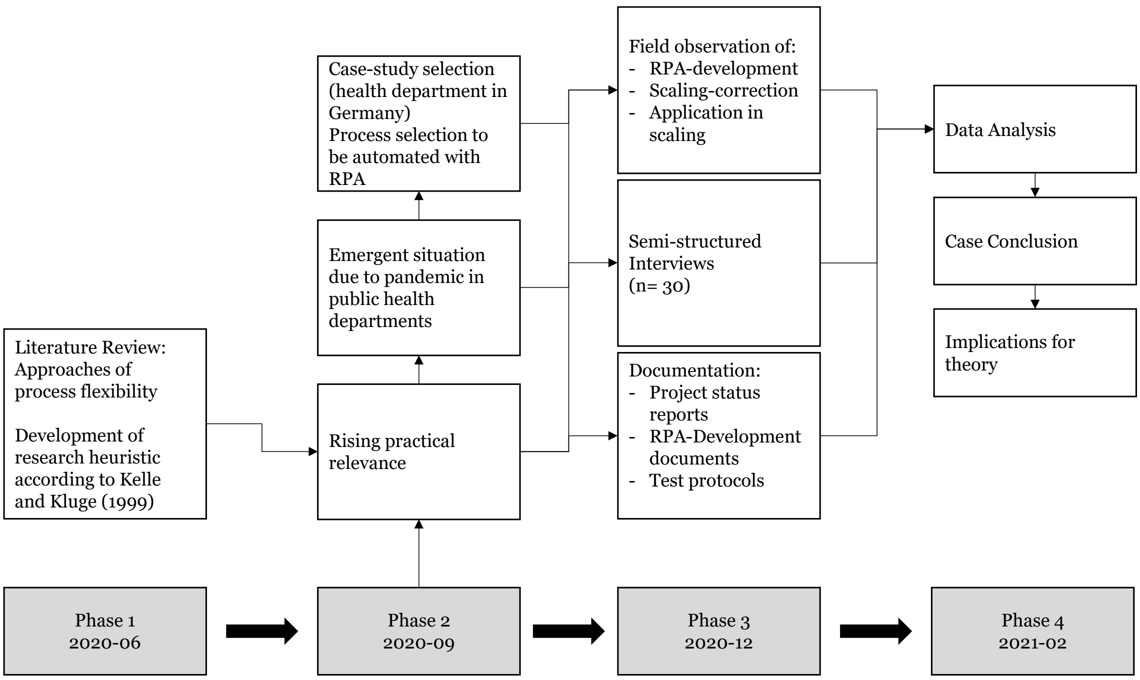

Figure 3-6: Case Study Research Process of P7

On the other hand, a multiple case design is used when the aim of the research is to describe, theorise or test the theory or hypothesis (Yin 2018). For this purpose, against the background of chapter 1.2, this thesis uses P6, P9 and P11. Figure 3-6 shows how the case study research process was conducted in P9. In P9, multiple case study research was conducted to investigate the possibility of autonomous development of process automation by the healthcare end-user. To this end, several qualitative case studies were conducted to understand what factors influence the ease of use, intention to use and usefulness of existing RPA solutions.

Regarding the research objective derived in chapter 1.2, the research methodology is particularly well suited in the form of both single study and multi case study, as the method can make a valuable contribution to the progress of knowledge of RQ4 - especially because it is explicitly suitable for testing hypotheses in the field

3.2.5 Design Science Research

„*Since design is both a noun and a verb, design is both a product and a process. As a product, a design is a plan of something to be done or produced; as a process, to design is to so plan and proportion the parts of a machine or structure that all requirements will be satisfied. Thus a design theory must have two aspects one dealing with the product and one dealing with the process of design.*“

Walls et al. (1992)

Design science research (DSR), as already presented in detail in Section 3.1.1, is one of the two important paradigms of contemporary IS research.

Design science develops and evaluates IT artefacts to solve identified organisational problems. DSR projects contribute to theory by generating two types of knowledge: descriptive and prescriptive knowledge. Descriptive knowledge is the „*what*“ knowledge about natural phenomena and the laws and regularities between phenomena, while prescriptive knowledge explains the „*how*“ of man-made artefacts (Beck et al. 2013).

DSR has been conducted in many IS research contexts, e.g., digital platforms (Costa et al. 2020), supply-chains (Wagner and Thakur-Weigold 2018), electronic health (Beinke et al. 2019). Over time, different methodologies for conducting DSR have been developed (Gregor et al. 2020). One of the most established conceptualisations of DSR in research is the framework proposed by Hevner et al (2004), as shown in Figure 3-7.

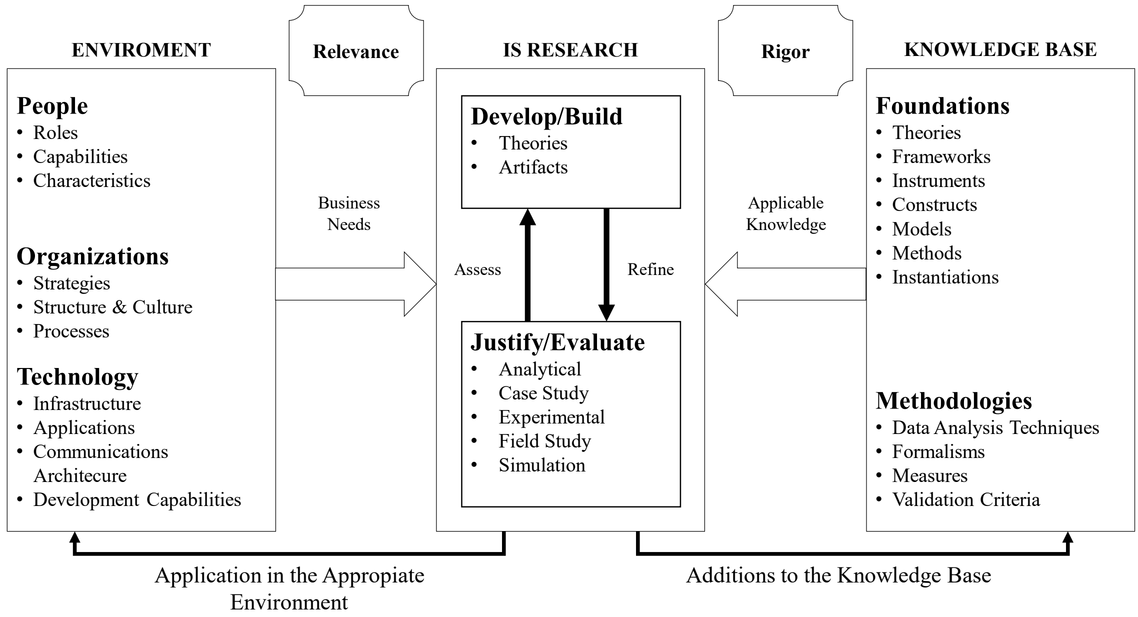

Figure 3-7: Information Systems Research Framework according to Hevner et al. (2004)

Hevner et al. (2004) propose a distinction between relevance, rigour, and design cycles relevant to the conduct of DSR research. The rigour cycle is used to derive findings from the scientific literature and enable researchers to apply them in the research context. The relevance cycles help to ensure the relevance of the DSR project by anchoring it in a practical setting. Using qualitative or quantitative research approaches, researchers identify the needs of the business community in a particular area. Building on the findings from science and practice, DSR projects then iteratively create and evaluate artefacts in design cycles. Many aspects of the framework are reflected in DSR methods (Peffers et al. 2012a).

One widely cited method is that of Peffers et al. (2012a), which the authors call the DSR Method (DSRM). It applies Hevner's framework by emphasising iterative design and evaluation cycles. In addition, like Hevner's relevance cycle, the DSRM encourages researchers to identify their problems in practice. The DSRM adds value by putting the phases in a logical order (Peffers et al. 2012a; vom Brocke and Maedche 2019).

As a result of academic discourse, the term DSR has been used consistently in the literature since 2011. Gregor et al. (2020) compiled various characteristics of DSR from different sources in 2020. According to them, the goal of DSR is the development of solutions to human-defined problems and the closely related pursuit of a practical benefit for the user of the solution. Practical utility often motivates the requirement for practical relevance of the problem as another important feature. This is also an important feature of DSR. In addition, the emergence of new knowledge while designing and applying the artefact is undisputed. Another feature of DSR is its normativity, Österle et al. (2011)

describe design-oriented business informatics as a normative discipline in the much-acclaimed Memorandum of Business Informatics.

Following the dichotomy of business informatics already mentioned in Section 3.1, there has long been disagreement about the exact object of an artefact. The basic scientific consensus in IS research has defined four types of artefacts (Peffers et al. 2012a; Davison et al. 2004; Baskerville 1999; Recker 2021): Algorithms and procedures, instantiations, implementations, and prototypes. Pfeffers (2012a) took this up and identified two further types of artefacts by dividing the artefact type methods into algorithms and methods and the artefact type models into frameworks and models.

In P12, following Peffers et al. (2012a), three evaluation cycles were used, implementing three different evaluation types. Since methods can be defined as artefacts of design science, in P12 PM was added to the existing Six Sigma method. This was done by designing a separate method artefact that, in the spirit of RQ5, enables the implantation, application and use of PM counter-knowledge. Figure 3-8 illustrates this research process of P12 using the DSR grid framework according to vom Brocke and Maedche (2019b).

Design Science Research Project Grid: *Process Mining for Six Sigma*

Problem Data analysis limitations of classical Six Sigma approach. Big data sources and digital process traces are typically not targeted and utilised during Six Sigma projects.	**Research Process** After developing a method how to combine Six Sigma and Process Mining (PM), three evaluation cycles are executed to refine and further develop its validity and usability.	**Solution** A method including a set of proposed situations and scenarios how Process Mining can be used in all five DMAIC phases of Six Sigma projects.
Input Knowledge Current body of knowledge how classical Six Sigma projects use data analysis methods and the DMAIC approach. PM theory and current PM software capabilities.	**Concepts** Process Mining, Six Sigma, DMAIC, Big Data Analytics, Data Mining.	**Output Knowledge** Designed and evaluated method how to use PM in Six Sigma projects, including recommendations for the potential applicability of three types of PM in each DMAIC phase.

Figure 3-8: The DSR Grid framework of P12

P12 uses two cycles of relevance in the DSR context with the technical experiment and case study and one cycle of rigour with the expert workshop. In view of the underlying research objective of this thesis and the link to RQ5, three design cycles were conducted during the research project that generated changes and design knowledge on the details of the method artefact against the background of the application of PM in the Six Sigma context.

In P13, a model (and the underlying algorithm) is the artefact to be developed using DSR. For this purpose, a four-stage DSR approach is used. Structured multi-stage qualitative expert interviews are conducted within the DSR cycles with the aim of model building. The resulting model generates a systematic approach to the suitability analysis of business processes for RPA. In terms of the underlying research objective of the thesis and the link to RQ5, it considers the economic, technological and process criteria and enables a subsequent categorisation and prioritisation. Figure 3-9 describes the four iterations of the DSR build assessment process in P13.

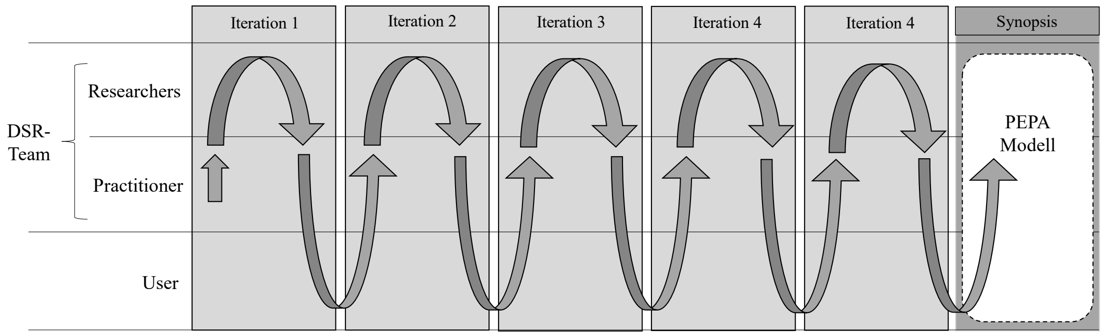

Figure 3-9: DSR build-evaluation process in P13

3.2.6 Action Research

„*The domain of information systems action research is clearest where the human organization interacts with information systems. The domain must also be one where a contingent value can be attached to the findings. The research addresses a specific social setting, although it will generate knowledge that enhances the development of general theory. Action research aims for an understanding of a complex human process rather than prescribing a universal social law*"

Baskerville 1999

Action research is based on the idea that complex phenomena can be effectively penetrated by changing them and studying their effects (Kemmis 2014; Peffers et al. 2007). The focus is thus on intervention that addresses concrete problems and aims to bring about change, but without neglecting the acquisition of theoretical knowledge (Davison et al. 2004; Sein et al. 2011). This research method is a way to actively intervene in the research and solve problems, like the case study research from Section 3.2.3, without being accused of not being able to distinguish direct influences (Kemmis 2014; Peffers et al. 2007). Action research is usually conducted in close collaboration between researchers and subjects in several iterations (Kemmis 2014). It is based on shared learning between the researcher and the subjects involved (Baskerville 1999; Davison et al. 2004; Kemmis 2014).

A cyclical process is followed, as Figure 3-9 and Figure 3-10 shows: Potential problems are identified by gathering information, often through interviews (Kemmis 2014; Peffers et al. 2007). Then an attempt is made to question these problems discursively and finally to overcome them. For this purpose, alternative courses of action are constantly developed and compiled in an action plan (Baskerville and Wood-Harper 1996; Peffers et al. 2007). This procedure is then tested. This is followed by a survey phase again, which leads to an adjustment of the action plan if necessary (Davison et al. 2004; Peffers et al. 2007). Against the background of this thesis and the research objective listed in chapter 1.2, there are two features that make the use of this research method seem reasonable, because the two main premises of action research are basically fulfilled by the postulated research objective (Kemmis 2014; Peffers et al. 2007): Firstly, the intention to bring about change in an area using information technology, and secondly, the fundamental aim of generating knowledge about it.

Due to the intervention in practice and the possible development of concrete solutions to problems, action research is a research process that differs significantly from, for example, case study research in Section 3.2.3. In contrast to the methodology of case study research, where a researcher as an uninvolved observer tries to get a picture of reality, the action researcher consciously exerts influence on the field (Baskerville and Wood-Harper 1996; Davison et al. 2004; Kemmis 2014). This influence can range from participant observation to active intervention in the actions of the participants (Peffers et al. 2007; Sein et al. 2011). Thus, as a rule, in the context of action research, the planning, design and implementation of the action as well as the reflection are carried out together (Davison et al. 2004; Kock 2004; Sein et al. 2011).

In P14, action research was used to better understand what problems PM has in implementing and using it for audit. Action research is defined in P14 as a problem- and solution-oriented method to initiate sustainable change that focuses on both theory and practice. P14 aims to use action research to apply and add to existing knowledge, in this case the barriers and inherent problems PM poses for use and process management in the audit context. This was done through an iterative process of promoting relevance in a situated practice through a six-month collaboration with an IT audit firm. The authors conducted participant observations and ad hoc conversations to collectively frame the problem. The research activities are explained in more detail in Figure 3-10.

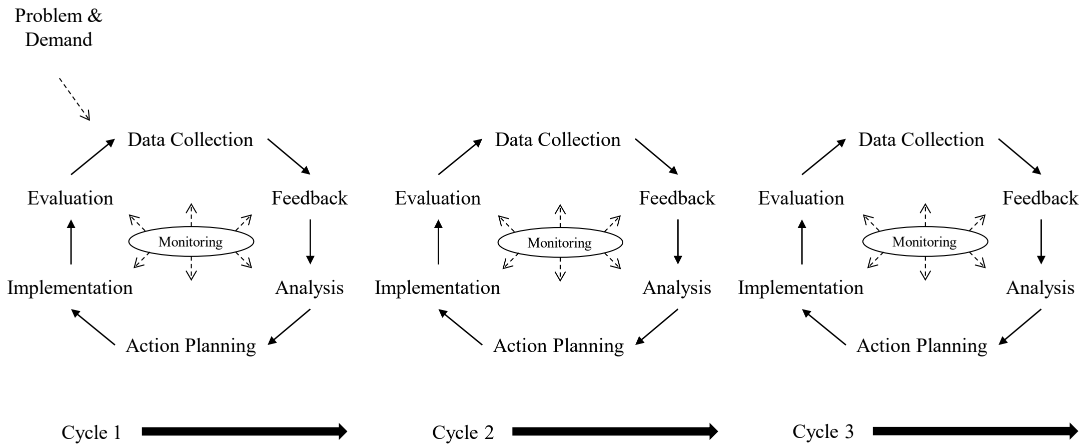

Figure 3-10: Action research process of P14

Three problem-solving cycles involving staff and managers were conducted to ensure relevance and shared learning from the situation.

P15 applies action research to analyse the applicability of RPA in the public sector. The related research process is shown abstractly in Figure 3-11. By training staff in RPA and disseminating the methods and tools, this thesis influences the progress of RPA development. The authors of P15 actively accompany the RPA development and are integrated into the project team. They develop their own solutions as well as joint solutions with the members of the development team. The development process is captured through various documentation such as the RPA execution logs, project status reports, RPA solution development histories and project documentation. The data collection reflects the metaphase of the action research in P15 and is continuously realised within the research cycles. Once an RPA solution is available, the development process is reflected through interviews with staff and data collection is completed accordingly.

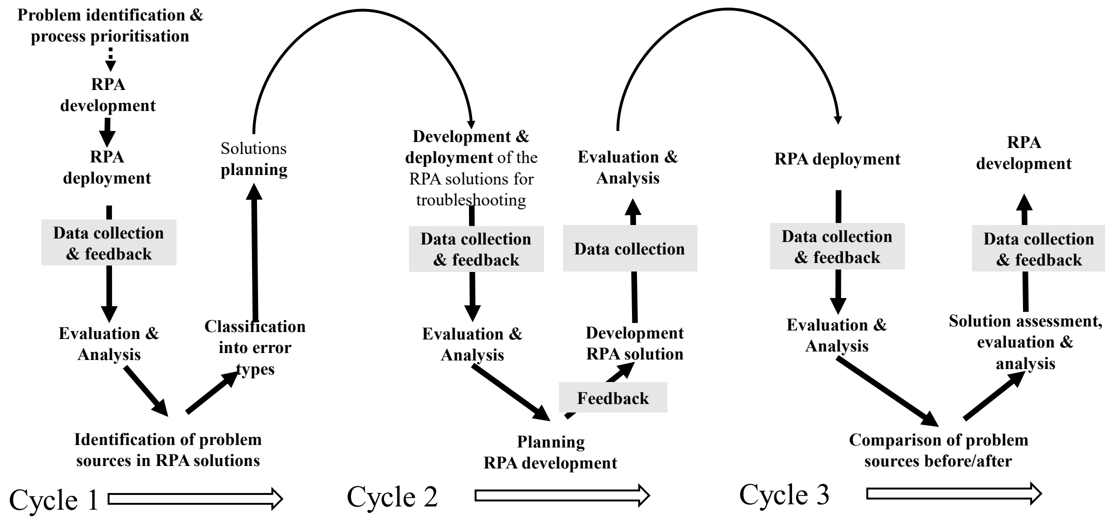

Figure 3-11: Action research process of P15

The results thus obtained in P14 and P15 are not understood as isolated, static information, but as dynamic moments within a change process. The use of action research aims, therefore, to make action contexts and patterns of interpretation clear and not, as in traditional research, to test hypotheses/theories about relationship contexts between independent and dependent variables. In the context of this thesis and chapter 1.2, it is important to note that the hypotheses formulated by RQ1-3 are also presented here as alternatives for action in the change process regarding specific design goals. The analysis and interpretation of these formed hypotheses takes place in discussion with the stakeholders and possible results are iteratively recouped in the discourse with the research subjects. This is done in order to check the validity of the hypotheses with regard to their orientation and, if necessary, to gain new insights. Action research as such is therefore particularly suitable for the last part of the HT proposed here in this thesis (Kemmis 2014; Sein et al. 2011).

4 Main Results

The research findings of this thesis are presented in the following sections. They are structured according to the six RQs in Section 1 (especially represented in Figure 1-2).

First, a grounded theory is used in Section 4.1 to develop a theory for the RQ1 „*What are the drivers and barriers for RPA and PM adoption*“. Concerning the research question, P1 aims to provide a deeper perspective and understanding of the drivers and barriers to the adoption and use of innovative process technologies. P2 investigates, to the research question, the potential barriers, and drivers for the use of RPA technologies in particularly sensitive process areas (here: healthcare). This is done in order to find out which factors influence the intention to use such automation solutions and which hypotheses can be derived from this.

In Section 4.2, RQ2 „*What are the main positive and negative issues in the life cycle of RPA technology?*“ is answered using a sentiment analysis. With the research questions in mind, P3 applies sentiment analysis to over 95,000 news articles about RPA published between August 2015 and September 2020 to investigate the public perception of RPA. Through sentiment analysis and topic modelling, it is possible to identify positive as well as negative and subjective as well as objective views. Further, it is possible to find the most important and common topics in the news media. In relation to the research question, this helps to derive hypotheses for this thesis.

Section 4.3 covers RQ3 „*What conclusions can be drawn from job advertisements in relation to the diffusion, use and implementation of RPA and PM?*“. In this context, P5 addresses a snapshot of current digitalisation-related recruitment in Germany by applying text-mining algorithms and statistical analysis to 6,661 crawled job advertisements to illustrate how public institutions shape their organisations, their strategies, processes, and required competences. Using quantitative text analysis and descriptive statistics, P4 also analyses the demand for IT skills profiles and IT-related job offers on a comparable basis. This serves to capture possible RPA- and PM-related skills and competence profiles for employees. Additionally, the intentions to use the technologies by public institutions and possible forms of job design regarding these technologies were identified. The hypotheses for this thesis are then derived from this. P4 reports the results of a research project on the impact of the Covid-19 pandemic on the public sector labour market in the context of RQ3. About the RQ, the job offer in the public sector in Germany and the development of certain job types are systematically analysed.

Section 4.4 takes up the obtained and formed hypotheses from the research questions RQ1-3 (Sections 4.1-4.3) and deals with the subsequent RQ5 „*What are the drivers,* *barriers and impacts in the use of RPA and PM in practice and what optimisation opportunities can be derived?*". Against this background, the Critical Success Factors (CSF) for RPA are initially analysed in P6 using corresponding contextual clusters. Building on previous literature on CSF, it is assessed to what extent the identified success factors are RPA-specific or also apply to other process improvement efforts in general. In P7, against the background of RQ5, a case study examines how the concept of „*flexibility-by-design*" can be influenced by RPA in the sensitive environment of healthcare and how exactly flexibility in process execution can be achieved with it. Furthermore, P7 shows which optimisation possibilities RPA offers to make rigid process models in existing healthcare processes more flexible. In P8, the current debate on PM is taken up and examined based on a case study, such as the actual benefits of these technique for anonymising process data and assessing their suitability for privacy protection. P9, in terms of the research objective of this thesis, explores the possibility of autonomous development of process automation by the healthcare end-user through a case study to understand what factors influence the ease of use, intention to use, and benefits of such automation solutions. P10 explores, using case study research, how the transformation and customisation of specific planning tools for RPA enables the realisation of integrated business processes based on digital twins. P11 also uses case studies to explore the impact of RPA in an industrial environment and the public sector. Regarding RQ4 „*What are the drivers, barriers, and impacts when using RPA and PM in practice, and what optimisation opportunities can be derived from this?*", the optimisation effects of RPA can be measured and insights into different factors of integration performance into BPM can be gained.

Section 4.5 takes up the obtained and formed hypotheses from the research questions RQ1-3 (Sections 4.1-4.3) and addresses the subsequent RQ5 „*How can process management be optimised by RPA and PM?*". P12 deals with a DSR project in which a method for integrating PM into the Six Sigma process management approach was developed and evaluated. This method is developed and further refined in three evaluation cycles through an expert evaluation, a technical experiment, and case studies in the company. This generates construction knowledge for the integration of PM into Six Sigma in relation to the research question.

In P13, a DSR project is carried out with the aim of creating a model. For this purpose, a new assessment model for detailed measurement and potential analysis of RPA technology is designed, developed, and evaluated in four cycles. Against the background of RQ5, P12 provides a systematic approach to analysing process suitability for BPM, considering economic, technological, and process-related criteria and enabling a subsequent prioritisation of processes in terms of their suitability for RPA implementation.

Section 4.6 takes up the obtained and formed hypotheses from research questions RQ1-3 (Sections 4.1-4.3) and addresses the subsequent RQ6 „*How can - firstly - process management and - secondly - processes be optimised by RPA and PM?*“. P14 addresses the problem of integrating PM into the existing process value construct of activities related to business review using action research against the background of RQ6. As a result of P14, first design approaches for the integration of PM are obtained and evaluated. In P15, against the background of RQ6, approaches for accelerated and flexible development of RPA solutions for the automation of existing administrative processes in an affected health authority in Germany will be investigated by means of action research. As a result, approaches for a faster and less complex integration into the existing process management and the faster development of RPA solutions in a very fast scaling and at the same time very heterogeneous IT system landscape are elaborated and evaluated in P15.

4.1 Hypothesis Formation

4.1.1 By Grounded Theory

What are the drivers and barriers for the adoption of RPA and PM?

In P1, a grounded theory study was conducted in professional football to identify the drivers and barriers for the adoption and use of innovative process technologies. In doing so, P1 drew on extensive data from a successful first division football club and a traditional third division football club and derived contributions to theories on technology adoption.

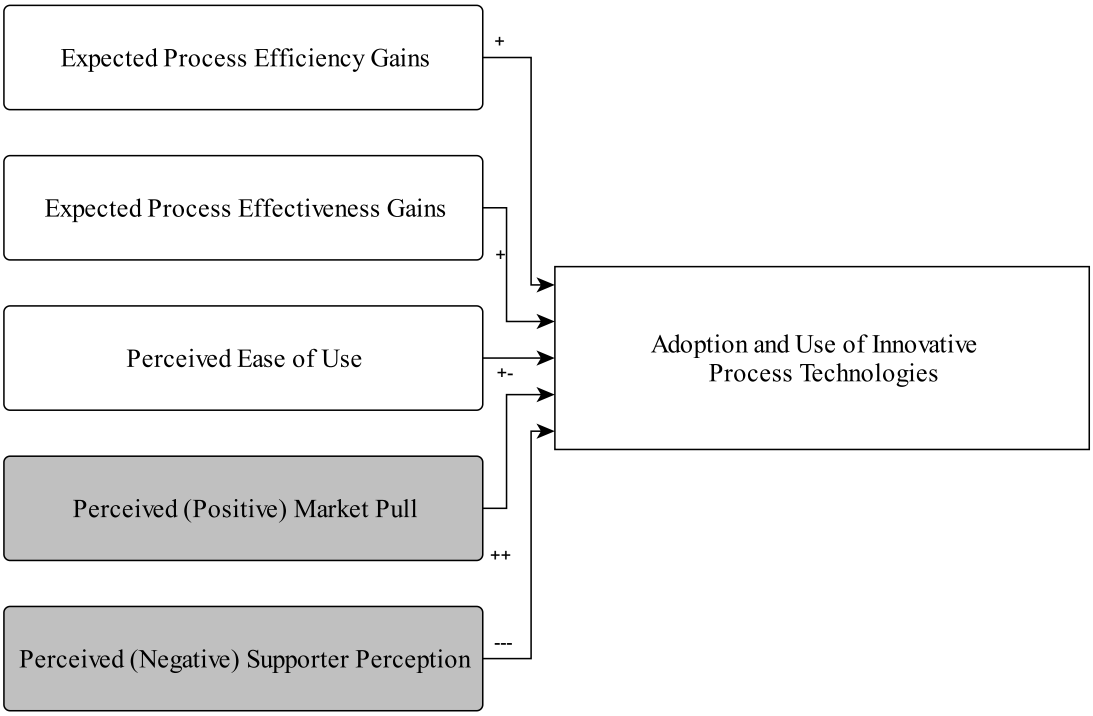

Figure 4-1: Constructs as a result of the grounded theory of P1

In the grounded theory study conducted there, five constructs emerged as a result that influence the introduction and use of innovative process technologies. Figure 4-1 shows the identified constructs that influence the adoption and use of innovative process technologies according to P1 (new constructs are highlighted in dark grey). Building on these findings, P1 reviewed the existing literature to gain a deeper understanding of these constructs. It was found that three of the constructs formed have been extensively addressed in previous research, while the other two appear to be new (Fernandes and Oliveira 2021; Marangunić and Granić 2015; Taherdoost 2018). With respect to the overall research object of „*Generate prescriptive knowledge for the design of Robotic Process Automation and Process Mining for improving process management*", the first two constructs that emerged from the empirical data in P1 were expected process efficiency gains and expected process effectiveness gains. The results in P1 show that innovative process technologies are adopted and used when the organisation and its decision makers expect an increase in process efficiency (i.e., an improvement in resource use to achieve the same outcomes) and an increase in process effectiveness (i.e., an improvement in value to the customer - e.g., in terms of service quality). Constructs such as these have a long tradition in both BPM and information technology research (Bagozzi 2007; Venkatesh et al. 2012). Against the backdrop of these thesis and RQ1, technology acceptance research shows that the extent to which a person believes that using a particular system would improve their job performance is an important driver for the adoption and use of a system (Davis 1989). Similarly, the literature argues that one of the drivers of technology use is expected outcomes, i.e., the expected performance-related consequences of behaviour (Bessant et al. 2001; Ratchford and Ratchford 2021). A closer analysis of the existing literature in P1 shows that earlier publications also distinguish between efficiency and effectiveness (Compeau and Higgins 1995; Williams et al. 2015). For example, Plattfaut and Niehaves (2015) also measure efficiency and effectiveness as elements of the ancestral tendencies of individual IT innovation use.

In relation to the results of this thesis and the RQ1, „*Perceived Ease of Use*“ could be identified as a third construct in P1. This refers to the ease or difficulty of adopting an innovative process technology. This construct is also well known in various scientific disciplines and especially in the literature on technology adoption (Davis 1989; Fernandes and Oliveira 2021). However, for the purpose of this thesis, P1 found differences in „*Perceived Ease of Use*“ between simpler innovative process technologies, such as RPA, and more complex technologies like artificial intelligence. One reason why RPA was more likely to be adopted was concluded to be the ease of use of the technology, with RPA being easier to implement than other innovative process technologies (Lacity and Willcocks 2018; Mendling et al. 2018; Röglinger et al. 2022; van Looy 2021).

In relation to RQ1 and the role of hypothesis formation, in P1, unlike the first three constructs, perceived (positive) market pull could not be explicitly mentioned in the existing literature on technology adoption and is, therefore, a contribution of the present grounded theory study. Perceived (positive) market pull refers to the two underlying constructs of sponsor and competitor pull. On the one hand, the research subjects strive for an innovative image which is transported with the use of the technology. On the other hand, it was found in P1 that the research subjects are more likely to invest in innovative process technologies if the competitors as well invest.

In relation to this research design and RQ1, P1 also reveals a new barrier to organisational adoption of innovative process technology. P1 then identifies „*Perceived Perception of Customers*“ as the negative portrayal of the technology (e.g. „*robotic*“) that has created fears among respondents that have reduced acceptance of the technology. This has been observed in P1 mainly in areas that are closer to the customer (customer interaction, operational processes, etc.) and less in areas that are more hidden from the customer (e.g., analysis of data).

Firstly, the perception that the research subjects want to participate in the innovative image of the technology in the market to enhance some images. Decision makers who have this perception are therefore more likely to adopt and use innovative process technologies.

Secondly, the perceived negative (end) customer perception is the fear that end customers will lose loyalty if innovative process technologies are introduced, as these technologies can negatively distort the brand image.

In P2, a grounded theory study was also conducted in which 17 RPA solutions were independently developed and used by the test persons during the study period. As a result, P2 found that the RPA application was able to perform processes in a measurably more time-efficient manner. The nominal time saving (measured as effort per study participant) compared to traditional data entry by a test person was up to 40%. With regard to RQ1, it could be shown that the subjects who successfully used stand-alone RPA solutions for processes always did so with identifiable limitations and barriers to their intention to use.

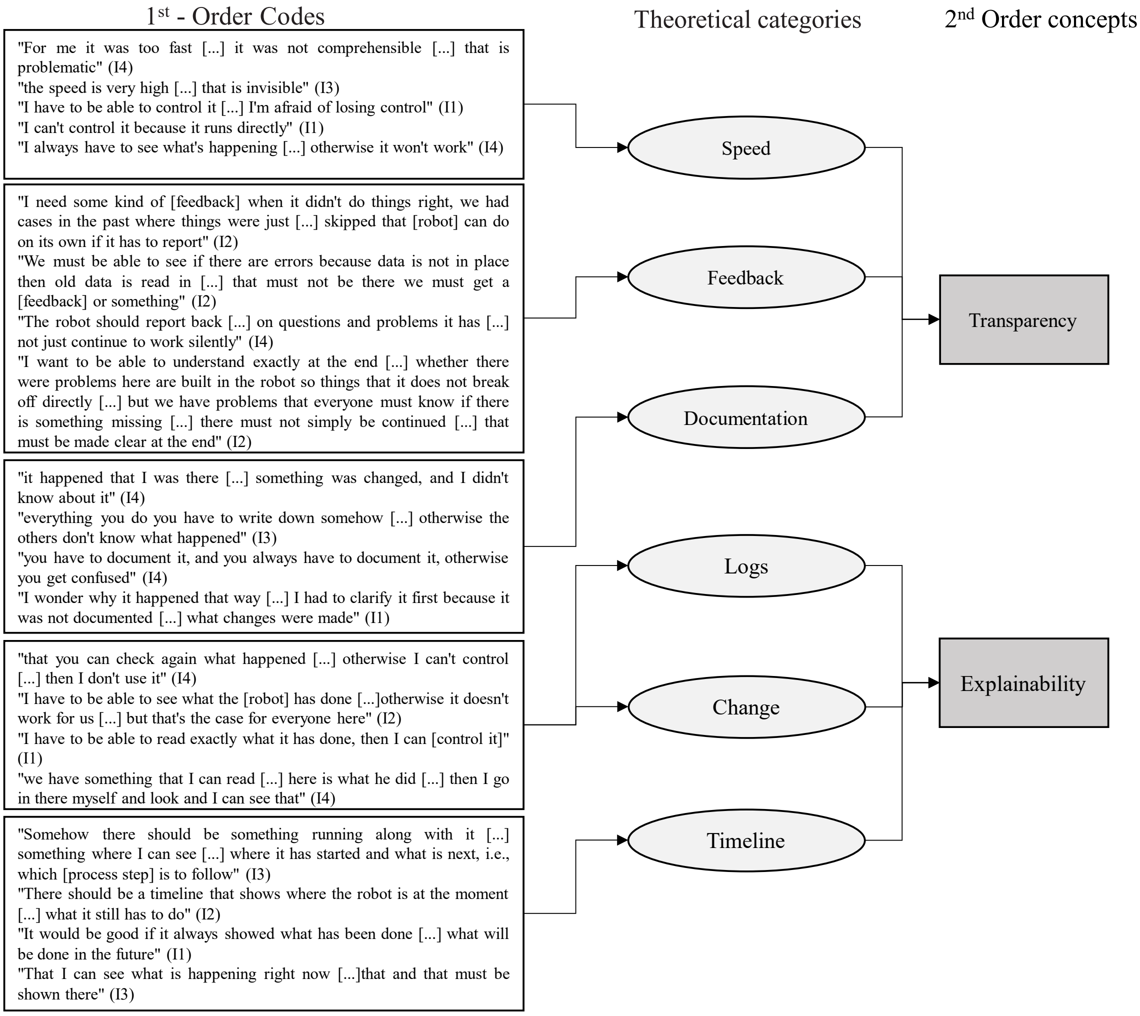

Figure 4-2: Grounded theory data structure and coding results of P2

In terms of this thesis and the research question, the results of P2 show that the participating subjects consistently selected the same types of processes for automation. The selected processes do differ between the study participants in terms of systemic implementation, e.g., the order of data input or output. However, the generally selected business process itself as well as the inputs and outputs required for it do not or hardly differ between the study subjects. These are the processes of extracting and compiling raw data, possible textual data transformations such as the exchange of master data, and the transfer to a target system such as another documentation system. Archiving processes such as the creation and storage of documents were also selected from all the study objects.

As shown in Figure 4-2, the data analysis in P2 revealed that the derived theoretical concepts can be divided into the six categories of speed, feedback, documentation, protocols, change, and timeline. The superordinate constructs „*transparency*“ and „*explainability*“ were then formed as second-order concepts (cf. Figure 4-2). These were increasingly addressed when using the RPA solution.

Therefore, the RPA solution was artificially slowed down by the RPA specialist, which then led to the RPA solution being more understandable for all subjects. When looking at RQ1, it becomes clear that RPA solutions often have the problem that they are not properly documented during a project. This often leads to confusion and uncertainty among the respondents about further use. This is characterised by the fact that the subjects want to understand exactly how the RPA solution works. This includes more information about what the solution does next and what it has done so far so that it becomes more transparent, and the user can understand the process execution. In the context of hypothesis formation, it is relevant that in P2 none of the subjects associated the scripting language provided by the RPA development environment with sufficient transparency and it was described as too complicated and rather confusing to use. Here, as a result of P2, it became clear that a sufficiently comprehensible documentation of the RPA solution is necessary.

In P2, the lack of permanent feedback from the RPA environment was also identified, which should not only stop in case of possible errors but also inform the user in time and without gaps about missing values or wrong entries. Overall, the traceability factor was an essential sub-result in P2 and, according to the participants' observations, should be presented in a comprehensible and traceable form, e.g., as a „*timeline*“, by logging the activities of the RPA solution e.g., in the form of log files parallel to the process execution.

In P2, a classification and comparison of the results with existing, mostly practice-oriented studies on success factors or barriers were made, which investigate, analyse and evaluate the introduction, use, and operation of RPA in different application contexts. The relevant literature consistently identifies the following factors as the most essential and prioritises the following drivers for RPA implementation: top management support, adequate involvement of all stakeholders, especially IT, and the establishment of a proof-of-concept. For example, the factor „*top management support*“ is often cited as the cooperation and continuously ensured support of management that implements RPA possible in the first place. P2 shows that the success factors mentioned in the literature in the form of „*management support*“, the „*use of a proof-of-concept*“ and the „*use of vendor support*“ are also found in P2 but play a very minor role (Güner et al. 2020; Ivančić et al. 2019; Lacity and Willcocks 2016; Syed et al. 2020).

4.1.2 By Sentiment Analysis

What are the main positive and negative topics in the life cycle of RPA technology?

In P3, 97,402 news articles were collected in a period of over five years between August 2015 and September 2020.

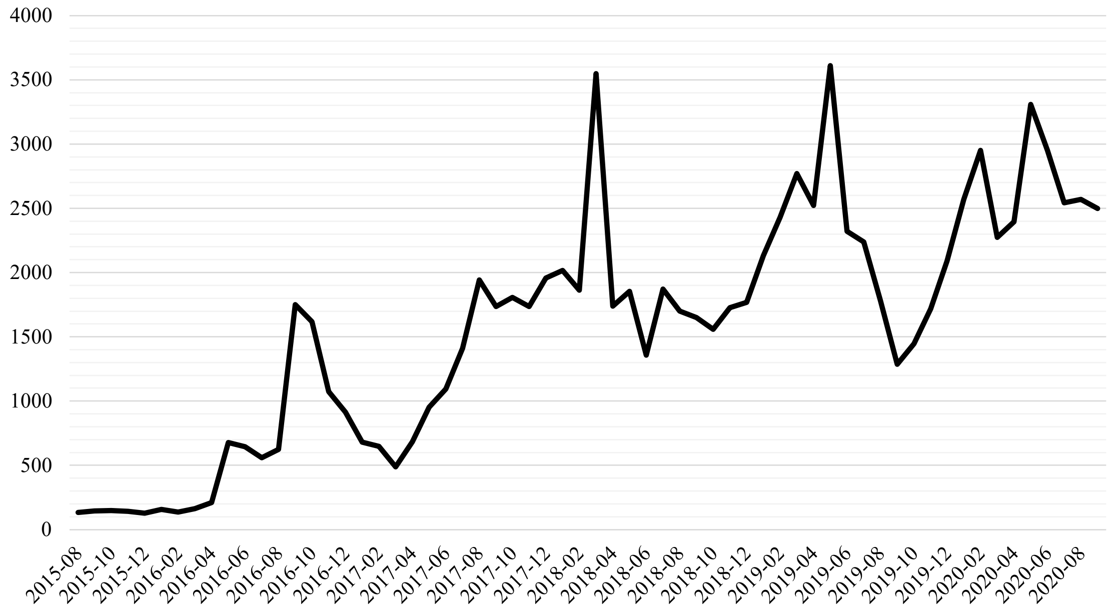

Figure 4-3: Number of RPA-related news articles per month in P3

Figure 4-3 illustrates the number of articles published per month: the highest number of articles was published in May 2019 (3611 articles), March 2018 (3549 articles) and May 2020 (3308 articles). The polarity and subjectivity analyses were visualised in P3 using boxplots. These allow the analysis of the combination of discrete and continuous data where the continuous data are the polarity/subjectivity values belonging to the respective month.

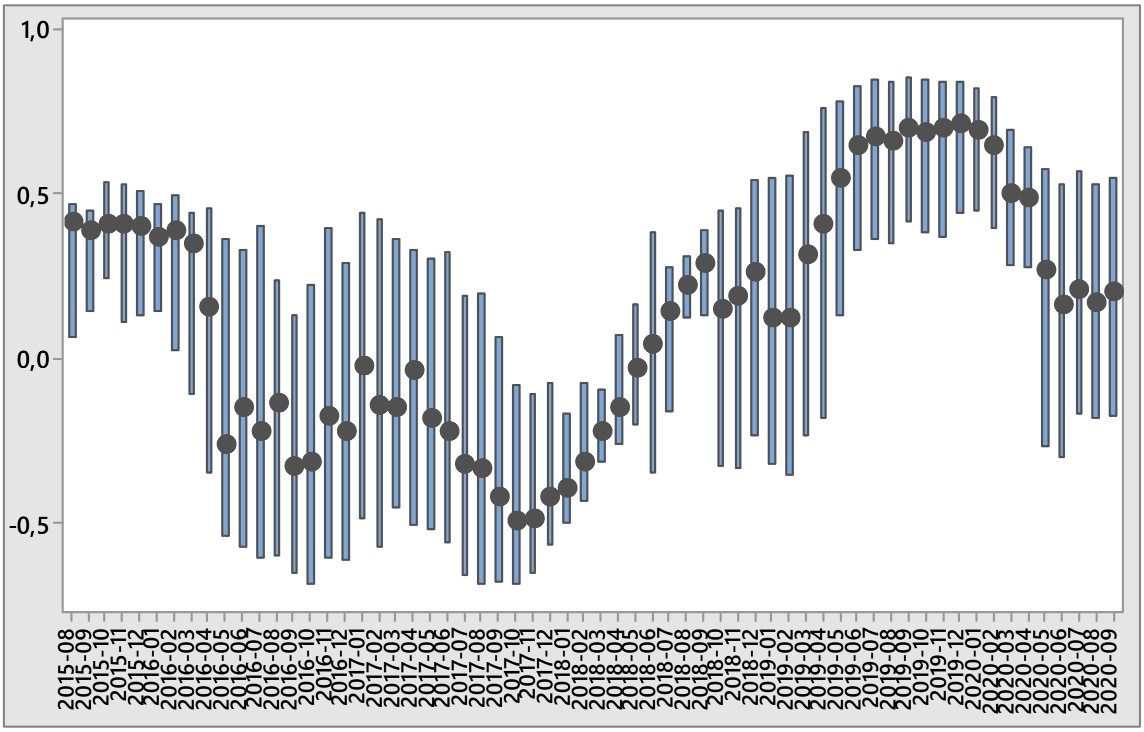

Figure 4-4: Polarity boxplot of news articles from P3 per month

The boxplot in Figure 4-4 illustrates the results of P3 as the polarity from August 2015 to September 2020. The sentiment analysis in P3 in terms of polarity shows some evolution. In the first year from August 2015 to April 2016, the mean polarity was above zero. This means that the majority of news articles were positive about RPA. Between May 2016 and May 2018, the general tone remained negative. However, there were large fluctuations in the polarity of news articles. From June 2018, the polarity improved until it peaked around the turn of 2019 to 2020.

P3 further used topic modelling to identify the most frequent RPA-related topics in the collected news articles per year. Table 4-1 describes the ten most frequent topics in each year from 2015 to 2020.

Table 4-1: The modeled topics in P3 on an annual basis in descending order of priority

#	2015	2016	2017	2018	2019	2020
1	ACCURACY	COST REDUCTION	HUMAN RESOURCES	RULES BASED	UIPATH	COVID-19
2	RULE-BASED	BLUE PRISM	ACCURACY	UIPATH	FUTURE OF WORK	UIPATH
3	WORKFORCE	FINANCIAL ACCOUNTING	RULE-BASED	COGNITIVE	REDUCE COST	COST SAVING
4	CONSULTING	CUSTOMER SUPPORT	FUTURE OF WORK	NATURAL LANGUAGE	NATURAL LANGUAGE	FUTURE OF WORK
5	FUTURE OF WORK	CONSULTING	WORK TASK	HUMAN RESSOURCES	ARTIFICIAL INTELLIGENCE	HUMAN RESSOURCES
6	BLUE PRISM	ARTIFICIAL INTELLIGENCE	WORKFORCE	ARTIFICIAL INTELLIGENCE	COMPUTER VISION	USER INTERFACE
7	HUMAN RESOURCES	ENTERPRISE SYSTEM	USER INTERFACE	FUTURE OF WORK	SAP	WORKFORCE
8	NATURAL LANGUAGE	FEAR	CONSULTING	BLUE PRISM	FINANCE ACCOUNTING	DIGITAL TRANS-FORMATION
9	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	HUMAN RESOURCES	NATURAL LANGUAGE	DIGITAL LABOR	HUMAN RESSOURCES	SAP
10	WORK TASK	FUTURE OF WORK	COMPLIANCE	CONSULTING	BLUE PRISM	RULES BASED

With regard to this thesis and RQ2, the results of P3 show that news articles focused on explaining and defining RPA with topics such as accuracy, rule-based, work task, etc., especially in the early period. Over time, it became clear that the benefits and expectations of RPA became more substantive, as evidenced by identified topics such as cost reduction, future of work and digital work. In 2020, the Covid-19 pandemic also dominated news articles about RPA. Here, P3 concluded that RPA can be seen as a positive way for companies to respond to the Covid-19 shift. Furthermore, the results also show a change in dominance in the RPA vendor landscape. A closer look at the number of news articles on RPA over time shows some spikes. However, these are not due to scientific publications, but rather to published reports by consultancies, market research agencies or to major mergers and acquisitions. The underlying RQ2 of this paper and the associated hypothesis formation are underscored by the results of the topic modelling analysis conducted in P3. For example, this shows how RPA focused initially on explanations (introduction), then on expectations (operation), and in recent years on more general topics such as the Covid 19 pandemic (environment). Here, referring to RQ3, shows that in P3 RPA is perceived as a more mature but also complex and complicated technology that can now be used to solve important problems both in companies (e.g., the future of work) and in society at large (e.g., the impact of Covid-19 pandemic).

4.1.3 By Text Mining

What conclusions can be drawn from job advertisements regarding the dissemination, use, and implementation of RPA and PM?

In relation to this thesis and the formulated RQ3, P4 used text mining to collect a total of 33,643 unique job ads. Of these, 6,661 were collected in August 2019 and 26,982 from March to September 2020. In all weekly samples, the number of vacancies ranged from 5,276 to 8,324. The results of P4 make several contributions to this thesis- In addition to describing the „*what*“, insights into the „*why*“ can also be provided, as in P4 it could be observed that public institutions try to compensate for internal process inefficiencies by putting more pressure on prospective applicants. In relation to RQ3, it was subsequently observed in P4 that some new posts were created specifically to deal with the impact of the Covid-19 pandemic. However, RQ3 showed that this number was very low, at around 70 vacancies per week.

P4 showed that the data indicated a significant increase in demand for IT professionals in all positions. It is important to note that the data from P4 also showed a significant increase in IT support and IT maintenance professionals - these specific skills could be identified, but there was no demonstrable, measurable, or identifiable increase in positions related to, for example, RPA or PM, or involving business process automation and optimisation. Therefore, no specific skill and ability profiles could be identified either.

Considering RQ3 and the superordinate research object, 6,661 job advertisements from the year 2019 were also analysed by text mining in P5. The content analysis of the identified text elements revealed three major IT-related occupational categories in relation to the implementation of digitalisation approaches. The ads could be categorised as targeting IT specialists, IT generalists, and project managers without specific IT skills. A qualitative manual analysis of the job ads revealed that IT specialists typically create and implement digitisation concepts and advise managers and employees on new technologies. IT generalists have a stronger focus on maintaining IT infrastructure and systems and supporting employees with digitisation-related requests. The category of project managers without specific IT skills is required for the general management of digital transformation, change, and process improvement.

P5, as a contribution to this thesis, shows that specific expertise or even specific technology competence for RPA or PM was not necessarily required. Nevertheless, it can be assumed that the core competences of many classic administrative professions will shift more and more in the future and become detached from the classic job descriptions.

Thus, job advertisements very often demand a considerable affinity for new and further training. Since it can be assumed that the changes in job profiles will increase in the future, continuous professional development is becoming more important. P5 shows as a result that there is no significant demand for many completely new specialist roles, especially regarding innovative technologies and accordingly also against the background of RPA or PM.

In this context, P5 shows, against the background of this thesis and RQ3, that the concept of digitalisation is primarily derived from the closely interwoven IT investment decisions formulated in job advertisements. As a result, it could also be shown that the formulated requirements in this context of potential applicants need an IT-affine, impact-oriented process management, with networked processes and proactive action. P5 thus shows that potential new employees should support and implement these changes in the BPM and thus be able to implement the new requirements in a targeted manner, usually within the framework of projects. At the same time, the employees should actively support and help to shape the change. To this end, P5 identified the need for increased staff development through training. It includes further education, training, supervision, and coaching.

At the same time, a trend towards supporting and accompanying digitalisation and IT affinity can be read from most advertisements in P5. However, most job advertisements do not describe specific technical skills that are also needed with regard to process management and process optimisation. Taken together and synthesised, the findings of P4 and P5 allow the formation of hypotheses against the backdrop of the research objective of this thesis.

4.1.4 Synopsis

Following the research procedure in the previous chapters, RQ1-3 (in P1-5) taken together and condensed can justify the following hypothesis formation against the background of the research objective posed in this thesis:

- Hypothesis 1: *The introduction and use of RPA and PM is even more effective the better the requirements of the application systems for the IT competences of the users match their actual existing ones*

This hypothesis can be derived from all research contributions P1, P2, P3, and P4, which are assigned to the RQ1-3. Hypothesis 1 seems at first glance to be an easily generalisable hypothesis that can be applied to many subtypes of information technology application systems. In this thesis, however, it is formed against the specific background of technology, which assumes extensive use by the business department rather than IT specialists as its essence. In the context of the technology, the narrative about the user compatibility of RPA technology and PM technology is thus shaped by the providers, but also by the decision-makers and the IT departments. This narrative presents itself in such a way that the introduction, implementation, development, and use can be carried out by the end users with very less or no IT expertise. This is in line with the scientific consensus in the field, which assumes and sums up that RPA technology, but also PM technology, can be adopted by employees without much IT knowledge. Back in 2016, Allweyer described that „*The robots are not programmed in the traditional sense, but* '*trained*' *with the help of recorded user interactions, supplemented by flowcharts and the like. This training can be carried out by business experts without the support of IT developers.*"

Hofmann et al. (2020) additionally comments on this in current research: „*As the analysis of different RPA tools demonstrates [...] no specialized programming knowledge is required for developing software robots [...] While this fairly low IT complexity makes RPA an easy-to-use tool for different people and functions in a business*". While Andrade (2020) might add that „*RPA is part of a bigger solution movement of* '*low code*' *or* '*no code*' *tools that are different from traditional software coding which allows for faster and easier deployments*". Agostinelli et al. (2019) also agrees with this and says that „*The behavior of SW robots can be classified as* […] *low-code* […] *that - in addition to drag & drop facilities - provide low-coding functionalities to semiautomatically create software code*". Thus, in their recent research Berti et al. (2019) say that PM „[…] *put a significant emphasis on non-expert usability, i.e., by means of providing an easy to use graphical user interface* […] *such an interface helps to engage non-expert users and, furthermore, helps to showcase process mining to a larger audience*". With a similar conclusion, Ullrich et al. (2021) describe the users of PM as „[…] *they have little or no experience with code*" and that PM „[…] *empowering users with non-technical backgrounds to be involved in the development process* […] *that allows* […] *to build, deploy, and maintain analytical and operational process mining applications in one centralized space*". Against this background, the hypothesis contributes to the existing understanding of research and defines a contrasting position to the existing scientific consensus by introducing a new perspective.

The next hypothesis that can be derived from all research contributions P1, P2, P3 and P4, which are assigned to the RQ1-3 is:

- Hypothesis 2: *The traceability of process instances to be supported by RPA and PM applications increase their effectiveness*

This includes the comprehensibility with which RPA or PM application systems are presented and executed, but also how the generation of results is mapped. Although the time saving is highlighted as a major advantage of RPA in the scientific literature, the resulting lack of traceability of the process steps and the procedure was perceived negatively by the users in the studies presented here. This contrasts with previous studies in the scientific literature and therefore opens up a new aspect to the existing aspects in this area.

The last hypothesis that can be derived from all research contributions P1, P2, P3 and P4, which are assigned to the RQ1-3 are:

- Hypothesis 3: *The compact visual process representation to be supported by RPA and PM applications will increase their effectiveness*

The research presented here shows that the core of hypothesis 3 is to present the involved and interrelated background process of the solutions in a much more visual, compact, straightforward, and clear way to achieve a better user understanding of the interrelated use and maintenance of the application solutions.

Both, RPA and PM, are characterised by the fact that all major vendors have already implemented predominantly graphical or visual programming languages in their respective developer environments (Martin et al. 2020; van der Aalst et al. 2012). Accordingly, the basic solution development via these environments is already partly intuitive and more appealing to use than, for example, via textual programming languages (van der Aalst et al. 2012a; van Dongen et al. 2005). In the development environments of the RPA vendors, visual programming, for example, provides the elements of the automation solution in the form of graphically designed building blocks. Based on the appearance and labelling of these building blocks, it is possible to identify which task in the programme flow can be solved with each of them. The pictograms created in this way serve as orientation and avoid highly complex structures or strong abstractions for the user. However, this visual component focuses exclusively on the representation and design of the concrete automation solution as part of a larger process. The higher-level embedding in the context of the whole process is missing for the user's understanding and makes the overall picture unclear, e.g., the overall process in which the solution operates. This representation of background information in the developer environments has not been part of the scientific debate in this research area so far and is therefore a valuable contribution to the research flow by providing an additional perspective on the development of these technologies.

Table 4-2 provides an overview of the formation of the three hypotheses from the corresponding previous Sections 4.1-4.3. The table represents the respective research paper (P), the corresponding section in chapter 4 and its contribution to the formation of the particular hypothesis.

Table 4-2: Overview of hypothesis formation from Sections 4.1-4.3

Research area	Section	RQ	Research method	P#	Hypothesis 1	Hypothesis 2	Hypothesis 3
Hypothesis Formation	4.1	RQ 1	Grounded Theory	1	F	F	F
				2	F		
	4.2	RQ 2	Sentiment Analysis	3	F		F
	4.3	RQ 3	Text Mining	4	F		
				5	F		

F= Hypothesis formation

4.2 Hypothesis Testing

4.2.1 By Case Study Research

What are the drivers, barriers and impacts when using RPA and PM in practice and what optimisation opportunities can be derived from this?

P6 has achieved two major contributions against the background of testing the hypotheses from RQ1-3 (see synopsis in Section 4.4). Firstly, the identified Critical Success Factors (CSF) for RPA provide an overview of the preconditions for the success of RPA from previous scientific literature and highlight existing interdependencies between individual CSFs. Secondly, case study research succeeds in highlighting the specifics of RPA and to what extent CSFs are general or technology-independent for process automation and process digitisation. The main result from P6 the CSF framework for RPA closes the research gap identified by Syed et al. (2020). Despite the growing number of RPA vendors and products on the market, there is no clear understanding of how an organisation can successfully use and implement this technology. The literature contains many references and considerations for RPA, but it is unclear what the critical success or failure factors are (Aguirre and Rodriguez 2017; Enriquez et al. 2020; Plattfaut 2019; Plattfaut and Borghoff 2022; Syed et al. 2020). However, P6 also shows that automation projects, and especially RPA, are at high risk of failure.

One aspect worth noting considering RQ4 is that CSF are technology agnostic within contextual cluster development structures. This is more surprising as several authors have argued that RPA is a new form of IT. Thus, it is argued that RPA is low-code and corresponding capabilities can be found outside the responsibility of the IT department on the business side. However, as a contribution to this thesis, P6 also shows that RPA low-code software development draws on the insights and paradigms of traditional software development.

Regarding the hypotheses raised and RQ4, P4 provides the importance of development competences and skills outside the IT department and shows that business departments are now increasingly enabled to develop their own RPA solutions. New factors become crucial for success that were not so important in the past. These include questions of governance structures and coordination processes. Companies need to find new ways to balance local RPA development driven by the business units with central IT security and architecture maintained by the IT department. It is therefore crucial to define such RPA governance in terms of technology, standards, and organisation. While it must be different from existing legacy IT structures, concrete guidance on what such governance should look like has been lacking so far.

P6 shows that linking RPA to business strategy raises new questions. About RQ4, RPA is seen as a new type of technology and therefore a new relationship with IT. It has been shown that RPA is not used or capable of optimising existing business processes, but instead a solution that takes over manual tasks exactly as they are, i.e., with all their inherent inefficiencies and shortcomings. If the management of the company follows a radical change according to the BPR of existing processes discussed in chapter 2 and especially Section 2.1, RPA does not fit this strategy.

P7 has analysed the six realisation options of the concept „*flexibility by design*“ by means of case study research against the background of testing the hypotheses from RQ1-3 and examined the respective design options for process automation and optimisation. P7 provides as a contribution to this thesis the design approaches to make RPA in existing process designs and the associated process management subsequently more flexible.

At the beginning, it was determined in P7 that the redesign of existing processes required adjustments in different system environments due to the fragmented IT infrastructure. Therefore, redesigning processes in this infrastructure was not an option due to these differences in the prerequisites of the systems as well as the non-transparent process specifications. In addition, the originally proposed redesign of the existing processes with RPA also did not work for the following three main reasons. Firstly, the set-up costs to learn the tool in this stressful environment were too high and caused resistance from the employees. Secondly, the testing period of the new RPA solutions was too short. Thus, the pressure on the workers was also too high due to the short testing time. In addition, P7 found that the failure of the process redesign with RPA was the enormously high collection of requirements. According to the interviewees, these requirements changed abruptly and indiscriminately, so that only insufficiently good RPA solutions could be developed. Finally, according to the interviewees, the failure to completely redesign processes with RPA led to a different approach.

The contribution of P7 to this thesis is that a solution must be designed to proactively consider possible changes in environmental conditions, so that the processes can flexibly be adapted to any environment that may actually occur. Following this, P7 has identified and implemented an approach to optimise processes by creating ex-post flexibility in the process design through an RPA solution that balances all environmental parameters - a flexibility layer.

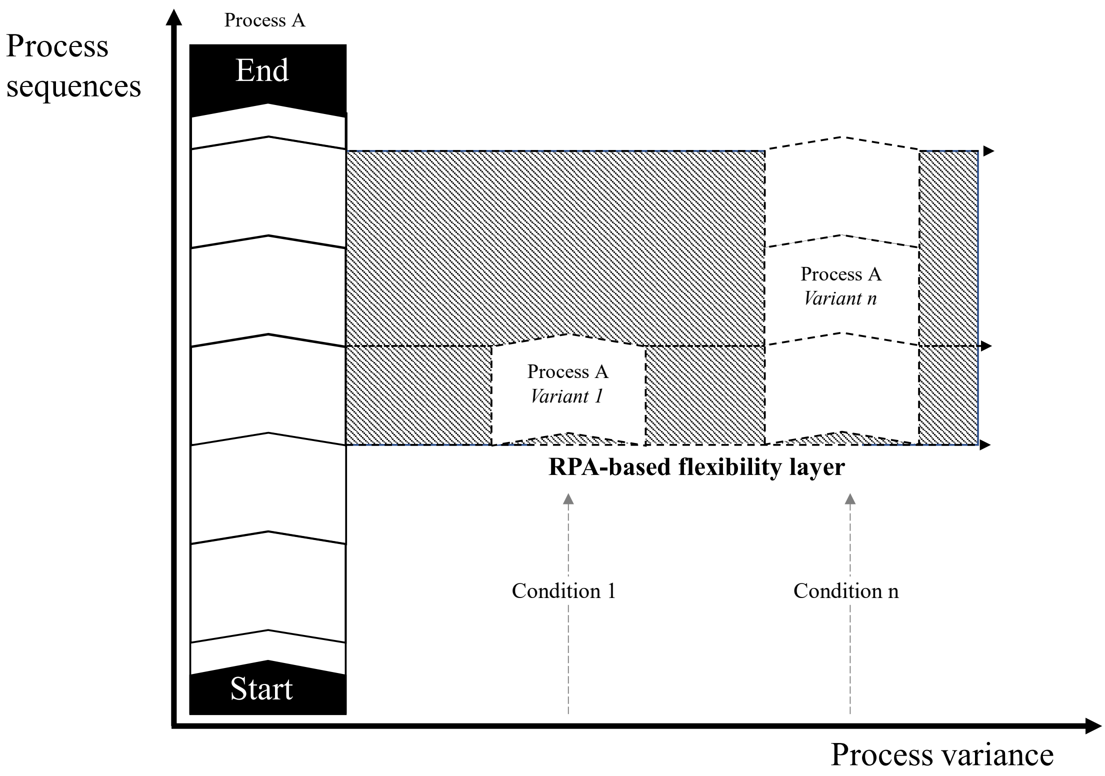

Figure 4-5: RPA-based Flexibility Layer in P7

The RPA-based flexibility layer can be understood as a bundle of additional, alternative process flows that are „*attached*" to the existing process model (cf. Figure 4-5), but without changing it or making technical changes to the underlying (fractal) systems. Thus, alternative process variants are offered from which the appropriate one can be selected depending on the current context.

With the help of these RPA solutions, process execution can be variably adapted to fluctuating exogenous requirements, both retrospectively and on the fly, while being tracked, monitored, managed and controlled by individual users. Thus, the RPA solution is only used proactively by employees when certain orders of magnitude are reached, i.e., when the process volume increases by leaps and bounds. In this way, RPA-based technology ensures the scalability of high-volume processes while providing the necessary management and control of the processes. As shown in Figure 4-6, the flexibility layer approach through RPA can realise three realisation options of the second level of the „*flexibility by design*“ theory, namely *parallelism*, *iteration*, and *multiple instances*. The *Cancellation* option could not be supported. As a result of the case study, in P7 the six implementation options were combined into two aggregated theoretical dimensions (cf. Figure 4-6): *Range* and *Response*.

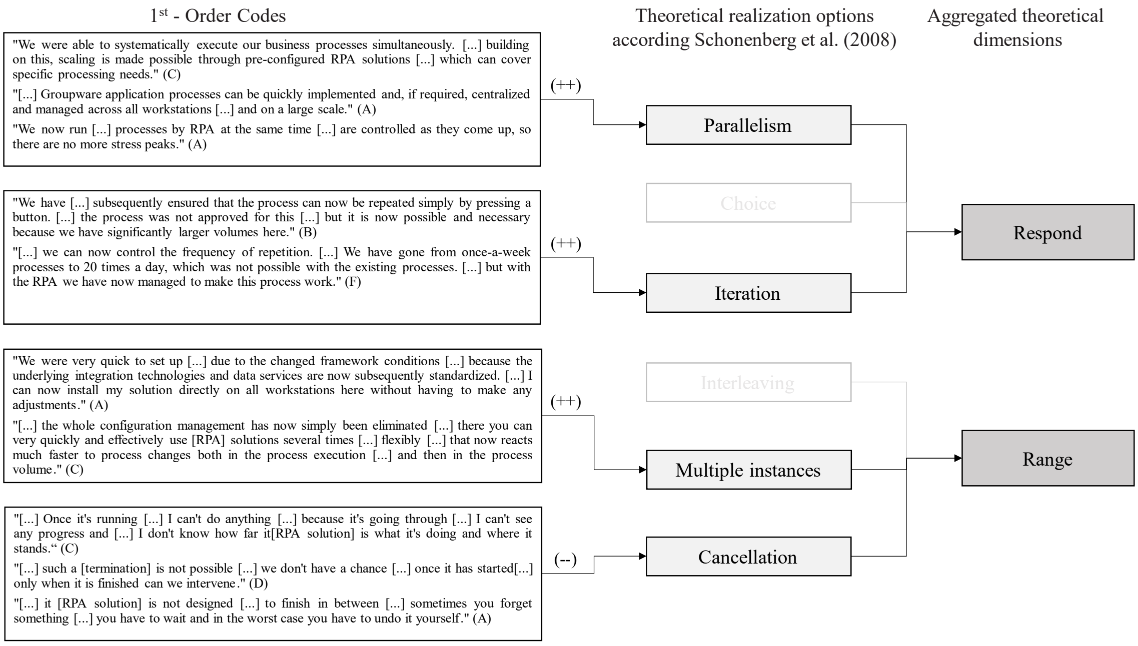

Figure 4-6: RPA-supported flexibility options in P7

„*Respond*“ in P7 describes the extent to which a solution can adapt and therefore includes the realisation options „*Parallelism*“ and „*Iteration*“, while „*Range*“ is the speed at which the solution can adapt and therefore includes the options „*Multiple Instances*“ and „*Cancellations*“. However, no relevant influences were found in P7 for the other realisation options „*Choice*“ and „*Interleaving*“ of the Flexibility-by-Design theory.

The results in P7 against the background of RQ3 show that the described approach unifies the IT-supported environment variables and thus enables flexible introduction, implementation, and simultaneous automation of the individual process steps. P7 was thus able to show that existing processes can be flexibly changed, extended, or automated with an RPA-based flexibility layer. This indicates that existing processes can be partially changed retrospectively with the help of RPA to adapt the environment to the existing fixed process model. This enables a visible fast, flexible response to sudden changes in the organisation under study. It was also shown that the RPA flexibility layer unifies dependencies, links, and configurations for operating system environment variables. The flexibility layer homogenises the existing heterogeneous structures and processes can be flexibly re-implemented, extended, or even replaced without further adjustments.

In P8, against the background of testing the hypotheses from RQ1-3, an analysis was done by means of a case study how the real benefits of PM techniques for anonymising process data and assess their suitability for privacy protection must be designed. For this purpose, P8 investigated how responsible users and specific user groups can be identified despite the common technical anonymisation options offered by PM technology. The PM data examined in P8 contained 3.913 complete executions of the master data process under investigation. It was found that in about 17% (n = 661) the master data did not comply with the process-compliant flow and were always changed later than the initial entry. In 71% (n = 469) of these error cases, the cause of the error could be assigned to a specific identifiable user or user role by the other users running the process, even though the system had anonymised the data through technical protection measures.

Based on the recorded traces, it could be shown in P8 that the occurrence of these irregular process executions or irregular changes to the master data has certain patterns. This made it possible to establish a recognisable connection between certain execution routines and the erroneous master data manipulations and changes. Consequently, a user group or in many cases (n = 188) even the respective process owner could be identified via the corresponding process knowledge of the process owners, which represented a clear deficiency in the design of the PM technologies. As a contribution to this thesis, this brought insights into the design implications and design knowledge of PM systems, especially of technical protection measures and the associated data collection and data storage problems.

In P9, a case study was also conducted, and RPA solutions were developed by the stakeholders using RPA, either independently or with the help of an RPA expert. In P9, as a contribution to this thesis, it was found that the RPA application performs the processes studied in a measurably more time-efficient way: The time saving in comparison to the traditional process of data entry by a nurse was up to 70%. In relation to RQ3 and the previously stated hypotheses, P9 can confirm that nurses can develop RPA solutions for nursing documentation on their own, but it was able to establish that these are associated with limitations and the fulfilment of certain framework conditions. The results of P9 show the following findings regarding the usability of RPA development environments: None of the participants use the scripting language provided by the RPA development environment. This was described as too complicated and rather dissuasive, which in many cases even inhibited the use of the RPA technology. Without exception, all participants in P9 work with the so-called desktop recorder function of the RPA environment. The recorder makes it possible to automatically record mouse movements of the user interface and keyboard activities to generate automation scripts from them without having to do any programming themselves. In the data analysis of P9, the „*explainability*“ of the RPA solution was also increasingly addressed as a contribution to this thesis. Therefore, as a design approach, the RPA solution was artificially slowed down by the RPA specialist. Another implementation was the „*simplicity*“ with which the development of RPA solutions was possible in the RPA development environment provided.

In P10, against the background of testing the hypotheses from RQ1-3, it was shown that a design approach in the form of a digital twin promises advantages from an organisational perspective compared to previous development models and the integration of RPA into the existing process management. To this end, a case study was conducted in P10 with the design of an implementation of a complex business process automation solution based on the digital twin concept. The result is shown in compacted form as a model in Figure 4-7.

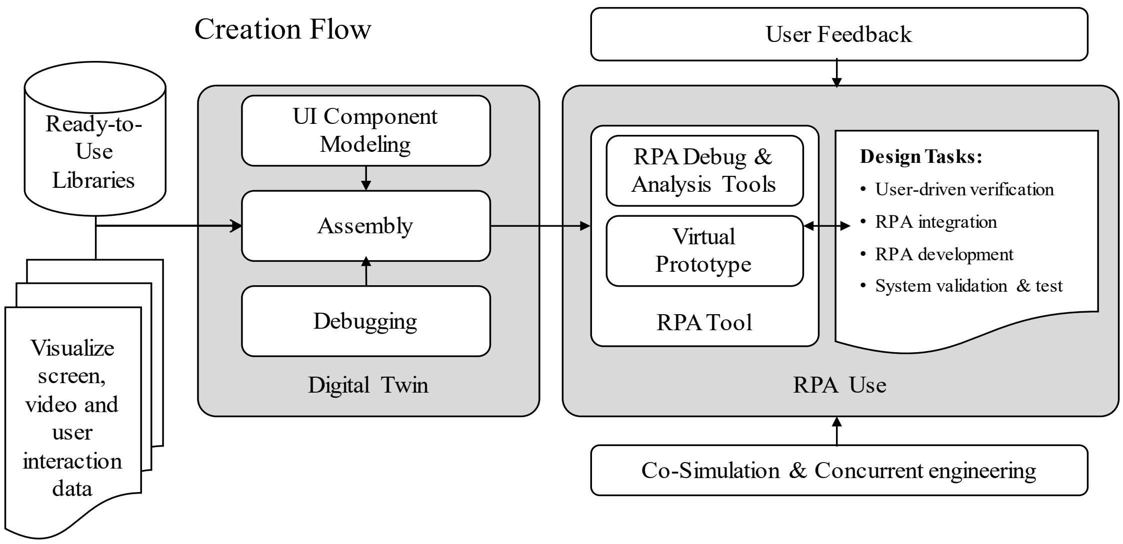

Figure 4-7: Model for the implementation of the digital twin for RPA in P9

As a contribution to this thesis, this research shows that such an implemented solution can significantly reduce specific development times. It became clear as a result in P10 that the RPA developers did not know the employees and process owners for whom they were developing the solution. The question of who would carry out the processes based on their individual skills could not be answered by the developers in any of the cases studied, i.e., the RPA developers were not aware of the other process and system interfaces. About RQ4, it can be stated that the decisive successful use of RPA does not require profound process knowledge, but rather the right IT skills to be able to deal with simple script code.

4.2.2 By Design Science Research

How can process management be optimised through RPA and PM?

P12 has achieved the following significant contribution to RQ5 and to this thesis against the background of testing the hypotheses from RQ1-3 (and the synopsis in Section 4.4). In P12, a method for integrating PM into the Six Sigma process management approach was developed, which was evaluated and improved in a DSR project with the help of an expert workshop and a technical experiment, and finally its practical applicability was demonstrated by means of a case study. It was shown that PM requires quite complicated introduction mechanisms into the organisation IT systems and necessarily requires a wide range of prior knowledge. In particular, the integration and the benefits with regard to BPM must inevitably be adapted to the individual system landscape, and therefore also to the data and database architecture of an organisation. P12 also encountered several concerns that kept coming up. Firstly, data quality in general was of paramount importance, meaning that a comprehensive data and IT architecture also influences the potential and success of PM. Secondly, human factors are another important aspect. Project managers must always keep in mind how to use PM as a tool in their overall process management agenda, not using PM as the only source of information and performance control.

Table 4-3: Six Sigma experts' evaluation of PM types and the DMAIC in P12

PM Aspect	Define	Measure	Analyse	Improve	Control
Discovery	low[3] / high[1,2]	high	high	low[3] / medium[2] / high[1]	low
Conformance	medium	high	high	low[3] / medium[2] / high[1]	high
Enhancement	low[3] / medium[1,2]	high	medium[3] / high[1,2]	high	low[1,2] / high[3]
Potential Benefits	low[3] / medium[1,2]	high	high	medium[2,3] / high[1]	medium

[1]: Project team members; [2]: Head of IT; [3]: Head of Process Improvement

An important contribution to this thesis and to RQ5 is the assessment of the potential and applicability of PM, as summarised in Table 4-3. The most potential for PM is seen in the measuring and analysing phases. As they form the core data analysis, PM can usefully assist in quantifying process problems, identifying root causes and finally quantifying their impact. However, P12 also shows great disagreement on the improvement phase of Six Sigma. P12 showed little potential for PM in this area at present, but that PM can be used well to test and verify improvement actions and thus directly support and accelerate a successful improvement phase. The application of PM in the control phase was consistently rated as of little value. The results from P12 show against the background of this thesis and RQ5 that PM is well suited to enrich process management. The event logs collected and analysed by PM in P12 proved to be very valuable sources for process improvement projects. It became clear that PM supports and accelerates the documentation, improvement, and control of processes, leaving project managers more time for process improvement. Therefore, P12 concludes that it is recommended to integrate PM into the Six Sigma methodology. However, it is only a useful extension for process managers where mature process management is already in place and embedded in an organisation, and where the process managers already have technical experience and technical skills.

P13 made the following significant contribution to the thesis and RQ5 considering the testing of the hypotheses from RQ1-3 (and the synopsis in Section 4.4). The results of a DSR project to develop the scoring model for process management for automation using RPA were developed and presented. The model developed within DSR thus builds on existing models used in practice as well as on the scientific literature on RPA. Within P13, the model was then iteratively designed, developed, and refined in four build/evaluate cycles with a case study partner from the manufacturing industry. The advantages of using the model for the case study company lie in the formal decision-making structures and the standardised communication about the selected processes. However, within P13, the application of the model initially also meant more effort for the BPM, as the required information was available but had to be collected and organised.

From the evaluation in both organisations studied, the following advantages and disadvantages of the model could be worked out. First, the model provides a consistent overview of the selection process and the metrics that influence the prioritisation decision in the context of process management, exemplified in a section of the surface of the result representation of the designed scoring model in Figure 4-8. Second, the model enables a systematic approach to information collection and evaluation across different attributes and levels in process management.

Evaluation process suitability

Criteria	Score	Weighting	Result
Suitability for automation			
Type of process	5	2	10
Source of data	5	1,5	7,5
Type of data	4	1	4
Suitability for automation			
Stability	1	1	1
Complexity	3	0,75	2,25
Standardisation	2	1	2
Risk	4	1	4
Suitability for automation			
Involved applications & systems	3	0,5	1,5
Error-proneness (man. editing)	5	0,5	2,5
Automation in other systems	5	1,5	7,5
Economic impact			
Processing time	3	3	9
Case frequency	2	3	6
Results			
Automation suitability	**50 / 65%**		
Economic impact	**18 / 35%**		
Overall result	**68 / 100%**		

Figure 4-8: Exemplary presentation of the results in the user interface of the scoring model of P13

As a result, in addition to the pure prioritisation decision, in many cases a lot of new information about the actual process flow was produced for process management. Thirdly, by applying the model, the process management of the case study organisations were able to justify the selection of certain processes and have stuck to the decisions during the RPA implementation projects. Nevertheless, by applying it to BPM, P13 was able to show that the role of in practice application is more relevant to RPA projects with lower budgets where little or no structured decision making has been used before. In practice, the scoring model presented here also supports BPM by taking traditional financial methods into account in the decision-making process. This is done by the fact that the model records the investments in the process to be automated in a broken-down manner and can thus, in combination with the technical framework conditions, provide a transparent, suitable process structure that then benefits BPM.

4.2.3 By Action Research

How can - firstly - process management and - secondly - processes be optimised through RPA and PM?

Article P14 shows, with reference to RQ6 and as a contribution to this thesis, the design knowledge for optimising PM based on action research in the audit domain. To this end, in P12, action research was conducted in three iterations following Coughlan and Coghlan

(2002a) to investigate the extent to which data collection methods, data access and process data can be optimised in their design in PM. P14 reports on action research on the effectiveness and applicability of the novel design guidelines proposed in this context. As part of the research design, researchers evaluated, designed, and developed design principles with researchers to optimise PM traceability and usability. This was done to optimise the performance of the application software by making it easier to detect end-user manipulation of event log data.

The knowledge gained in this way could then be used in P14 to gain and improve insights for the systematic design of PM about a more compact visual usability of PM as well as the design optimisations for an improved traceability of PM results in a scientifically sound way. As a specific addition to this thesis, the effectiveness and applicability of these design principles could be confirmed during the study. The original design guidelines were refined while the study. The guidelines are a further development of the existing PM design and offer additional principles in the form of a more compact and clearly visual development of PM interface processes as well as better traceability of the generated results by linking the presentation of the results with a jump and drill-down option to the original data basis. Against the background of the testing of the hypotheses from RQ1-3 (and the summary in Section 4.4), P15 has made a significant contribution in the form of designing a solution approach that enables the rapid development of RPA solutions, which thus initially contribute more quickly and more valuably to process management and subsequently to process optimisation.

In the study subject, the enormous increase in employees due to the pandemic and the associated increase in IT systems has led to a very large number of disparate individual systems in a short period of time, representing a confusing and heterogeneous operational IT system landscape. Due to these differences in the prerequisites of workplace systems, the action research conducted in P15 identifies two approaches to develop RPA solutions under high time pressure with low time expenditure. The joint elaboration and development of the RPA solutions by and with the employees, considering all the experiences of the researchers in the use of a respective RPA solution, the collected error data, and the documentation (consisting of project status reports, RPA execution protocols, development histories) enables the derivation of the solution approaches presented below:

1. *Use of an RPA solution as a translation layer*
2. *Incremental RPA development*

The result from P15 and contribution to this thesis describes the use of an RPA solution that captures the environment variables of the respective operating system and adds a translation layer. This translation layer is developed as a standalone RPA solution and acts as a prerequisite for the use of all other RPA solutions. This RPA-based translation layer is used to identify initial sources of errors such as inconsistent software versions, different folder structures or drive naming. The translation layer then creates a layer with consistent dependencies, links, and configurations for the operating system's environment variables.

In P15, the effect of creating a translation layer between the original system and the actual RPA solutions to automate sub-processes is that these RPA solutions can be scaled faster with less time. According to the interviewees, this avoids serious conflicts, setup errors and system crashes, allowing the respective RPA solutions to work without obstacles and without rework. Additionally, the interviewees mentioned, that the autonomy of the RPA application was ensured and continuous thesis without downtime under high time pressure could be guaranteed.

The following Figure 4-9 visualises the result as the use of the RPA translation layer. The left side reflects the conditions in the heterogeneous system landscape and illustrates that an application of RPA solutions to automate administrative tasks cannot work without a holistic system restructuring.

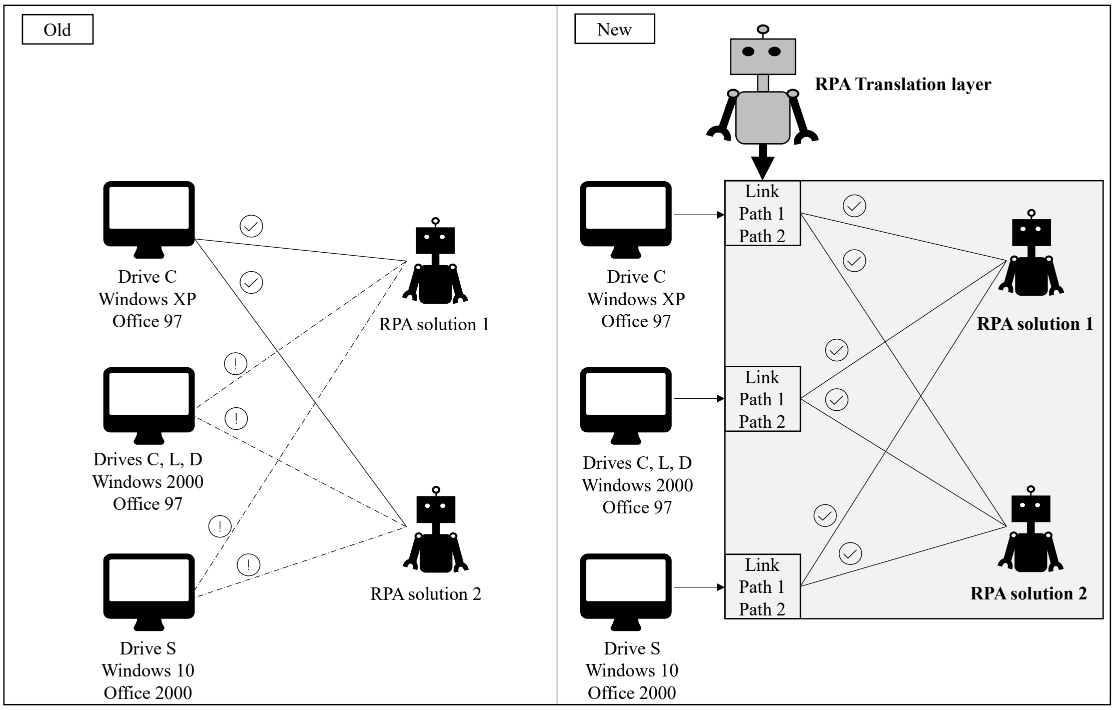

Figure 4-9: Schematic representation of the RPA translation layer in P15

The further development of RPA solutions in P15 on this basis makes it possible to quickly deploy the various RPA solutions for process management in different system environments with little or no change and installation effort. In this way, a valid and uniform environment for the process management agent is created, on which a directly executable development of RPA solutions is then guaranteed.

The solution approach presented in P15 initially leads to an increased effort in recording, identifying, and assigning the described error types, especially the various environment variables and operating system parameters. However, as P15 progresses, the RPA-based translation layer measurably reduces the effort required for change, installation, scaling and deployment processes on other systems. As the action research within P15 progressed, a faster development process and a higher quality of RPA solutions were demonstrated. On the one hand, this is reflected in a lower production of errors. On the other hand, the processes through the RPA applications show more flexibility in terms of adaptability and less downtime ergo also the reduction of resource consumption.

The second approach identified and explored as a result of P15 to accelerate the development of RPA solutions describes the incremental development of RPA solutions and the flexible process management required for this. This approach includes the deliberate selection and partial automation of process increments, i.e., individual sub-processes, as well as the targeted deployment and selected use of these RPA solutions.

When RPA solutions are first deployed on the employee's operating system, the described system customisation processes are first consistently implemented with a corresponding RPA solution. Only then did the process manager prioritise the RPA solutions to be developed at the sub-process level. In P15, an RPA-based translation layer was developed for system homogenisation. This homogenisation of the system landscape made it possible to establish compatibility between the individual RPA solutions. This made the solutions compatible between end-user systems and allowed them to be shared between organisational units. Instead of automating a process in its entirety with RPA, the individual process sections, i.e., the sub-processes, are now considered and prioritised for automation.

4.2.4 Synopsis

Following the same research procedure as in the previous chapters, RQ4-6 (in P6-15) taken together and condensed can justify the following hypothesis testing against the background of the research objective and the hypotheses formulated in Section 4.1.4. The hypotheses formulated there were tested for their validity based on the respective research questions and could all be confirmed in consequence by this thesis. For this purpose, multi-perspective (public service, health care, industry) and cross-method (Case Study Research, DSR, Action Research) research approaches were used.

The summary of the hypothesis testing is presented in Table 4-4 and provides an overview of the specific research contributions discussed above, as well as the associated research areas, research questions (RQs) and publications (P), and hypotheses raised. For the two research areas (HT and HF) of this thesis, the results are broken down as follows: For HF, these are represented by the symbol *F*. For HT, the result of the respective verification is symbolised by a *V*.

Table 4-4: Overview of hypothesis

Research area	Section	RQ	Research method	P#	Hypothesis 1	Hypothesis 2	Hypothesis 3
Hypothesis Formation	4.1	1	Grounded Theory	1	F	F	F
				2	F		
	4.2	2	Sentiment Analysis	3	F		F
	4.3	3	Text Mining	4	F		
				5	F		
Hypothesis Testing	4.5	4	Case Study Research	6	V		
				7	V	V	V
				8			V
				9	V	V	V
				10	V		V
				11	V	V	V
	4.6	5	Design Science Research	12	V	V	V
				13			
	4.7	6	Action Research	14	V	V	V
				15	V	V	

Hypothesis- F= Formation; -V= Verification

5 Conclusion

To conclude this thesis this chapter, first, classifies and summarizes the treated contributions (P1-15) to the linked RQs (RQ1-6) and to the three extracted hypotheses. Second, this chapter summarizes the main contributions to theory and practice. Finally, in the last section, limitations of this research are mentioned to evaluate their generalizability and link them to future research opportunities.

5.1 Contributions and Retrospect

RQ1: *What are the drivers and barriers for the adoption of RPA and PM?*

This thesis provides five contributions to RQ1. This thesis has shown that ten drivers and barriers to the adoption and use of RPA and PM have been identified. In the three case study companies studied, the successful adoption of these technologies depends in particular on expected efficiency and effectiveness gains, perceived ease of use, documentation of the automation solution, traceability, and logging of how an automation solution has worked in the past.

While these first five constructs can be found in the existing literature on technology acceptance and success factors for technology adoption, the following five constructs represent an original contribution to this line of research and their particular drivers and barriers:

- *Perceived (positive) pull of the market*
- *Perceived (negative) pull of the customers*
- *Speed at which the technology executes the process*
- *Feedback the system provides to the user*
- *Provision of a time frame for the user in executing the automation*

In the context of this thesis, it was found that the totality of these examined constructs of technology use intentions are interconnected in two different, overlapping ways. First, usage intention and usage success are strongly influenced by the „*explainability*“ of the RPA solutions used. One possible explanation is that the employees involved changing their role in the business perspective of a BPM by using this technology - namely, from a passive to an active role. Since the subjects in their new role now develop and implement technical solutions for process improvement themselves, they demand complete traceability and controllability of this technology, which is not yet provided by the existing application systems to a sufficient degree to increase the intention to use it. This fact rises the less IT competence the respective user has.

In summary, it can be described that with the use of technology, the change from a purely executive role to a shaping role, the self-image regarding one's role in BPM also changes. This leads to the conclusion that the subjects of the study no longer focus stringently on gaining effectiveness, but rather on the quality of execution and the control mechanisms, e.g., the lower execution speed of RPA for control purposes, due to the „*responsibility*" the user has gained.

RQ2: *What are the main positive and negative topics in the life cycle of RPA technology*

This thesis makes the following three contributions to RQ 2. The first contribution is that the analysis of news articles published between 2015 and 2020 on the topic of RPA shows that the general media continue to cover the topic at a high level and with high frequency. This level has remained stable over the last two years of analysis. This thesis shows that there is no evidence of a decline in media attention to RPA so far.

The second contribution of this thesis to RQ2 is that the polarity of the news articles analysed shows the very positive media coverage of RPA in the beginning of the observed and analysed timeslot. From 2016 to mid-2018, the polarity turned negative before turning positive again in the last two years observed. This indicates that public perception went through a phase with a more fearful narrative. During the same period, the articles became more objective as their subjectivity scores decreased linearly over time.

The third contribution to the research question two is that the topic modelling analysis reveals that RPA is perceived as a more mature technology that can now be used to solve important problems both in companies (e.g., the future of work) and in society at large (e.g., the impact of Covid-19 pandemic). The most modelled and measurable positive themes were cost reduction, future of work, and accuracy, while fear of job loss was the most important negative theme. However, the extreme polarity of the measured themes decreased steadily over the years of news article publication, and at the same time, the objectivity of the news articles increased - these changes in the leading themes also suggest that more realistic use reports of the technology over time in the media reduced workers' fear of e.g., job loss.

RQ3: *What conclusions can be drawn from job advertisements regarding the dissemination, use and implementation of RPA and PM?*

This thesis makes two specific contributions to RQ3. The first contribution is how exactly the field under study deals with and handles the concept of digitalisation and technological change. For this purpose, the analysts of the job advertisements were asked, among other things, about the requirements for digitalisation in BPM. It turned out that future employees should particularly be focused on flexibility and lifelong learning, the management of efficient processes, networked processes, and proactive action. The new employees should support and implement these changes, and thus be able to implement the new requirements in a targeted manner, mostly within the framework of projects. At the same time, it is clear that the employees should support and help to shape the change. To this end, increased personnel development has been identified above all. It includes further education, training, supervision, and coaching.

The second contribution of this thesis to RQ3 is that the studied sector does not seem to have an active and clear vision and strategy for the issues and applications of RPA and PM. Thus, it was found that there is a lack of concrete competences and competence profiles for the deployment or use of these concrete technologies. This suggests that companies believe that technologies such as PM or RPA do not require employees to have any special skills or abilities to deploy, implement, use, or maintain them.

RQ4: *What are the drivers, barriers, and impacts when using RPA and PM in practice, and what optimisation opportunities can be derived from this?*

Based on the research conducted, this thesis developed three hypotheses to be tested in practice. Against the background of these hypotheses, this thesis was able to make the following three contributions to RQ4.

Hypothesis 1: *The introduction and use of RPA and PM is even more effective the better the requirements of the application systems for the IT competencies of the users match their actual existing ones*

The research presented in this thesis has shown that this hypothesis is true. In this thesis, this is evidenced by the fact that technologies that are often described as user-friendly or end-user centred often have a much higher demand for complexity in practice. This contrasts with the much lower level of skills and competencies required as described by vendors, the literature, and our research in the context of job advertisements in RQ3. Although it is generally assumed that increasing process knowledge of a user, remains in more efficient use of RPA and PM, the research in this thesis has shown that while this is also true, the IT skills required for successful implementation account for a measurably significant proportion. However, this has not yet been addressed either in the research discipline of RPA and PM or in practice, e.g., among the decision-makers themselves, and forms a research gap.

Hypothesis 2: *The traceability of process instances to be supported by RPA and PM applications increase their effectiveness*

The contribution of this thesis concerning hypothesis two and especially RQ4 is that this hypothesis can be considered valid. The change in the work process in the sense of a shift in responsibility is a major reason why the research subjects see a deficiency in the design of the previous application systems for RPA and PM. The employees and in particular the end users become developers but are fully responsible for the correctness of the execution of the automation by the RPA solution. This means that they also take qualitative responsibility for the correctness of the process execution through the technologies they use and design. From the point of view of the users studied, this requires differently designed application systems than those used so far. These management principles then place demands on better controllability, especially better traceability.

Hypothesis 3: *The compact visual process representation to be supported by RPA and PM applications will increase their effectiveness*

In connection with RQ5, Hypothesis 3 could also be confirmed in this thesis. Although the presentation and design of the application systems are designed for a visual and low-threshold elaboration of the respective solutions, the likewise required visual embedding in the overall process context is missing. Without the embedding, the examined users could neither recognise the context of the solutions as in the RPA environment of automation of a superordinate process or business process. This was also not possible for the examined users when classifying and linking the PM results. In both cases, the interpretability and meaningfulness were significantly reduced and the intention to use was impaired as a result. For RPA, therefore, more extensive modelling of the higher-level process context had to be conceived to enable the users and the measurability of the respective automation also as a means of differentiation. For the PM application systems, the underlying database and the associated data connectors and interface processes had to be designed in a better, more compact, and more visual way to be able to classify the results by the users in terms of their value, consistency, and correctness.

RQ5: *How can process management be optimised through RPA and PM?*

Based on the research conducted, this thesis developed three hypotheses to be tested in practice. Against the background of these hypotheses, this thesis was able to make the following three contributions to RQ5.

Hypothesis 1: *The introduction and use of RPA and PM is even more effective the better the requirements of the application systems for the IT competencies of the users match their actual existing ones*

This hypothesis could be declared correct concerning the investigation conducted in RQ5 of the thesis. Thus, the method for integrating PM into Six Sigma presented in this research required not only in-depth process knowledge but also the necessary IT competencies, which have not been considered by those responsible in practice so far and led to problems in the integration capability of the solutions. The recourse to the corresponding IT department was necessary for the functionality of the solution, but then it did not make it possible to independently classify the data streams correctly, comprehend them, or interpret them conclusively. Although the possibility of using the solution for Six Sigma could be demonstrated and a corresponding methodology could be developed, there are also further findings here. The application of the statistical PM approaches seems to be problematic for practitioners, as they cannot judge the consistency of the data basis. This led to different assessments of the feasibility and usefulness of the application systems of the different Six Sigma phases (along the DMAIC cycle).

Hypothesis 2: *The traceability of process instances to be supported by RPA and PM applications increase their effectiveness*

Hypothesis 2 could also be declared correct about the investigation carried out in RQ5 of the thesis. As this work shows, the measurements and correctness checks were heavily dependent on the process knowledge of the individual users. Thus, on the one hand, the necessary IT expertise for initialisation was lacking, and the application systems used also did not allow any usable conclusions to be drawn. On the other hand, the application systems used did not allow any usable conclusions to be drawn about the database used without the necessary expertise. Thus, the research here shows that the results were ultimately not comprehensible and thus in many cases not usable. The methodology could therefore not be designed and created for all phases of process improvement within the Six Sigma concept with the same operability, instrumentalization, and usability. Regarding the use and acceptance, the corresponding integration methodology had to be adapted. This had to be designed in such a way that transparency and traceability could be created for the users and thus trust in the database ergo the data streams could be achieved.

Hypothesis 3: *The compact visual process representation to be supported by RPA and PM applications will increase their effectiveness*

This Hypothesis 3 could also be declared correct about the research conducted in RQ5 of the thesis. The usefulness for the mentioned research subjects, who could not be assigned to an IT or IT-related competence profile, decreased rapidly. Against this background, much more visual development of the solution was necessary, as well as the design of a comprehensive visual representation of the underlying database system, the database structure, the use of event logs or links in the overall process, and the integration of the method into a compact visual representation using process maps.

RQ6: *How can - firstly - process management and - secondly - processes be optimised through RPA and PM?*

Based on the research conducted, this thesis developed three hypotheses to be tested in practice. Against the background of these hypotheses, this thesis was able to make the following three contributions to RQ6.

Hypothesis 1: *The introduction and use of RPA and PM is even more effective the better the requirements of the application systems for the IT competencies of the users match their actual existing ones*

This hypothesis could also be explained as correct concerning the research conducted in RQ6 of the thesis. The development, use, and maintenance of RPA and PM application solutions also proved to be difficult, error-prone, and characterised by a long and high number of repetitions for certain user groups. These user roles are consistently characterised by users with low IT competency profiles, while users with higher IT competencies achieved significantly faster results. In this thesis, it was shown that through the research conducted, a methodology in terms of a redesigned development process for RPA could be applied.

Hypothesis 2: *The traceability of process instances to be supported by RPA and PM applications increase their effectiveness*

This hypothesis could be declared correct in relation to the research conducted in RQ6 of the thesis. According to this research, the problems that users had in using and applying the application systems were mainly due to problems with the heterogeneous infrastructure of the information system. These were mainly system variables and environmental parameters of the respective operating systems. By supporting the homogenisation of the systems through design principles and thus reducing the system environment-related problems, development processes could be carried out faster and with fewer errors and thus also with fewer iterations. These effects were particularly evident with less IT-experienced users. The resulting prescriptive design knowledge suggests that the elimination of system inconsistencies and outdated frameworks can positively influence the comprehensibility of error messages by users within the RPA deployment and thus the intention to use them.

Hypothesis 3: *The compact visual process representation to be supported by RPA and PM applications will increase their effectiveness*

This hypothesis 3 could also be declared correct concerning the research conducted in RQ6 of the thesis. Therefore, this thesis conceived the design of visually visible traceability options in the PM environment that led to a significant increase in the manipulation security of the data and thus its usability. To this end, drill-down options were provided to link raw data to more advanced PM results, while traceability was supported by visual components to provide a low-threshold entry point for less IT-experienced users. The source codes of the inbuilt pre-configured database connectors that extract the event logs were converted to the *GraphML* format. This format for the exchange of graph structure data enabled their representations as formal models with interaction possibilities for the users. This led to an increase in the intention to use and acceptance of the PM application system.

5.2 Limitations

The results presented in this cumulative thesis and the solutions developed are not without limitations. Since the individual limitations have been discussed in the respective publications (*Part B*), six general limitations of the entire thesis are summarised in this section. This section is structured by the limitations regarding each RQ of this research.

As it is an empirical method, this contribution to RQ1 presented here is subject to some limitations. First, our results are not readily transferable to other organisations outside the two domains studied, namely sports clubs and the health sector (Flick et al. 2004; Yin 2018). While this thesis assume that the results also apply to other, more traditional, or conservative types of organisations, further research is needed for this.

Second, the thesis relied on a limited data set of eleven respondents in total (Yin 2015). Although it is also based on additional sources of knowledge and theoretical saturation could be reached after the data collection presented here, the results could still be biased (Charmaz 2014; Yin 2015). One of the main criticisms of the grounded theory methodology carried out is the low generalisability due to the naturally different interpretation backgrounds (Bryant and Charmaz 2007; Chun Tie et al. 2019). To ensure the underlying quality criteria of plausibility (Bryant and Charmaz 2007; Glaser and Strauss 2017), trustworthiness (Corbin and Strauss 2014) and credibility (Bryant and Charmaz 2007), an attempt was made to make all relevant information as well as each step of analysis in the research process transparent. To this end, quality assurance procedures were applied, which included the formation of a research group during the research process (Wiesche et al. 2017) to exchange information about the research and evaluation process and to code the extracts together using special evaluation software

(Hutchison et al. 2010). However, there is still room for a more detailed longitudinal study to further explore the findings on the hypotheses raised and their implications.

Third, all data presented here came from direct staff or project managers. Data collected from external people could of course provide further insights here (Flick et al. 2004; Kaplan and Maxwell 2005). Finally, while this thesis did not explicitly review the academic literature on the adoption (Glaser and Strauss 2017), integration (Chun Tie et al. 2019), or design (Wiesche et al. 2017) of these types of technologies, instead of following established guidelines for the grounded theory working method (Charmaz 2014; Glaser and Strauss 2017), our research may, of course, have been influenced by our prior knowledge of theories in the field.

The limitations of RQ2 are, on the one hand, that computer-aided sentiment analysis generally has technical limitations in recognising certain aspects of natural language (e.g., idioms or irony) (Aggarwal and Zhai 2012; Chintalapudi et al. 2021). It can be assumed that such elements of language are not correctly recognised in the texts studied and thus possibly distort the results and interpretations of individual moods (Cambria et al. 2017). However, since this thesis analysed texts that are objective in their linguistic nature, in the form of news articles, it can be assumed that this limitation is irrelevant (Allahyari et al. 2017; Liu 2010; Schumaker et al. 2012). Secondly, descriptive text features and meta-information such as text length, number of certain technical words, etc. were not given extra weight (Pang and Lee 2008; Vinodhini and Chandrasekaran 2012). The reputation and reliability of the sources were not evaluated either. Nevertheless, due to the large number of text elements examined, it can be assumed that valid data was used for the analysis (Liu 2010; Pang and Lee 2008).

The limitations of this thesis in addressing RQ3 are first that only snapshots of 33,643 job vacancies advertised on a single platform for public sector jobs in Germany between August 2019 and September 2020 were analysed. Although this is relatively extensive in a scientific comparison, it still only represents a section of a period of time. Seasonal or interseasonal (Aken et al. 2010) effects or exogenous factors (Debortoli et al. 2014) were not considered. Secondly, the text mining method is subject to technical limitations (Aggarwal and Zhai 2012; Debortoli et al. 2014; Kayser and Blind 2017). These lie in computational knowledge discovery, which is based on a mixture of information technology data mining methods and natural language processing (Feldman and Sanger 2008; Kumar et al. 2021). The topic modelling algorithms used in this thesis, which in turn are based on machine learning approaches combined with natural language processing, naturally have limited result accuracy and expressiveness (Allahyari et al. 2017; Blei 2012; Feldman and Sanger 2008; Manning et al. 2009). This is because the information extraction method presented here is based on a three-stage hierarchical Bayesian model and is therefore susceptible to overfitting (Islam et al. 2007; Kayser and Blind 2017; Mimno et al. 2011). In this type of text mining as a research method, this is an inherent limitation that is a direct consequence of the linguistic complexity of the analysed text and its drain of irregularity (Debortoli et al. 2016; Feldman and Sanger 2008; Kumar et al. 2021). Nevertheless, due to the high number of job descriptions, a suitable data field was assumed, which can be used well for quantifiable comparisons and content-based qualitative analyses (Debortoli et al. 2016; Manning et al. 2009).

The limitations of the contribution of this thesis by RQ4 are the inherent limitations of this type of case study research in the form of participant interview bias and due to the usually limited number of respondents (Kaplan and Maxwell 2005; Recker 2021), processes covered (Myers and Avison 2002), and organisations studied (Recker 2021; Yin 2015). The use of perceived findings from the participant interviews conducted always comes with the limitation that these are also to some extent highly subjective (Recker 2021; Tashakkori and Teddlie 2007). One of the limitations of this thesis is that the results may not be generalisable (Yin 2018). Due to these limitations, this thesis has nevertheless attempted to conduct as pluralistic research as possible to obtain valid conclusions (Kaplan and Maxwell 2005; Tashakkori and Teddlie 2007; Yin 2013). To this end, this thesis studied eleven different organisations with a total of 43 participants regarding RQ4. Approximately 5,500 minutes of interviews were conducted with the participants. Other data obtained included event logs, program source codes, change logs, database schemas, program flow charts, bug reports, interface definitions, progress reports, project documentation, installation logs, test and verification reports, acceptance reports, requirements specification, and system test case specification (Tashakkori and Teddlie 2007; Yin 2013). In addition, only the RPA development environment *UiPath* and the PM application system *ProM* and *DISCO* were used to establish comparability between the case studies. It should be noted, however, that the information collected is often not fully comparable. Furthermore, in case study research, the natural subjectivity of the researcher in collecting information comes into play (Pries-Heje et al. 2008; Recker 2021). Despite the above limitations, this thesis has shown that case study research is an established tool of academic research in various disciplines (Flick et al. 2004), especially in IS research (Kaplan and Maxwell 2005; Recker 2021; Wohlin et al. 2003). Accordingly, given these limitations, the case studies conducted in this thesis in relation to RQ4 were largely conducted in such a way that the data could be quantified and triangulated through further secondary data collection (Recker 2021; Yin 2018).

The limitations of this thesis in terms of contribution to RQ5 are that the design science projects carried out in this thesis can only represent an initial potential (Beck et al. 2013;

Peffers et al. 2012a). The maturity of the presented method and models is therefore limited to a proof-of-concept level (Peffers et al. 2012a). This means that the results are based on Design Science objects at an early stage (Peffers et al. 2012a; vom Brocke and Maedche 2019). Another limitation is that the research on RQ4 conducted in this thesis has only been applied in two companies and their unique process environments. Although the DSR projects in this thesis have been developed and applied based on scientific publications in close collaboration with the practice companies, a scaled test outside the companies is still pending (Beck et al. 2013; Helfert and Donnellan 2012; Hevner et al. 2004). The results in this thesis are therefore also based on extensive literature research (Helfert and Donnellan 2012; Hevner et al. 2004; vom Brocke and Maedche 2019). An attempt has always been made to be complete (Helfert and Donnellan 2012), but the methodological bases collected in this way (Pries-Heje et al. 2008), or the previous models are based on findings from the literature that may not be fully comparable or have not been fully recorded (Helfert and Donnellan 2012; Peffers et al. 2012a). This is of course also due to the always different study designs and the different focus and range of participants (Helfert and Donnellan 2012; vom Brocke and Maedche 2019) or study subjects in the underlying literature (Peffers et al. 2007). To ensure further and broader generalisability (Beck et al. 2013; Pereira et al. 2013), further evaluations (Gregor et al. 2020; Peffers et al. 2007), also over longer periods of time (Pereira et al. 2013; vom Brocke and Maedche 2019), must therefore be carried out under different, operational (vom Brocke and Maedche 2019), infrastructural (Beck et al. 2013; Pereira et al. 2013) and personnel conditions (Gregor et al. 2020; vom Brocke and Maedche 2019). This could mitigate the limitation of the possibly low generalisability and low maturity of the models and methods developed here to other areas and requires further empirical testing and replication of the DSR cycles (vom Brocke and Maedche 2019).

The contribution of this thesis to RQ6 is initially limited by the fact that the action research presented is restricted to a health department and an auditing company. However, despite the rather focused area of experimentation, it can be assumed that the results are transferable to many other companies and other areas of application due to the comparable process structures (Davison et al. 2004).

The Covid-19 pandemic also limited generalisability and comparability of this thesis due to the very specific framework conditions that cannot normally be taken as given. To properly assess these limiting conditions against the background of the theoretical contribution (Davison et al. 2004), the context of operational conditions during the pandemic must be taken into account. This manifested itself in significantly changed process behaviour in terms of process volume, frequency of process changes, new IT solutions or systemic framework conditions, or even in the creation of completely new processes at short notice. These pandemic conditions must be taken into account when considering the generalisability, comparability, and knowledge contribution of this thesis.

Moreover, the objectivity of the results of action research is always limited (Sein et al. 2011). The approaches presented are primarily based on data that were not collected quantitatively and are therefore naturally exposed to a certain degree of subjectivity (Davison et al. 2004; Kemmis 2014). The action research methodology used is also limited by the fact that subjectivity can be amplified by the researcher involved and the bias that may exist in the analysis of the results (Cole et al. 2005; Kemmis 2014). This is because the cyclical research process in action research is focused on understanding and action (Cole et al. 2005; Kemmis 2014), so there is always a direct, but also indirect dependency between the involved collaborators and the results (Kemmis 2014; Peffers et al. 2007). Accordingly, although the approaches presented were developed in and together with practice, there was no testing (Kemmis 2014; Kitchenham et al. 2002), evaluation (Kitchenham et al. 2002; Kock 2004), or reproduction (Kemmis 2014; Sein et al. 2011) of the results in other contexts (Davison et al. 2004; Kock 2004). These limitations should be addressed in the future by demonstrating the quantitative impact of the presented approaches on project success to ensure further validity (Davison et al. 2004; Kemmis 2014) and generalisation (Baskerville and Wood-Harper 1996; Sein et al. 2011). Further evaluations need to be conducted in other organisational contexts, including over longer periods of time (Davison et al. 2004; Kemmis 2014), using other research methods (Kitchenham et al. 2002) that do not involve researchers too much (Baskerville 1999; Kock 2004).

5.3 Implications for Research and Practice

The results of this thesis provide new motivations for action in the design of RPA and PM application systems through the corresponding use at the respective end user regarding the optimisation of process management and processes. The results contain both - concrete recommendations for practitioners and promising suggestions for further research efforts. They result from a consideration of the underlying 15 research papers, all of which contain extensive practical implications and are compiled and summarised here. In the following, the implications are structured firstly according to the design of the concrete RPA and PM application systems and secondly according to the design of the BPM for the use of these application systems. The concrete implications can be summarised as follows:

Design of the application systems in practice

The practical design knowledge created by this thesis and summarised in the contribution of the research presented here is that this thesis has identified and explored implications for the adoption, usability, intention to use, and success of RPA and PM application systems that promise concrete practical benefits or address practical sources of problems. The conceptual and technical solutions identified can be enumerated as follows.

First, the results show how the perceived usefulness of the technologies is influenced. The thesis can recommend vendors of RPA and PM application systems to use these perceptions to develop a coherent and consistent strategy for user-centred technology deployment. For example, vendors of RPA and PM technology systems should consider the identified drivers and barriers when designing their application systems at the time of implementation and later during use. In this way, vendors can reduce potential barriers to the adoption of their solutions and contribute to improved adoption and solutions. The thesis has shown that the intention to use and the success of the technologies correlate with the information technology knowledge and skills of the users. If the solutions are to continue to be useful in practice for the widest possible range of users, the problems associated with the use of the technologies should be addressed in a design-oriented manner. In this context, the results here have shown that while users are aware of the process and have a high level of process knowledge, they are generally unaware of the integrated systems in which the solutions are used. This leads to problems as the RPA and PM application systems work within immanent operating system boundaries and their functionality very often depends on recourse to multiple operating system processes. However, the users usually do not have the necessary background knowledge to adequately identify or solve the resulting problems. In this case, the design shown in this thesis can minimise the sources of errors on the operating system side by homogenising the system environment. As shown in the thesis, this contributes significantly to increasing the usefulness and acceptance of the solution.

Secondly, the main finding of this thesis becomes clear, which lies in the employee-centred design of RPA and PM application systems. From a practical perspective, the contributions gained in the thesis offer implications for target group suitability. Accordingly, the thesis provides insights that can be summarised under the three hypotheses raised in the context.

In addition to the goal of making the development of RPA and PM application solutions as self-explanatory and low-threshold as possible, e.g., users do not write any program codes, but use purely visual programming in the form of graphic pictograms, building blocks, and modules. It is also a question of making the execution of these solutions even more explainable and comprehensible, to give employees complete transparency about the process for which they are responsible.

The results of this thesis show that in contrast to the hindering factors previously identified in the literature, the constructs formed are primarily rooted in the designated „*traceability*“ in the use of RPA and PM technologies. The contribution of this thesis in this context was a design of the adaptation option of the execution speed to the wishes of the user, who could thus track and control the execution of the solutions. Other design contributions were the representation of temporal sequences of solution execution to show where a solution was at the time, i.e., which activities had already been completed and which still needed to be done. This was achieved through a simulated flowchart of the automation process, which graphically accompanied the automation process in a meaningful way and was visible to the user. This thesis was able to contribute to the fact that it is possible to technically counteract the perceived loss of control of the employee when using these technologies. The results of this thesis contribute to the critical factors of RPA and PM development and thus to the increase of willingness to use these solutions. The design presented within the thesis and research contributions shows that a simple representation of contextuality, considering the overall process in which automation takes place, already leads to positive effects. Consequently, the design of application systems in the future should also visually pick up on and represent much broader embeddings and contexts within the development environment.

Design of the application systems in research

For research, this thesis offers numerous new and novel starting points and perspectives for further reflection and consideration. The constructs of traceability have not been addressed or have been insufficiently addressed in the established scientific literature on RPA and PM. The issue of loss of control, which has been identified as a novel obstacle in this thesis, should also be further addressed in this regard. This research should happen especially against the background and in connection with the contextual adaptation of the role understanding of BPM managers. The prevailing narrative that information technology competence need not be necessary or subordinate to the use of application systems should be broken down, dissected, and reflected upon more critically than has been the case to date. New underlying issues and aspects may need to be included in the required skills of BPM managers, e.g., concerning a profound detailed knowledge of data flows, database schemas and operating system processes, in order to realise the full potential of software enablement for BPM. Future research should therefore expand the scope and diversity of analysis in dimensions such as new application areas.

To this end, in addition to behavioural science methods, such as case studies, researchers could also use more focused design research methods to observe or generate more real cases and thus more real problem and solution spaces. Further research is needed on how to create and measure real value for organisations using technologies, such as RPA and PM . Future research needs to address the specification and quantification of these indicators. Research knowledge must be guided by these indicators and the success of research must also be measured against them.

Design of process management in practice

This thesis also provides three contributions to new insights on the integration and integrability of these new technologies regarding BPM. These are divided as follows:

First, it is shown that, contrary to the objective presented and demanded in the scientific discourse, RPA cannot only automate existing business processes. As a contribution, this thesis shows that the use of RPA can also meaningfully optimise infrastructures through new and even novel processes and offers added value in system optimisation itself. Thus, this thesis offers a new starting point for existing RPA research and makes a significant theoretical contribution in the form of an innovative application of RPA in a previously unexplored deployment scenario in the context of BPM. Therefore, this thesis can contribute to the existing research strand on the benefits and possible deployment scenarios of this technology. Accordingly, a discourse space opens here to further reflect on the possible use of RPA for a new concept of BPR activities.

Secondly, this thesis also shows that BPM and RPA can be combined very well to achieve a higher level of automation of business processes even faster, so that RPA can be integrated into a BPM solution and thus enhance the solution. In this way, the thesis creates a contrast to previous literature, which claims that BPM, in contrast to RPA, offers an environment in which processes are continuously improved, but exactly this possible process improvement can also be achieved by RPA or PM. Through targeted use, completely new, previously impossible processes can be created. Or new, previously impossible integrations of process concepts, such as the „*Flexibility by design*“ theory, can be incorporated into existing and established process structures and applied. Accordingly, the conclusion can be drawn here to redesign the previous integration of RPA as a skeletal sub-instrument of an overarching BPM. A redesign of BPM based on the new possibilities of RPA seems to be a partial counter position to the established research in this field but can draw on the empirical foundations mentioned in this thesis.

Thirdly, the competence assumption and equipment of future and current business process managers' competences, self-image and role understanding will have to be readjusted.

The expectation that technology will increasingly turn and adapt to the competence profiles of users may, as shown in this thesis, lead to a simplification of use, but has the consequence that existing process managers will have to significantly upgrade their competences. In particular, the underlying operating systems need to be explored in detail to fully understand, evaluate, and apply the benefits of the technologies. The RPA application systems run on the graphical user interface but use inherent functionalities of the operating system to be able to work performantly and with the widest possible application radius. A lack of awareness of the process flows inherent in an information system can therefore quickly limit the potential of an RPA solution and, in the worst case, even prevent errors from being detected during execution. It is not enough to rely on aggregated results from the application systems; without knowledge of the underlying data structure and data origin, the allocations then made are not verifiable, not classifiable, and thus not traceable.

Design of process management in research

This thesis provides some new insights that are worthy of further consideration by the research community, especially because the topics of RPA and PM continue to keep the field of BPM research very busy and will continue to do so in the years to come. The shift in the required competencies of process managers and BPM experts needs to be reviewed in this regard. This thesis shows that the penetration of business processes by, but also with, digital technologies require an adjustment of the self-image of future process managers in the direction of the required IT competencies, especially in the direction of databases, data science, and beta systems, for which further research will be necessary. The integration questions of how or with what IT technology can support, complement, and also change BPM are already being dealt with comprehensively by the established science in this area.

For this current BPM research, especially for research in the field of the integration and linkage possibilities of new technologies with BPM, this thesis provides new insights and perspectives for further research. In the established literature, both RPA and PM are usually declared as part of a toolset to be integrated for BPM or specific BPM tasks and usually do not focus on the improvement of processes, but only on their automation.

This thesis shows that this view needs to be supplemented, as new and novel business processes can very well be realised with RPA technology that would not be possible without the use of the technology. For example, RPA- or PM-based activities can already be used in business process design, e.g., to map subtasks in the form of a design designed for maximum automation possibilities or to generate the necessary process infrastructure as shown. It should therefore be scientifically investigated further whether RPA solutions can not only be a supplement to BPM but also to BPR, to enable a revolutionary process redesign here, where this has not been possible so far. The limitations mentioned in Section 5.2 need to be addressed in particular through more comprehensive studies that cover several areas and extend over a longer period of time.

PART B

6 Preserving the Legacy - Why Do Professional Soccer Clubs (not) adopt Innovative Process Technologies? A Grounded Theory Study

Table 6-1: Fact sheet publication P1

Publication Type	Journal
Publication Outlet	Journal of Business Research
Ranking[1]	**B**
Authors	**Name** Plattfaut, Ralf Koch, Julian
Status	Published
Full Citation	Plattfaut, R.; Koch, J. (2021): Preserving the legacy - Why do professional soccer clubs (not) adopt innovative process technologies? A grounded theory study. In: *Journal of Business Research* 136, S. 237-250. DOI: 10.1016/j.jbusres.2021.07.024.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Preserving the Legacy - Why Do Professional Soccer Clubs (not) adopt Innovative Process Technologies? A Grounded Theory Study

Abstract:

Technologies such as Robotic Process Automation or Artificial Intelligence are becoming increasingly recognized as essential elements and engines of digital transformation in businesses today. However, especially in the professional sports industry the adoption of these technologies appears to be lacking behind. This paper aims to give a deeper perspective and understanding on the drivers and inhibitors of adoption and use of innovative process technologies in professional sports. To this end, we conduct a grounded theory study of data collected from two German professional soccer clubs, one from the first league (Bundesliga) and one from the third league (3. Liga). Our study shows that adoption depends upon expected efficiency and effectiveness gains, perceived ease of use, perceived (positive) market pull, and perceived (negative) supporter perception. While the first three constructs are well known in technology acceptance literature, the latter two are comparably new in this research stream. We thus especially discuss the impact of perceived positive market pull, i.e., a pull from clubs' sponsors and competition, and perceived negative supporter perception, i.e., the fear that customers might lose loyalty due to increasing process digitalisation, on adoption and use of innovative process technologies in professional sports.

6.1 Introduction and Motivation

In 2019, a publication of the world's largest annual multi-segment convention for the sports industry has posed a provocative question: „*Is the sports industry oversleeping the process of digitalisation?*“ (Thieringer 2019). This practice-related question emerges as virtually all organisations around the world are engaged in the digital transformation. Although there is no common definition for the term, it is clear that in the course of digitalisation new technologies can be used to innovate products, services, processes, and business models (Ali and Park 2016; Armbruster et al. 2008; Potts and Ratten 2016; Wiesböck and Hess 2020).

In line with such an understanding and focusing on sports management, Ratten calls this technological innovation and sees the need for sports management to invest in innovative technologies that can support new or improved products, services, processes, or business models (Ratten, 2016). Here, Ratten explicitly calls for more (also qualitative) research on sports technological innovations from a previously neglected administrative perspective, a demand that is consistent with the provocative question mentioned above.

These innovative technologies have many facets. One is innovative process technologies, a group of technologies that can be used to radically change the way business processes and services are executed and delivered (Lacity and Willcocks 2016; van der Aalst et al. 2018b; Willcocks 2020). Examples for these innovative process technologies include Robotic Process Automation (RPA), Cognitive Automation, and Artificial Intelligence (AI). These innovative process technologies can affect the entire organisation having an impact on business performance (Armbruster et al. 2008; Attaran 2004; Hammer 2010). They are therefore of interest to sports managers responsible for the administration, control, and organisation of operational procedures and economic performance of sports clubs. In the next few years, all procedures and processes in these clubs will probably be converted to digital procedures or completely rethought (Ferreira et al. 2020; Fleischmann and Fleischmann 2019; Ratten 2018; Ratten and Dickson 2020; Stark 2020).

In this article we focus on innovative process technologies which support innovation of both services (or, service innovation) and internal business processes (or, administrative innovation) within the professional sports industry (Ratten 2016). Within this industry, especially professional soccer is of particular interest as it had to rapidly scale in the last years from national to international activities and had to adapt accordingly (DFL Deutsche Fußball Liga GmbH 2020). McKinsey even puts the speed of economic growth of German soccer at ten times that of German industry (Netzer et al. 2015). At the same time, regardless of their economic success, most sports clubs are by nature old-fashioned constructs with deep local roots and a high degree of cultural preservation (Gibbons

2016). As illustrated by the provocative question from the beginning, adoption of innovative process technologies in the professional sports industry seems to be lacking behind. As such, we formulate two research questions:

RQ1: *What are drivers and inhibitors for the adoption of innovative process technologies in professional soccer?*

RQ2: *How far do these drivers and inhibitors match the established technology adoption theory?*

To conduct this research, we employ the grounded theory method. This method is an established procedure in qualitative social research for this kind of acceptance research, as it combines the greatest possible openness towards the research subject with rule-based theory formation (Glaser and Strauss 2017; Urquhart and Fernández 2016; Wiesche et al. 2017). For this purpose, we identified and examined two professional German soccer clubs, both of which can look back on a history of more than 100 years. One club is economically very successful in the first division, the other club has completely different economic conditions and plays in the third division.

Our results suggest that the adoption and use of innovative process technologies in professional sport is influenced by five variables. Firstly, expected process efficiency gains refer to the expectation of decision makers in sports clubs that innovative process technologies improve process efficiencies. Secondly, expected process effectiveness gains capture the expectations of decision makers that processes become more effective through innovative process technologies. Thirdly, the adoption is also influenced by a perception of the ease of use of said technologies. Fourthly, we contribute a new antecedent of technology adoption: perceived positive market pull. This variable can be related to brand image fit as discussed in marketing literature. However, our study also suggests that decision makers tend to adopt innovative process technologies if they perceive their sponsors to request these technologies. Lastly, we also contribute the new antecedent of perceived negative supporter perception. Apparently, certain decision makers fear that their fans will lose club loyalty when the introduction of innovative process technologies is noticed by fans.

After a presentation of the research background, we will describe our research approach. Then we will present our results. This will be followed by a discussion of our results and contributions to theory and practice. The paper ends with a final summary, limitations, and a short outlook.

6.2 Research Background

6.2.1 Innovative Process Technologies

The automation and digitalisation of business processes using innovative process technologies is considered one of the most important success factors for digital transformation (Aydiner et al. 2019; van der Aalst et al. 2003; van der Aalst et al. 2018a; Willcocks 2020). The current scientific literature describes that any organisation, independent of size and sector, that does not deal with this topic will sooner or later disappear from the market. Because very soon the value-added processes will either be too slow, too expensive (because they are executed manually), or too flawed - and in the worst case all of them together (Aydiner et al. 2019; vom Brocke and Rosemann 2010). As customer requirements are, in this case, no longer met, customers will turn away from the company. Hence, organisations employ innovative process technologies as one way of continuous innovation of services and management (Birkinshaw et al. 2008; Ratten 2016; Vaccaro et al. 2012).

Following Willcocks (2020) we define innovative process technologies as *computer technologies used to mimic cognitive and other functions that humans associate with human mind*. Willcocks calls these technologies „*AI branded*“ and argues that they cover RPA, cognitive automation, as well has strong AI (Willcocks 2020).

Artificial Intelligence can be defined as „*the capability of a machine to imitate intelligent human behavior*“ (Artificial Intelligence n.d.). The foundations of Artificial Intelligence are not new. Early concepts, such as artificial neural networks, were introduced in the 1960s (Schmidhuber 2015; vom Brocke et al. 2018). In a 1984 Delphi study, Dickson and colleagues could show that AI was not among the top 10 information systems management issues. They argued that, while AI was ranked low, it „*may become much more important by the end of this* [1980s] *decade*“ (Dickson et al. 1984). While it took some decades longer, AI is now, due to the increases in computing power and availability of training data sets, in transit from theory to practice (vom Brocke et al. 2018).

Today, we are in the age of the rise of AI, as reported by mainstream media (Lohr 2018). In 2017, self-learning AI algorithms were able to beat any chess or go player (both human or traditional chess computers) (Silver et al. 2018). But AI usage has not stopped in these „*regulated*“ and controlled environments (vom Brocke et al. 2018). Today, organisations are using AI to improve decision making on all levels, e.g., through dynamic pricing and match-making in the taxi business (Cramer and Krueger 2016), Industry 4.0 and improved business models, such as predictive maintenance (vom Brocke et al. 2018) or advanced recommender systems in the tourism industry (Borràs et al. 2014).

As Willcocks argued, a lot of technologies are now AI branded. One example for this is RPA. RPA is one means to automate business processes going beyond traditional core system automations such as Enterprise Resource Planning (ERP) systems (Penttinen et al. 2018; Plattfaut 2019). In contrast to these traditional process automation technologies, RPA can be defined as a technology that allows the easy development of computer programs (i.e., bots) which automate computerized business processes through the usage of a Graphical User Interface (Lacity and Willcocks 2016; Penttinen et al. 2018; van der Aalst et al. 2018a; Willcocks et al. 2017). As such, RPA uses software and algorithms to automate human actions to support efficient business processes (van der Aalst et al. 2018a; Willcocks et al. 2017). Instead of using human labor to type, click, and analyse data in various applications, a software robot is used where it is too expensive or inefficient for humans to perform a task or process (Hofmann et al. 2020; Plattfaut 2019). Especially in volatile professional sports environments, there are rapidly growing demand spikes that can occur seasonally, e.g., at the start of a new season or championship, or quasi-sporadically, e.g., before the match-day (Byers 2018; Lis and Tomanek 2020; Sandy 2017). Particularly during peak demand periods RPA can reduce seasonal operating costs.

Literature on RPA in the related event and tourism industry highlights three main themes where RPA can support organisations: operational efficiency, service quality, risk management and compliance (Enríquez et al. 2020; Ivanov et al. 2017). All of these topics are also highly relevant in the professional sports business environment (Brown et al. 2021; Byers 2018; Higham 2018; Potts and Ratten 2016). However, the adoption and use of RPA as one instance of innovative process technologies in professional sports has not been researched, yet.

There are numerous publications and studies in the field on how RPA can impact and improve operational efficiency in general. Most importantly, RPA saves manual labor and workload (van der Aalst et al. 2018a) with a significant reduction (30% to 70%) in task processing time, process flow, and waiting time (Lacity and Willcocks 2016). Moreover, the processes that are automated through the use of RPA are easily modifiable. RPA robots can be re-configured by changing actions of a process being executed by a worker. This is in contrast to traditional core system automations which require advanced coding to make changes to a system (Penttinen et al. 2018; Willcocks 2020).

There are two main ways how RPA can improve service quality. Firstly, RPA bots can work around the clock, which is an important factor in offering services 24/7 without drastic increase in staff, especially in the tourism and leisure industry (Gretzel 2011; Ivanov et al. 2017; Mendling et al. 2018). Secondly, as RPA automates the tedious tasks (see above), employees can spend more time on value-added work and improved decision making (Lacity and Willcocks 2016), which increases service quality. The need for increases in service quality is of recurring relevance in professional sports business (Blumrodt et al. 2012; Higham 2018; Kuper and Szymanski 2018; Verhoef et al. 2017).

RPA supports the implementation of risk management approaches and process compliance. Exemplarily, the use of RPA reduces erroneous data sets that result from human error. In customer relationship management (CRM), RPA software can keep a log of tasks performed to ensure that automated processes meet regulatory requirements. Through this, compliance and risk management requirements can be fulfilled (Aguirre and Rodriguez; Zhang 2019).

As RPA imitates human behavior, it is sometimes argued that RPA bots are one instantiation of AI (Dias et al. 2019; Tsaih and Hsu 2018). While there is some debate on this, especially as RPA focuses mostly on rules-based and repetitive tasks, it is nevertheless AI-branded and one example of innovative process technologies (Willcocks 2020).

Another example of such an AI branded technology is cognitive automation. Cognitive automation (CA) can be defined as „*a software tool that analyses unstructured data using inference-based algorithms to produce probabilistic outcomes*“ (Scheepers et al. 2018) and as such relies on supervised and unsupervised learning instead of predefined rules to support decision making and action taking (Lacity and Willcocks 2016). CA can be used in processes to automate also parts of customer interaction, e.g., to recommend the next product to buy or deal with customer service requests (Scheepers et al. 2018). While the application spectrum of RPA has been thoroughly researched, established, and implemented in recent years, CA applications are still in the development phase (Enríquez et al. 2020; Jarrahi 2019). Literature suggests that CA is an umbrella term for the application of technologies such as computer vision, optical character recognition (OCR), natural language processing (NLP) and sound processing to automate tasks that would otherwise require manual effort (Davenport et al. 2020; Dwivedi et al. 2019; Jarrahi 2019; Mendling et al. 2018; van der Aa et al. 2018; Zhang 2019).

As mentioned earlier, traditional RPA approaches are limited to automating processes that involve structured data and require quick, repetitive actions without much contextual analysis or handling of contingencies. This means that, RPA can only work effectively if decisions follow an 'if/then' logic, with no human judgement required in between. However, this rigidity means that RPA approaches are unable to capture meaning and further process unstructured data (Chakraborti et al. 2017; Dwivedi et al. 2019). In contrast, CA can consider both structured and unstructured data to automate more complex processes (Canhoto and Clear 2020; Lacity and Willcocks 2018). CA and RPA are increasingly intertwined, so that bots can draw on cognitive elements to extract meaningful information from unstructured plain text and then input that data into core systems, just as a human did previously (Kannan 2018; Scheepers et al. 2018).

These innovative process technologies are one means to innovate services and business processes within companies (Lacity and Willcocks 2016). Technologies like them enable both new customer experiences and higher efficiencies and, thus, drive business performance (Ratten 2016, 2018).

6.2.2 Professional Soccer and Innovative Process Technologies

The adoption and use of innovative process technologies is an area in which professional sports, especially professional soccer, are well suited for research. Soccer clubs are generally not technologically oriented enough and usually have limited experience with modern procedures and state-of-the-art instruments (Byers 2018; Uhl and Zenhäusern 2019).

Moreover, the professional sports environment has been growing exponentially for years, economically speaking, in the influx of new global supporters and in areas of services to be provided. In the last 50 years, the image of the non-profit association with a non-profit character has changed at almost all professional soccer clubs into purely profit-oriented companies. For decades, the commercialisation of soccer has been closely linked to two factors. The first factor is the media's interest in soccer (Anderson and Sally 2014; Kuper and Szymanski 2018). For it was only through the growing public attention that soccer became attractive to commercial interests. This in turn made soccer matches a suitable platform for the placement of advertising (Prigge and Tegtmeier 2019). The second factor is the enormous development of soccer towards professionalisation, which also has a direct impact on commercialisation (Kuper and Szymanski 2018). This created a web of relationships between the media, sponsors, the public and soccer (Kuper and Szymanski 2018; Rohde and Breuer 2016). Accordingly, the clubs must present their annual reports in order to be able to report increasing turnover figures to their shareholders.

In addition to sporting success, discussions about annual turnover, sponsorship income, ticket sales and financial competition now determine the clubs' strategies. According to the literature, sporting success and the economic situation can no longer be separated in professional soccer (Byers 2018; Kuper and Szymanski 2018; Rohde and Breuer 2016;

Sandy 2017; Woratschek et al. 2014). The socio-political interest is also reflected in the increasing commercialisation, for example in the form of the massive public interest in high-profile studies such as the „*Deloitte Football Money League*" (Deloitte Sports Business Group 2021).

Professional sport therefore offers a great potential for examining the automation factors for service provision, value creation and information exchange between themselves and their supporters (DFL Deutsche Fußball Liga GmbH 2019; FIFA Finance 2019).

The academic literature describes and divides the predominant customer structure of a soccer club into the following five components: first, the fans and the sports audience (Bauer et al. 2005; Kuper and Szymanski 2018), second, the sponsors & other advertising partners (Biscaia et al. 2014; Kuper and Szymanski 2018), third, the other soccer clubs (as transfer partners) (Pick and Gillett 2018; Woratschek et al. 2014), fourth, the marketers (as buyers of licensing rights) (Ko et al. 2008; Park et al. 2011) and fifth, the media (as buyers of broadcasting rights) (Henseler et al. 2011; McCarthy et al. 2014).

Of these market participants, fans and sponsors form the most important reference group and the most important customer group for soccer clubs in monetary terms (Ko et al. 2008; McCarthy et al. 2014; Woratschek et al. 2014). For these reasons, we will discuss these two groups in more detail in the following sections.

However, since the totality of fans differs in their values, norms, social forms and patterns of action, they do not form a marketing unit and are therefore divided into individual groups or categories (Bauer et al. 2005; Koenigstorfer et al. 2010; Kuper and Szymanski 2018; Pick and Gillett 2018; Tapp 2004; Wann and James 2018). In the scientific literature, especially on German professional soccer, a distinction is made in the classification between the consumption-oriented, the soccer-centered, the experience-oriented, and the critical fan.

Consumption-oriented fans consume the game as a leisure activity, which they pursue either alone or in a group.

Soccer-centered (sports-centered) fans consume the game in fixed communities in an organised form of the fan club.

Experience-centered fans see the game as an event; consumption here takes place in smaller cliques and less in organised fan clubs. Here, it is not primarily about the success of the team, but about the fun and the shared experience (Pick and Gillett 2018; Tapp 2004; Wann and James 2018).

Critical fans, lastly, attach great importance to rituals before and after a game (Bauer et al. 2005; Park et al. 2011; Pick and Gillett 2018; Samra and Wos 2014). They are active and try to have a positive influence on the fan scene or soccer (Pick and Gillett 2018; Samra and Wos 2014; Yoshida et al. 2014).

The sponsor customer group, which comes into contact with the fan via the club, provides a sports club with money, goods and/or services and in return receives the communicative use of the club's brand rights to achieve its own corporate communications objectives (Biscaia et al. 2014; Woisetschläger et al. 2010). The sponsor generally uses its involvement with a club as an instrument for achieving its own market-psychological and market-economic objectives. The income from sponsorship commitments, such as shirt and equipment sponsorship, perimeter advertising and the granting of naming rights to a venue, forms a central revenue component for clubs (Woisetschläger et al. 2010). In order to achieve the greatest possible benefit for the club and the sponsor in the cooperation, the literature speaks of a „*brand fit*“. This assumes that the brands of the sponsoring company and the sports club must have similar characteristics and thus both influence each other positively in their brand strength (Ko et al. 2008; Zaharia et al. 2016).

The use of innovative process technologies in professional soccer is not comprehensively addressed in current research. There is research on usage of AI to improve sports performance, e.g., to mitigate problems of physical education (Constantinou and Fenton 2017; Miljković et al. 2010), improve sports training (Puchun 2016), and support decisions for human trainers through artificial intelligence (Brown et al; Rein and Memmert 2016). Previous research was mainly conducted in the areas of individual, player-specific data analysis (Sarmento et al. 2014) and training programs tailored to the needs of the player (Link et al. 2016), e.g., in the area of artificial intelligence-based generation of fitness plans to prevent injuries (Fister et al. 2016; Millington and Millington 2015). The integration and application of different technologies to cover the whole range of sports measurement (Edgecomb and Norton 2006; Memmert et al. 2017), sports training and physical education by supporting virtual reality and AI / machine learning is also mentioned several times in the research (Randers et al. 2010; Xiao et al. 2017) without being a focal point. While there is some research on AI and sports performance, there are hardly any papers on AI or RPA to improve supporter interaction (e.g., digital marketing) or internal optimisation in professional soccer clubs. A deeper understanding of the usage of AI and RPA in sports management would also help closing the research gaps on service innovation and technological innovation raised by Ratten (2016).

However, looking at related sectors such as the tourism sector, the leisure sector, and the events sector, we are able to identify possible similar or transferable application areas. These can be illustrated by various use cases from the literature, most notably as AI-based personalisation of content based on customer data, pattern recognition for content capture and AI-based communication control with customers.

Common application scenarios include the use of AI-powered data-driven attendee management. Use cases outlined there for the sports (event) industry include personalized attendee management processes, such as the creation of personalized event websites. Use cases for areas where solution knowledge is incomplete, such as the impact of advertising banners on the purchasing behaviour of sports audiences, as well as strategic event planning, market research, data analysis and advertising effectiveness research are also frequently found in the literature (Davenport et al. 2020; Gretzel et al. 2015; Neuhofer et al. 2020; Tussyadiah 2020; Verhoef et al. 2017). Especially in the event and leisure industry, there are many exemplary application scenarios of AI-based business processes for the design of an effective customer journey, such as the processes for the intensive application of personalisation for the purpose of meaningful product recommendations; tailored to the customer's purchasing behaviour or last event visit (Buhalis et al. 2019; Gretzel et al. 2015). In addition, there are many use cases in the literature where AI-driven pattern recognition is used to identify regularities and patterns within a data set. This can be further divided into NLP, which is used to automatically process human languages including speech and text-based communication, and face or image recognition, which is based on visual features (Canhoto and Clear 2020; Ogle and Lamb 2019; Tsaih and Hsu 2018; van der Aa et al. 2018). This is where the research describes visitor flow management in terms of facial recognition, in that at various types of events, attendees can be verified by Face ID as they enter (Ivanov et al. 2020). Here, the research talks about an AI-powered customer journey, which is already being explored and implemented in the form of admission control, badging and smart event apps (Davenport et al. 2020; Ivanov et al. 2020; Tussyadiah 2020).

6.2.3 Technology Acceptance and Adoption

The question of why individuals and organisations accept, adopt, and use a specific information technology has a long tradition in management science and information systems research starting from the first introduction of information technology into organisations (Lee et al. 2003). In this sense, adoption refers to „*the decision to make full use of an innovation as the best course of action available*“ (Rogers 2003). As such, researchers often conceptualize adoption as an intention to act, i.e., an intention to use a system, and thus precedeing actual usage. This understanding is closely related to the theory of reasoned action (Fishbein and Ajzen 1975).

For information technology, the first theory to understand antecedents of technology adoption was the technology acceptance model, or short, TAM (Davis 1989). TAM can be regarded as a starting point for a remarkable stream of research and can be considered the leading model of technology adoption for nearly two decades (Bagozzi 2007; Lee et al. 2003). TAM argues that the technology adoption is driven by perceived ease of use and perceived usefulness of the technology. In this regard, individuals assess whether a new technology is easy to use and is beneficial.

Building on TAM, researchers created and tested multiple alternative models and approaches which led to the development of the Unified Theory of Acceptance and Use of Technologies (UTAUT) by Venkatesh et al. (2003). It is currently the most widely used model to understand technology adoption (Williams et al. 2015). UTAUT postulates that next to perceived ease of use (or effort expectancy) and perceived usefulness (or performance expectancy), individuals are also influenced by their social surroundings, i.e., by the perception of friends, family, or peers, when adopting a technology.

However, TAM, UTAUT and other similar models mainly regard the adoption of technologies by individuals. Technology adoption research has not put an emphasis on adoption within organisations (Bagozzi 2007). Exemplarily, prior research studied the adoption of digital voice assistants, another form of AI-branded automation technology, by individuals and identified that these technologies are adopted when they are perceived to be (in line with TAM and UTAUT) useful and easy to use but also when they are not perceived as humane, i.e., when they show a low level of anthropomorphism (Fernandes and Oliveira 2021).

Studies of the adoption of innovation are often based on similar arguments. Research could show that the perception of the characteristics of an innovation (irrespective whether it is a technological or managerial innovation) has impact on the adoption of the innovation. (Frambach and Schillewaert 2002). In this case, the adoption of an innovation by an organisation may be necessary to maintain the market position as non-adoption would lead to competitive disadvantage (Frambach and Schillewaert 2002) or lower levels of profitability (Sinclair and Cohen 1992).

6.3 Methodology

6.3.1 Research Approach

Our research approach follows the inductive grounded theory method (Charmaz 2006; Glaser and Strauss 2017; Urquhart and Fernández 2016) to investigate the specific conditions of acceptance of innovative process technologies in soccer clubs. In particular, we aim at addressing questions such as „*Which constructs are relevant for the acceptance of innovative process technologies in professional sports clubs?*“, „*What are the antecedents of a possible acceptance?*“ or „*To what extent can these constructs be integrated into existing theories?*“ by the here-presented research. The grounded theory approach is particularly applicable in explorative studies. It is often used to study socio-technical behavior in emerging research domains, such as the adoption of innovative process technologies by professional sports clubs (Wiesche et al. 2017). While technology acceptance research has a long tradition in the field of information systems (e.g., Davis 1989; Venkatesh et al. 2003), our study can still be considered explorative as innovative process technologies in the field of professional sports have not yet been scientifically investigated. We need to acknowledge that in line with Strauss and Corbin we were aware of the background in professional and disciplinary literature but refrained from carrying out an extensive initial literature review both to prevent potential biases in data collection and analysis and to not restrain the researchers' creativity (Corbin and Strauss 2014).[1] However, through grounded theory we are able to, based on a rich description of empirical observations, develop a theoretical model including different variables and their relationships (Wiesche et al. 2017). Based on the goals of our study and the research methodology, we carefully selected our cases of investigation.

6.3.2 Case Selection

We selected professional soccer clubs which have experienced a substantial increase in supporter interaction, particularly in the last decade, while still being considered „*traditional*“.[2] This sampling can be considered purposeful (Birks et al. 2013; Charmaz 2006; Glaser and Strauss 2017) and focuses on finding data that would provide the greatest opportunity to learn about the phenomenon under study (in this case, the drivers

[1] Please note that the background section on technology acceptance and adoption was written after the finalization of the study and included in this paper to increase understandability for the reader.

[2] Examples for organizations that would not fit these criteria in German professional soccer are TSG 1899 Hoffenheim, a German soccer club that became professional in the last 20 years mainly due to funding by SAP cofounder and main investor Dietmar Hopp or RB Leipzig, a German soccer club that became professional in the last 10 years mainly due to heavy investments of an energy drink company.

and inhibitors of the adoption of innovative process technologies in professional sports) (Božič et al. 2020; Charmaz 2006; Wiesche et al. 2017).

To address our research question, we analyse two professional soccer clubs that show some similarities and some differences. Both soccer clubs are from Germany and have long histories. They started as registered non-profit associations (eingetragener Verein) more than 100 years ago. Subsequently, both have changed their legal status and are now profit-oriented companies. As per our selection criteria stated above, both clubs have experienced an increase in supporter interaction.

However, our two case organisations also have differences. One of them has been fairly successful overall and in recent years (and will be called CHAMPION in the following). CHAMPION plays in the German Bundesliga (highest league) and regularly competes on an international level (UEFA Champions League or UEFA Europa League). With over 500 fan clubs worldwide and one of the highest number of fans travelling to away games, CHAMPION's fan base is one of the largest, most passionate, and loyal in the world. As such, this fan base consists of vocal soccer-centered and critical fans, which have a strong visibility and influence within the fan scene. In the 2019/2020 season, CHAMPION was able to generate a turnover of about 500 million Euros (see Table 6-2).

Table 6-2: Key statistics of CHAMPION

Employees (Full time equivalent)	~400
On professional level since	> 50 years
Turnover (2018/2019 season)	~500 Million EUR
Biggest success in last 25 years on national level	Win of a major European tournament
Average number of stadium guests in league game	> 50k guests
Club members	> 100k members

The other club has a stable supporter base and a long history (and will be called LEGACY in the following[3]). They participated on the highest league and were runner-up to the national champion over 50 years ago. Over the last few decades, their success has declined. Recently, they were able to succeed on a regional level and are currently competing in the third league (Dritte Liga), which is the lowest professional soccer league in Germany. LEGACY has a very homogeneous, critical, and experience-oriented fan culture that is tradition-conscious and supports the club because of its local roots. LEGACY is able to generate around 7 million Euros revenue per year (see Table 6-3).

[3] Both clubs asked for the protection of their privacy and are referred to as pseudonyms only.

Table 6-3: Key statistics of LEGACY

Employees (Full time equivalent)	~100
On professional level since	> 50 years
Turnover (2018/2019 season)	~ 7 Million EUR
Biggest success in last 25 years on national level	Regional champion
Average number of stadium guests in league game	~ 5k guests
Club members	~ 2k members

Data Collection

We collected data from several sources. These sources included news articles on technologies used, press releases from clubs, experience reports from supporters in social media, as well as supporter clubs and informal interviews with supporters. Our main source of insight, however, were semi-structured interviews with 6 experts from the two differently oriented and differently successful soccer clubs. Participants were selected to represent all stations along the customer value chain of a professional sports club in the field of supporter interaction. We interviewed our participants about their previous digitalisation journey and potential drivers and inhibitors of adoption of corresponding innovative process technologies. The interviews each lasted about one hour and were conducted in person. (with one exception where we needed to conduct the interview over the phone) by one of the authors. We used the principles of cognitive interviewing (Beatty and Willis 2007; Willis 2004) because of its effectiveness in regaining people's memories (Beatty and Willis 2007). All interviews were recorded digitally and transcribed literally. Interview transcripts were shared with the interviewees and signed off by them. In case of necessary changes to the interview transcripts, we discussed them with the interviewees to gain deeper understanding. During interview transcription of the first interviews we adapted our guiding questions for the later interviews when needed.

In total, we conducted five interviews for CHAMPION and as stated above, one interview for LEGACY. The duration of the interviews was approximately 39 to 71 minutes per interview (see Table 6-4).

Table 6-4: Data Collection Results

	CHAMPION	LEGACY
Number of Interviews	5	1
Total Duration of Interviews	298 min	48 min
Average Duration of Interviews	59,6 min	48 min

The interview partners came from different levels of the organisational hierarchy. We were able to interview one of the managing directors of CHAMPION, and department and team leads, as well as a senior developer. As such, we have a diverse group of interviewees from the whole organisation. At LEGACY, we were able to interview the chief operating officer who has, due to the size of the club and their position, a good oversight to give rich insights into LEGACY. Descriptions of the role of each interviewee can be found in Table 6-5

Table 6-5: Description of Interviewees

	Interviewee Role	Responsibilities
CHAMPION_1 63 Min	Head of Team 'Key Account Management'	CHAMPION_1 is the head of Key Account Management. She ensures that existing supporters of the club remain satisfied. Her primary goal is to establish close supporter relations for a sustainable increase in turnover. Main tasks include active management of supporter needs and expectations and the derivation of corresponding solutions as well as the development and implementation of customer development strategies in cooperation with the sales and marketing team.
CHAMPION_2 71 Min	Senior Developer for Intelligence & Analytics Solutions	CHAMPION_2 is a senior developer for intelligence and analytics solutions. His primary tasks include administration, further development and migration of the data warehouse system and optimisation of databases and data models. Within the club, his responsibilities include the development, creation and analysis of controlling reports, the design and optimisation of internal processes and workflows as well as the management of external partners and cooperation with all IT departments.
CHAMPION_3 55 Min	Head of Digital Division (Chief Digital Officer)	CHAMPION_3 is the head of digital (Chief Digital Officer). His primary responsibilities include the development of IT strategies for digital and traditional business models, including strategic requirements and structuring links to the club's business strategy. He is also responsible for managing large and complex IT transformations resulting from strategic business changes or mergers and acquisitions.
CHAMPION_4 70 Min	Content Manager in Sales and Marketing Department	CHAMPION_4 is a content manager in the sales and marketing department. His tasks include the development of target group-specific content strategies to position the club on the national and international markets as well as the creation, organisation and planning of various online content for a broad lead and campaign management, especially websites, e-mailings and newsletters.
CHAMPION_5 39 Min.	Managing Director	CHAMPION_5 is one of the three managing directors of CHAMPION. He has the overall corporate responsibility for the club's costs, performance, results and sporting quality. His tasks also include positioning the club in the market and realizing sustainable and profitable growth. He is responsible for the representation of the club towards the supporters, local partners, sponsors, politics, the public, the media and the economy as well as the supervision of public relations.
LEGACY_1 48 Min	Chief Operating Officer	LEGACY_1 is the chief operating officer of LEGACY. His responsibility is to manage day-to-day operations and ensure continuous process improvements and profitable growth. The focus of the task is the stringent implementation of club planning and the implementation of a solid cross-divisional performance measurement

		system, as well as troubleshooting and continuous optimisation of the support processes

As stated above, next to the interviews we collected written material from and about both clubs. While access to interview partners at LEGACY was somewhat limited, the full data set still allows us to gain insights along a spectrum of clubs ranging from great success from both an economic and sports perspective (CHAMPION) to strong financial constraints and low competitive success in recent years (LEGACY).

6.3.3 Data Analysis

After the correctness of each transcript was verified with the corresponding interviewee, the transcript as well as the collected written material was read and evaluated by both researchers. We examined each line of the data for its underlying meaning (i.e., the initial coding), using line-by-line coding as a heuristic tool (Charmaz 2006). General questions helped with the conceptualisation, e.g.: What happens in the data fragment? or What does the data fragment express? (Bryant and Charmaz 2007; Wiesche et al. 2017). To support this coding we employed NVIVO 12. NVIVO is a computer-assisted qualitative data analysis software which is deemed to be especially useful in the facilitation of grounded theory research (Bringer et al. 2004; Hutchison et al. 2010).

During our analysis we constantly compared each line of coded text with other lines of already coded text (e.g., from different interviews) and their corresponding initial codes (i.e., constant comparison). We gave data that indicated the same concept the same conceptual label. In case of differences in coding and the interpretation of sentences and paragraphs, the authors conferred until agreement was found.

While we analysed the first interviews and written material, we found an increasing number of new codes. We abstracted from individual codes and, thus, reduced their number (Charmaz 2006). These emerging codes guided our further data collection and analysis. We nevertheless continued line-by-line coding throughout the study to avoid omitting new theoretical insights. Our goal was to further develop the codes in progress and their preliminary relationships with this newly incoming data. This was supported by the creation of analytical memos and diagrams which were discussed among the researchers (Charmaz 2006; Corbin and Strauss 2014; Urquhart and Fernández 2016). We stopped looking for new interview partners when we reached theoretical saturation, i.e., when the incoming data gave us nothing new about the developed concepts and their relationships (Birks et al. 2013; Corbin and Strauss 2014; Wiesche et al. 2017). An overview of our first order codes and the related concepts is given in the following results section (esp. Figure 6-1).

Results

Our results with regards to important codes and derived concepts are shown in the following Figure 6-1. We could identify five drivers and inhibitors of innovative process technology adoption in our data set: Expected efficiency gains, expected effectiveness gains, perceived ease of use, perceived (positive) market pull, and perceived (negative) supporter perception. These drivers and inhibitors and their grounding in the data will be presented in the following after a short introduction into the state of digitalisation and innovative process technology adoption in both case organisations. We will discuss them in light of existing theories on technology adoption in the discussion section.

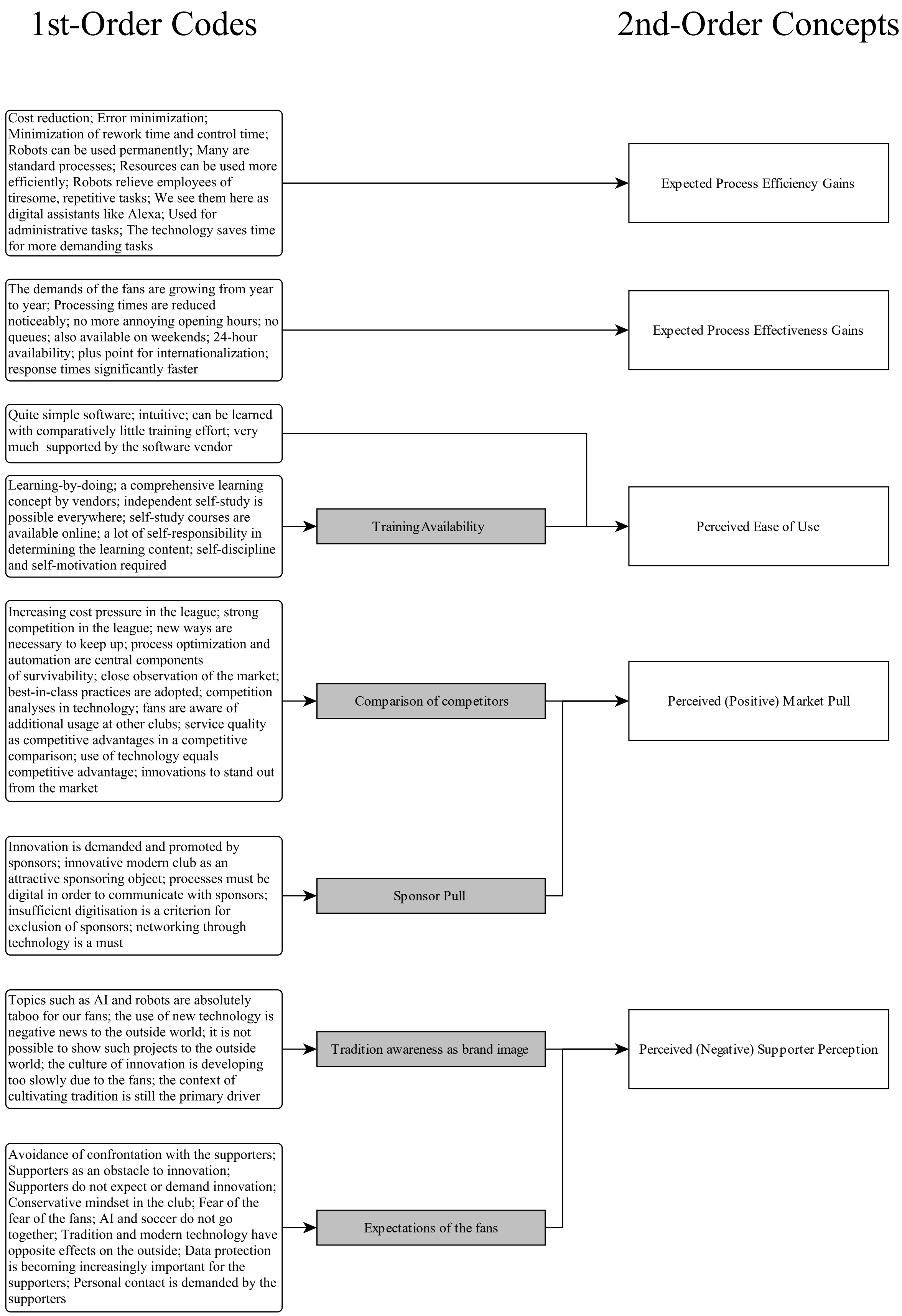

Figure 6-1: The data structure

In both professional soccer clubs, senior management has acknowledged that „[they*] are in the midst of digitalisation of professional sports*“ (CHAMPION_5). It is clear that „*automation and digitalisation will become more important than they are today*“ (CHAMPION_4). However, both clubs are also perceived to be behind the competition, with regards to CHAMPION especially at an international level. Here, top managers look to the U.S. and to Great Britain, where they perceive the sports industry to be far more digitalized than in Germany.

Concerning the actual usage and the willingness to adopt innovative process technologies, both clubs show a two-sided perspective. While the clubs state that „*you cannot exclude AI from professional soccer*“ (CHAMPION_3) and that „*further growth is only possible through the increasing use of such technologies and sustainable solutions* [...]“ (LEGACY_1), we can differ between the core sports perspective and the perspective of service innovation (e.g., engagement with supporters) and process or management innovation (e.g., internal optimisation). On the one hand, innovative technologies are used to better analyse training data. Here the clubs are dependent on special external solutions. On the other hand, there are only few implemented use cases for innovative process technologies to improve supporter loyalty or to optimise internal processes. Here the assessment „*AI is far too big a topic for us*[...]“(LEGACY_1) or „*We see AI rather as a topic which we cannot develop internally and where we have to rely on new know-how which comes from outside*“ (CHAMPION_5) is reflected in the self-perception of the clubs. This is shown by the fact that the credo „[...] *we are still only a football club*“(LEGACY_1) is always present.

Expected Process Efficiency Gains. Both clubs argued that they will use innovative process technologies as they expect corresponding efficiency gains. With regards to RPA as one innovative process technology, a top manager argued that „*everything that is not value adding and repetitive should be done by RPA*“ (CHAMPION_5). As such, RPA is used to improve internal administrative process efficiency, e.g., through automated report consolidation and distribution or „[...] *the sending of matchday e-mails, escalations, representative regulations and the exchange with existing supplier systems or ticketing*“ (LEGACY_1). The „*professional sports industry offers a lot of potential, be it in the area of complaint and stadium management, mail and invoice processing, contract management and supporter management, or to finally automatically use data in processes such as optimisation or campaign control in social media*“ (LEGACY_1). Already now, LEGACY has succeeded in significantly reducing the manual effort in certain reporting processes (LEGACY_1). Both clubs use this reduction of manual effort to save process costs and refocus on service quality: „*Bots take the annoying, repetitive tasks and support us in our administrative duties. They give us time to focus on the core value-adding* *activities that make a difference*" (CHAMPION_4), which should ultimately result in a higher profitability. CHAMPION refers to direct international competition in the UK and finds the „*aggressive use of technology innovation*" (CHAMPION_5) at English first division soccer club Manchester City remarkable. Manchester City remarkably has „[…] *its own chief digital officer, so there is a personal union with the subject (digitisation of processes)*" (CHAMPION_5) which allows them to reap the benefits of innovative process technologies.

Expected Process Effectiveness Gains. Next to expected efficiency gains, both clubs also argued that an expected increase in process effectiveness will drive adoption of innovative process technologies. Firstly, managers use these technologies to drive process standardisation. Currently, several processes are handled differently depending on the employee. Employees show a resistance to standardize their processes. Innovative process technologies are an „*excuse*" that is now employed to enforce process standardisation. Secondly, innovative process technologies improve customer experience. As an example, customer service requests are now partially handled by RPA bots. In this case, the service is available 24 hours a day, 7 days a week. This becomes clear when LEGACY repeatedly mentions that innovative process technologies are to be used with high priority to improve the customer experience. In general, „[...] *supporter centricity leads to an improved supporter experience, which in turn leads to more supporter satisfaction, greater supporter loyalty and the acquisition of new supporters*" (LEGACY_1). In this context, the service aspect of customer retention is also often emphasized. LEGACY aims at using innovative process technologies to engage existing supporters and allow them to interact more deeply with the organisation. This should increase turnover in the long term (LEGACY_1). At LEGACY, the head of the organisation realized that, regarding the innovative process technologies, „*by digitizing and streamlining many aspects of supporter interaction, from stadium visits to shop communication, supporter interaction with us will be so much easier.*" Moreover, innovative process technologies improve decision making „*because data can be accessed from the system in seconds with a single click*" (CHAMPION_2) and is available with „ *minimizing errors and increasing quality*" (CHAMPION_4). CHAMPION draws comparisons to international competition and explicitly cites the sports industry in the US and UK as outstanding examples of professionalisation to ensure process effectiveness gains. In particular, the communication processes between the club and the international and globalized fans through „*social Customer Relationship Management [...] which has successfully achieved a huge increase in worldwide users and fans interacting with Man City* [Manchester City] *through the Messenger chatbot, works very well and is impressive to me*" (CHAMPION_5). This chatbot as an example for CA makes the fan interaction processes more efficient. Another international example mentioned by the interviewees were the Golden State basketball team from San Francisco. Here, innovative process technologies are used to automatically send game highlights via Facebook Messenger via a „*tech assistant for the playoffs that uses AI to communicate directly with fans*“ (CHAMPION_5). Again, this significantly eases the burden on customer service on match days with high communication volumes, while at the same time increasing the quality, scope, and, thus, effectiveness of the service.

Perceived Ease of Use. While currently both clubs do not have all capabilities to adopt all innovative process technologies internally, they select technologies which are more easy to use or adopt, first. We could observe RPA as an earlier form of AI-branded technologies to be implemented more heavily in both clubs. This is because RPA is perceived to be easy to learn by referring to the initial „*ease of implementation using RPA* [...]“ (CHAMPION_5). The RPA solutions both clubs employ offer possibilities for „*comprehensive*[...] *and well thought-out*“ (CHAMPION_3), „*independent self-study*“ (CHAMPION_1) with structured, didactically efficient online learning material. Moreover, due to the low-code development system of RPA, „*regular use already represents a learning concept*“ (CHAMPION_1). In addition, both clubs recognize that employees are generally motivated and want to learn how to use new technologies to „*keep up with digital change*“(CHAMPION_5) so that employees can also „actively promote development within the club“(CHAMPION_5). Here, the „[...] *employees see a sustainable benefit*“ and are intrinsically encouraged to do „[...] *what is essential for success, namely, to enjoy working with RPA*“ (LEGACY_1). In this way, employees and the club are „*additionally well prepared for the future*“ (CHAMPION_5), if the technology is correspondingly easy to use and learning materials are made available online.

Perceived (Positive) Market Pull. Both clubs also reported a market pull that forced them to adopt innovative process technologies. On the one hand, „*the introduction of RPA opens up possibilities for us such as to meet the changing customer requirements and to generate competitive advantages*“ (CHAMPION_4). This holds especially as „*anyone who wants to remain competitive in the Bundesliga in the long term is therefore clearly working digitally*“ (LEGACY_1). The clubs accept the future viability of these technologies. They see corresponding investments as a precondition for economical and sports success, e.g., Legacy sees innovative process technologies as a precondition to achieve their aspiration of qualification for the second league. On the other hand, both clubs also report on a rising demand of sponsors to interact digitally and use a digital brand of club. Exemplarily, a sponsor of CHAMPION from the information technology industry announced in their press statement that they have selected CHAMPION based on their passion for technology. In the third league, the lack of digitalisation is even seen as „*exclusion criterion in the selection of potential sponsors*" (LEGACY_1).

Perceived (Negative) Supporter Perception. Our results also indicate that for both clubs' usage of innovative process technologies is at least partially inhibited by a perceived negative supporter perception. One interviewee stated very openly that „*one reason why we don't do AI yet is that the supporter doesn't expect AI*" (CHAMPION_1). This was a common tenor that resonates with all interviewees. In another interview the employee argued that the general supporter community would be „[...] *too distrustful of new technologies*" and that the „[...] *club is a traditional club and AI does not fit in*" (CHAMPION_3). Especially the tradition of being a working-class club are for both organisations cornerstones of their brand image. The employees' general assessment even goes so far as to suggest that innovative process technologies could also lead to a general loss of trust in the brand as a „*traditional club*". Both clubs also mentioned groups of supporters that are very conscious of data security and data protection and that they would not anger this group. As such, innovative process technologies are more often used to improve purely internal processes or processes on the interface to other stakeholders, e.g., sponsors. The perceived negative supporter perception inhibits usage of technologies with regards to fan interaction. One interviewee even argued that this perceived negative supporter perception is the main inhibitor for innovation in general (CHAMPION_1).

6.4 Discussion

6.4.1 Usage of Innovative Process Technologies in Professional Soccer

Before discussing the results of our study, we can also reflect on the current usage of innovative process technologies in German soccer clubs. Using the example of two clubs and their understanding of the market, we can see that both have adopted innovative process technologies only to a low degree. Here, they focus on AI-branded technologies that have lower entry hurdles, e.g., RPA. Both organisations have begun to automate business process internally and on the interface to supporters and sponsors using this AI-branded technology. Moreover, both clubs also indicated their plans to continue implementation and expand their efforts. However, more complex innovative process technologies such as cognitive automation or artificial intelligence are rather rigorously rejected by both clubs. We were able to identify several corresponding drivers and inhibitors of adoption and use of innovative process technologies which will be discussed in the following. Interestingly, we could not find a direct influence of organisational context and discuss this at the end of the following subsection.

6.4.2 Drivers and Inhibitors of Innovative Process Technology Adoption

In our grounded theory study five constructs emerged that influence the adoption and use of innovative process technologies in professional soccer. These drivers and inhibitors are shown in Figure 6-2. Building on these insights, we searched existing literature to get a deeper understanding of these constructs. We were able to find three of our constructs being extensively covered in the literature while two constructs are comparably new (marked in dark grey in Figure 6-2).

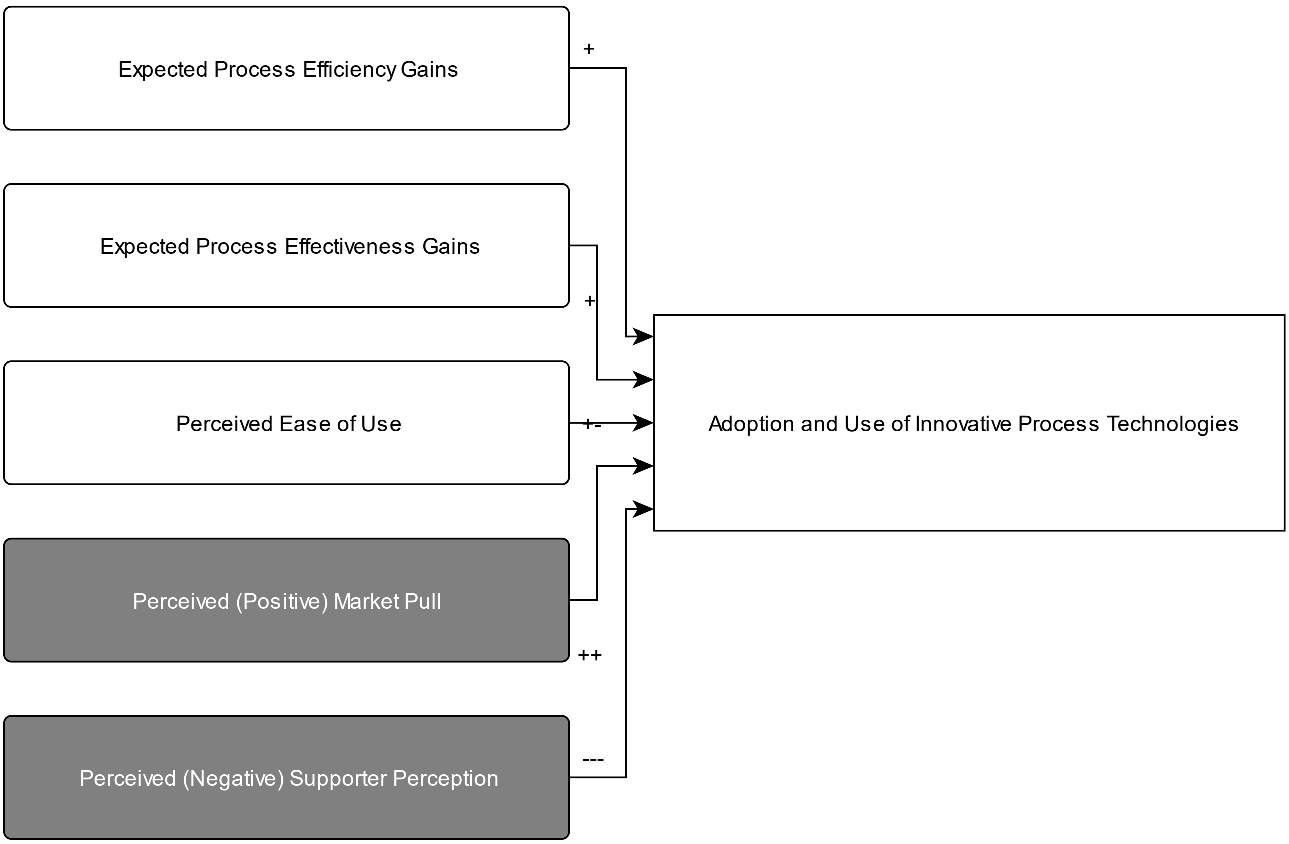

Figure 6-2: Emerged constructs that influence the adoption and use of innovative process technologies in professional soccer (new constructs marked in dark grey)

Expected Process Efficiency Gains and Expected Process Effectiveness Gains. The first two constructs that emerged from our empirical data are that of expected process efficiency gains and expected process effectiveness gain. Our results indicate that innovative process technologies are adopted and used when the organisation and its decision makers expect an increase in process efficiencies, i.e., an improve in resource consumption to achieve the same results, and an increase in process effectiveness, i.e., an improved value for the customer, e.g., in terms of service quality. Constructs like these have a long standing tradition in both psychological and information systems research. In their theory of reasoned action, Fishbein and Ajzen show that behavioural intention to act in a certain way is positively influenced by the attitude towards this behaviour, i.e., „*an individual's positive or negative feelings (evaluative affect) about performing the target behavior*" (Fishbein and Ajzen 1975). The expected effects with regards to efficiency and effectiveness might be trigger for such a positive feeling. Building on this understanding, technology acceptance research shows that „*the degree to which a person believes that using a particular system would enhance his or her job performance*" is a major driver of system adoption and use (Davis 1989). In the same way, Compeau and Higgins argue that one driver of technology use were the expected outcomes, i.e., the expected performance-related consequences of the behavior (Compeau and Higgins 1995). However, this understanding still covers both our emerged constructs of expected efficiency gains and expected effectiveness gains. A deeper analysis of existing literature shows that prior publications differ between efficiency and effectiveness, too. Exemplarily, Moore and Benbasat measure the relative advantage of an IT innovation using the five items (Moore and Benbasat 1991), two of those refer to efficiency (system use allows to „*accomplish tasks more quickly*" and „*increase* […] *productivity*") and three to effectiveness (system use „*improves quality*", makes the job „*easier*", and „*enhances* […] *effectiveness*"). In a more recent study, Niehaves and Plattfaut also measured efficiency („*increases* […] *productivity*" or „*accomplish tasks more quickly*") and effectiveness („*support* […] *activities*" or „*increase chances of getting a raise*") as items of antecedents of individual IT innovation usage (Niehaves and Plattfaut 2014).

Perceived Ease of Use. Perceived Ease of Use was the third construct that emerged from our data. It refers to the ease of difficulty of adopting an innovative process technology. Again, this construct is well-known to different scientific disciplines. In psychology, perceived behavioural control refers to „*the perceived ease or difficulty of performing the behaviour*" and is as such a major antecedent of performance of a behaviour (Ajzen 1991). In technology adoption literature, perceived ease of use refers to „*the degree to which a person believes that using a particular system would be free of effort*" (Davis 1989) and is again a prerequisite for system adoption and use. Differences in Perceived Ease of Use exist between the simpler innovative process technologies such as RPA and the more complex ones such as hard AI. Apparently, one reason why sports clubs are more likely to adopt RPA than to invest into hard AI is the ease of use of the technology with RPA being more easy to implement than other innovative process technologies.

Perceived (Positive) Market Pull. In contrast to the first three constructs, the fourth construct Perceived (Positive) Market Pull is not explicitly mentioned in existing literature and forms, thus, a contribution of this grounded theory study. Perceived

(Positive) Market Pull refers to the two underlying constructs of sponsor and competitor pull. On the one hand, sport sponsors as a major source of revenue for soccer clubs seek a brand match with the team itself. Therefore, sponsors from the technology industry are interested in clubs with a technology-savvy image. Prior research suggested that sponsors select sponsored events or teams based on a match between images. A company that wants to be seen as innovative selects an innovative sport, event, or team to sponsor (Amis et al. 1999). On the other hand, soccer clubs are driven to invest into innovative process technology as competitors invest, too. As such, the construct is, to a certain extent, related to the construct of subjective norm from the Theory of Reasoned Action. Subjective norm is defined as „*the person's perception that most people who are important to him think he should or should not perform the behavior in ques*tion" (Fishbein and Ajzen 1975). However, subjective norm would cover also other stakeholders of the organisation, a phenomenon we did not observe in our study.

Perceived (Negative) Supporter Perception. We have identified a new inhibitor of organisational adoption of innovative process technology: perceived supporter perception. Here, especially at CHAMPION, the fear of a mismatch between customer perception of the brand (based on tradition, working class, etc.) and of innovative process technologies, especially AI, has resulted in a clash that has worked against adoption of the technology. This could especially be seen in areas which are closer to the customer (customer interaction, operational processes) and less in areas that are more hidden from the customer (training data analysis). However, Perceived (Negative) Supporter Perception was considerably lower at LEGACY, mainly due to the pressing needs to adopt new technology due to more strained financial conditions. This could also be explained by the lower influence of critical fans on the basic population of fans at LEGACY in comparison to the fans of CHAMPION. Relating the construct to existing theory shows that especially fanatical supporters or supporters try to protect the brand and ensure the brand's continued existence and legacy (Samra and Wos 2014). From marketing research it is known that „*fanatical followers*" can be so attached to the existing brand that they are highly 'resistant to change' and retaliate against any changes in the brand positioning (Chung et al. 2009). Apparently, especially CHAMPION with its large number of highly devoted supporters and critical fans, fears their reaction when investments into innovative process technologies were to be made public.

No Direct Influence of Organisational Context. Although the two professional soccer clubs which were the source of our data are vastly different with regards to size, success, supporter structure, financial power etc., we could not identify any direct influence on adoption and use of innovative process technologies. We could also not see indications for a moderation of the influence of independent variables towards adoption and use.

When the data suggested a difference between the two clubs, this was directly translatable to a difference in one of the five variables from Figure 6-2, e.g., Perceived (Negative) Supporter Perception was higher at CHAMPION than at LEGACY. This is in contrast to existing theories. Prior research could show that different contextual features of organisations have a moderating effect between independent variables and technology acceptance/adoption (Bagozzi 2007; Benbasat and Barki 2007; Davis 1989; Legris et al. 2003; Marangunić and Granić 2015; Mathieson 1991; Venkatesh et al. 2003; Venkatesh and Bala 2008). There might be several reasons for this which can be subject to future research. Firstly, our data set contains data only from two soccer clubs. It might be that a more diverse set would give rise to direct or moderating effects of contextual variables. Secondly, it might be that contextual variables are antecedents of our five identified drivers and inhibitors and that these drivers and inhibitors mediate the relationship between contextual variables and adoption and use of technologies. However, further research is needed (see below).

6.5 Conclusion

6.5.1 Summary

We conducted a grounded theory study in the professional soccer industry to identify drivers and inhibitors for adoption and use of innovative process technologies. We relied on vast data from a successful first league (CHAMPION) and a traditional third league club (LEGACY) and derived contributions towards technology adoption theories. We could show that, while both clubs have an interest in innovative process technologies, they are reluctant to invest in the more AI-like forms of it (e.g., cognitive automation or AI). In both cases the adoption of innovative process technologies depends upon expected efficiency and effectiveness gains, perceived ease of use, perceived (positive) market pull, and perceived (negative) supporter perception. While the first three of these constructs can be found in existing technology acceptance literature, the later ones are contributions to this research stream. Perceived positive market pull mainly refers to the perception that sponsors from the technology industry are interested in clubs with a technology-savvy image. As such, decision makers in soccer clubs who have this perception are more likely to adopt and use innovative process technologies. Perceived negative supporter perception is the fear that fans will lose club loyalty when innovative process technologies are implemented, as these technologies distort the brand image of the club. This perceived negative supporter perception is higher when technologies include more AIs and thus destroy the image of a „*workers' club*“.

6.5.2 Limitations

As an empirical study, this research is beset with some limitations. Firstly, our results cannot be generalized to all soccer clubs around the world or other organisations out of the industry. While we believe that the results will hold true in other traditional sports organisations, further research is necessary. Secondly, we relied on a limited data set. Especially in the case of LEGACY, we were only able to speak with one interviewee. Although we also relied on additional sources of insight and have reached theoretical saturation after the six interviews, the results might still be biased. Thirdly, all of our data comes from club staff. Data collected from fans or other stakeholders of the soccer clubs might lead to further insights. Lastly, while we did not conduct an explicit review of the scholarly literature on adoption of innovative process technologies beforehand (in line with, e.g., Corbin and Strauss 2014) and while we followed established guidelines for grounded theory work method (Charmaz 2006; Glaser and Strauss 2017; Urquhart and Fernández 2016), our research might have been influenced by our prior knowledge on theories in this field.

6.5.3 Implications for Practice

Our grounded theory study has three main implications for practice. Firstly, our results show that sports club decision makers are influenced by a perceived perception of supporters towards innovative process technologies. Here, sports managers should try to substantiate this perception with data. Only then they can build a coherent and consistent a supporter-centric service innovation strategy. This is especially important as neglecting the potential benefits of innovative process technologies for the efficiency and quality of services could lead to a loss of financial competitiveness.

Secondly, designers of innovative process technologies should consider the identified drivers and inhibitors of adoption and use. This means not only communicating clear benefits and offering training programs (to address expected efficiency and effectiveness gains and perceived usability), but also demonstrating benefits to supporters and sponsors. In this way, providers can reduce potential barriers to adoption and help sports clubs improve their performance.

Thirdly, sports managers should identify smart ways of using innovative process technologies in areas without direct fan interaction. If supporters are, e.g., opposed towards interacting with cognitive automation, sports clubs could use these tools in non-customer facing processes, e.g., internal business processes or only as support systems for human employees. As such, the interaction with supporters can still maintain the traditional brand image while reaping some benefits of innovative process technologies.

Following these recommendations for practice, professional sports clubs can take advantage of innovative process technologies. For example, they could use RPA for automated document processing. Analogous to the examples in chapter 2.1. from the literature, which show how complex manual activities can be simplified by innovative process technology (Lacity and Willcocks 2018; Syed et al. 2020). The diverse document-based ticketing processes, clearing processes, ordering processes, or short-term billing processes (e.g., with exponential process volumes on game days) that occur in a business context have often been successfully automated in other contexts in the past, as shown in 2.1 (Enríquez et al. 2020; Plattfaut 2019). For example, important information such as seats, season ticket numbers, phone numbers, email addresses, cost types, order points, and the like can be extracted from various documents and processed automatically. These can be presented to staff, who can check everything and then automatically integrate it into the ERP or ticketing system at the touch of a button. This means a noticeable relief for employees and the fan, who otherwise must wait days for tickets, invoices, and orders to be processed because the processes behind them do not scale.

Clubs could also use cognitive automation to improve the efficiency of end-to-end customer processes with chatbots. This way, even a fan visiting a club's web presence in the middle of the night feels like they can talk to a full-fledged club employee, even though there is no 24-hour service. With cognitive automation, chatbots can be created that easily make changes to other systems, so that on match days, ticket data or ticket changes can be implemented on short notice to make automated decisions about ticketing processes, allocating new seats, or even shipping (Chakraborti et al. 2017; Lacity and Willcocks 2018; Tussyadiah 2020).

Finally, there is clear potential for the use of artificial intelligence in optimising the fan engagement process. Here, as explained in chapter 2.1, artificial intelligence enables personalisation via a data-driven approach that provides fans with individually relevant information according to their interests, needs and usage behavior (Davenport et al. 2020; Tsaih and Hsu 2018). Likes and preferences are determined from fans' historical behavior using machine learning. In this way, the use of artificial intelligence ensures personalized content or product recommendations that precisely address the needs of the fan and are thus relevant to them (Neuhofer et al. 2020; Verhoef et al. 2017).

6.5.4 Further Research

Future research can go into two directions. Firstly, future research can extend our theoretical contribution through additional case studies in related sports or other geographies. From a theory-building perspective it would be interesting to see whether other variables that influence adoption of innovative process technologies can be identified and which role context really plays. Secondly, future research could test the contributions to theory, e.g., through quantitative survey and analysis. Here, measurement models for the new constructs of perceived (positive) market pull and perceived (negative) supporter perception need to be created and tested, before the full theoretical model can be evaluated. Thirdly, the validity of the managers' perception could also be tested with data collected from fans and other stakeholders. It might be that the perception of managers that a negative supporter perception exists is just wrong and needs to be corrected.

7 The Fear of Losing Control - What Prevents the Automation of Business Processes in Sensitive Areas

Table 7-1: Fact sheet publication P2

Titel:	The Fear of Losing Control - What Prevents the Automation of Business Processes in Sensitive Areas
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 55th Hawaii International Conference on System Sciences (HICSS)
Ranking[1]	**C**
Authors	**Name** Koch, Julian Vollenberg, Carolin Plattfaut, Ralf Coners, André
Status	Published
Full Citation	Koch, J.; Vollenberg, C.; Plattfaut, R.; Coners, A. (2022): The Fear of Losing Control - What Prevents the Automation of Buisness Processes in Sensitive Areas. In: *Proceedings of the 55th Hawaii International Conference on System Sciences*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

The Fear of Losing Control - What Prevents the Automation of Business Processes in Sensitive Areas

Abstract

This article explores the potential barriers and drivers of end-user adoption of robotic process automation (RPA) technology in particularly sensitive process areas. For this purpose, the grounded theory method was used within a health authority to determine which factors influence the intention to use and the benefits of such solutions. RPA enables the automation of repetitive and rule-based processes. The development and usage experiences of the respective employees as users of the technology were recorded and used for conceptualisation. These found constructs were then compared with those from the established scientific literature. The results show that the obvious drivers can be described in terms of „*transparency*“ and „*explainability*“ and that these are novelty factors compared to established RPA-specific success factors from the relevant literature.

7.1 Introduction

Not only since the permanent burden of the Covid 19 pandemic has professional nursing been characterized by increasing work pressure, work compression, and growing physical and psychological stress (Burton-Jones et al. 2020; Hege et al. 2020; Konttila et al. 2019). This is accompanied by an increasing investment backlog in digitisation and technologization in the context of sensitive care processes (Burton-Jones et al. 2020; Cajander et al. 2020; Klinker et al. 2020).

At the same time, administrative and documentation processes are important basic processes for needs-based, quality-oriented, and safe care (Baumann et al. 2018). These nursing processes are immensely important and are the prerequisite for the treatment of a patient. Since these nursing processes represent the main working time of nurses in hospitals, they can be defined as the core supportive processes of hospitals and therefore considered as so called sensitive business processes (SBP), as they are defined as „*the heart of the activities of the organisation*“ (Hassen et al. 2016). In the light of increasing complexity and gaining requirements in healthcare, digitisation is very important in the provision of healthcare services and administrative processes. This is particularly true for hospitals.

In hospitals, the efforts involved in administrative work as well as the complexity of documentation increase enormously. Hospital staff spend a lot of time on data entry and transmission (Blum and Müller 2003; Levinson et al. 1997; Ong et al. 1995). Currently, hospital nurses in Germany spend about 36 percent of their working time on bureaucratic activities, especially manual documentation and data input or output (Deutscher Ärzteverlag GmbH 2015). Particularly in connection with administrative documentation obligations for patient-related data, high expenses arise and workload is getting higher (Becker et al. 2010). Hospitals are therefore actively seeking digital solutions to provide technical support as far as possible and to automate upstream and downstream processes.

However, there are numerous barriers, such as the lack of empowered staff, the lack of flexibility in volatile processes, or the lack of an infrastructural framework for implementing automation (Cajander et al. 2020; Hege et al. 2020). The scientific discourse describes that the possibility of self-service development of automation, preferably by the end-user, can allow to control the development costs and to deal more dynamically with changes in the overall structure and environment (Cooper et al. 2019). Syed et al. (2020) therefore call for further empirical investigations of possible success factors and their implications for the use and development of RPA (Syed et al. 2020).

This article intends to fill this postulated gap by addressing and investigating the hitherto unaddressed field of RPA use in the SBPs described. These SBPs are additionally characterized by special framework conditions and boundary constraints, which make it necessary to analyse these special operational boundary conditions and their effects on the intention of the use of process automation technology such as RPA in more detail. Especially the sensitive and critical environment in healthcare requires higher conditions on data security and knowledge managed in their SBP needs to be handled conscientiously to ensure the best treatment of the patient. Based on this, our research objects address the following questions to be investigated:

RQ1: *What are the drivers and barriers for the use and development of RPA solutions in sensitive areas such as the critical care process environment?*

RQ2: *To what extent do these drivers and barriers align with established success factors for RPA from the literature?*

The remainder of this article is organised as follows. First, we present the theoretical background of RPA and the involvement of employees in the development of process automation as well as the context of SBP. Then, we explain the research methodology we used. Next, we present the results, and in the last two sections, we conclude the paper with the implications for practice and the limitations of our research, as well as an overall conclusion of our main findings.

7.2 Background

The background section will give an overview of the technology of RPA and its advantages. We further point out the missing research on the usability during development and execution of RPA solutions. Additionally, this Background section introduces the field of SBP's and the role of RPA in this case.

7.2.1 Robotic Process Automation

Robotic Process Automation (RPA) is a term used to describe software tools that fully or partially automate human activities that are manual, rule-based, and repetitive. RPA works by replicating the actions of an actual human interacting with one or more software applications. The tasks performed may consist of data entry, processing standard transactions, or responding to simple customer service requests (van der Aalst et al. 2018a).

RPA solutions can also be thought of as virtual workers that operate on the systems' user interface like human users. For example, because RPA mimics user input via an application's user interface, there is no need to program an application interface.

With RPA, an organisation can automate routine tasks quickly and cost-effectively (Plattfaut 2019; Syed et al. 2020). RPA frees people from monotonous, low-value-added tasks like data entry tasks, helps increase the quality of output, and improves speed by finding and retrieving all the necessary data in the background (Plattfaut 2019). This makes employees available for higher-value tasks that require human ingenuity, decision-making, and trust (Boulton 2018). The RPA solutions do not change the existing information systems or software infrastructure. RPA bots can easily be integrated with other broader automation initiatives - such as process and decision automation or data collection initiatives - to add value to the automation program (Hofmann et al. 2020; Ivančić et al. 2019; Madakam et al. 2019).

Fittingly, RPA technologies are defined as technological interfaces that allow employees to create a solution on their own, without the direct involvement of service staff or IT (D'Onofrio and Meinhardt 2020; Plattfaut 2019). To express the notion of self-service in the context of RPA, there are several terms or concepts in the literature such as „*partial employee*", „*virtual employee integration*", „*co-production*" and „*co-creator*" (Aguirre and Rodriguez 2017; Hofmann et al. 2020; Syed et al. 2020). RPA technologies can thus be described as new operating models that imply new types of employee interactions and employee touchpoints, and they will play an even more important role in service delivery in the future (Asatiani and Penttinen 2016; Ivančić et al. 2019).

Autonomous employee input is a key success factor in realizing the potential of RPA technologies in the future (Junxiong Gao et al. 2019; van der Aalst et al. 2018a). In response to the increasing role of RPA technologies, researchers have begun to examine the various effects of RPA technologies from either the organisation's perspective or the employee's perspective (Kregel et al. 2021; Plattfaut and Koch 2021). Effects from the organisation's perspective include factors such as speed of delivery, accuracy, and alignment with employee preferences, cost reduction, as well as productivity and efficiency gains, and improved competitiveness and market share (Cohen and Rozario 2019; Ivančić et al. 2019; Syed et al. 2020).

From an employee perspective, RPA can provide opportunities to decrease their tedious works and realizes more time for value-added work. However, this is only possible if there is enough trust in RPA, as well as the good functionality of a RPA solution (Koch and Fedtke 2020). The active involvement of the employee in the development of the RPA solution as well as the understanding of quality aspects of RPA has to be promoted (Aguirre and Rodriguez 2017; Madakam et al. 2019). In these cases, the usability of RPA and the RPA development environment is very important to increase the trust of employees and engage them with this technology.

This paper takes the perspective of an organisation that offers RPA technologies and self-service development to its employees. In the organisational context, the authors point to the role of RPA usability. Usability can be defined as the extent to which a system, product, or service can be used by specific users in a specific context of use to achieve specific goals effectively, efficiently, and satisfactorily (Juristo et al. 2007). It includes several dimensions such as functionality, ease of use, predictability, accessibility, or intuition (Caniato et al. 2018; Plattfaut et al. 2020). Research has shown that by using the competencies of the involved employees in the process, usability is rising in each dimension.

Although issues related to the quality of RPA-solutions, in general, have been discussed in several conceptual and empirical publications, the area of usability has not been explored in detail - especially not in the context of healthcare, hospitals, and the development environment of RPA (Garmann-Johnsen et al. 2020; Hege et al. 2020; Vollenberg et al. 2021).

The literature of RPA further points out that the evaluation of critical success (or failure) factors and their different impacts have been insufficiently researched so far (Syed et al. 2020). A deeper understanding of the critical success factors of RPA can help organisations identify and better manage various elements to achieve the best results from using RPA. Further, these factors should be considered in the different organisational or process contexts in which RPA is used, e.g., as we study in sensitive business processes.

Apart from these initial statements confirming the research relevance of the topic, there are research gaps around usability during development and usability during the execution of end-user-based RPA applications. As RPA technologies become more widespread, usability becomes increasingly important. Previous research emphasizes that inadequate usability can lead to less trust of employees to RPA and decreasing value in case of RPA use.

The following work, therefore, attempts to fill this research gap by analysing the independent development of RPA by employees and the usability of RPA, and the development environments that can be improved in existing RPA software solutions.

7.2.2 Sensitive business processes

An SBP is essentially defined by the fact that it contributes significantly to the achievement of the organisation's objectives and always includes several critical and sensitive activities. Thus, an SBP is broadly classified as one of the organisation's most important core processes, which subsequently constitute the organisation's core activities. In the academic literature, SBPs are also understood as processes that transport crucial and important knowledge(Hassen et al. 2018). In addition, SBP involves activities that require the achievement, storage, sharing, and (re)use of individual and organisational knowledge, that contains a large amount of very important heterogeneous and sensitive knowledge. The execution of sensitive processes involves a large number of business units that have different experiences and levels of competence (Hassen et al. 2016). Therefore, a SBP possesses a high degree of dynamism in the realisation of its objectives, and high complexity (Hassen et al. 2018).

Hassan et al. (2016) define SBPs as activities that produce different types of knowledge: First, SBP produces „*imperfect individual and collective knowledge (tacit and/or explicit) (i.e., missing, poorly mastered, incomplete, uncertain, etc.) necessary for solving critical, crucial problems*“ (Hassen et al. 2016). Further, „*a large amount of heterogeneous knowledge stored in various knowledge sources (scattered and sometimes inaccessible)*“ (Hassen et al. 2016), „*expertise and/or rare knowledge held by a very small number of experts; flexible knowledge held by experts*“ (Hassen et al. 2016), and „*very important tacit organisational knowledge (such as competencies, skills, and practical experience)*“ (Hassen et al. 2016) are produced by SBP.

Against this background, SBPs are inextricably linked to critical, because sensitive, knowledge flows, such as documentation processes and the transfer of data, information, and knowledge objects between communicating and interacting process participants. This is, of course, of particular importance in sensitive process handling areas - such as critical care areas.

However, the adoption, use, and development of RPA and the impact of this SBP classification on RPA usability have not been sufficiently studied. Furthermore, there is a lack of research on possible drivers and barriers as success factors for the use and development of RPA in SBP's of a critical care area.

7.3 Methodology

Since the above-mentioned marginal and general conditions of SBP have not been addressed in existing scientific research and the existing literature differs too clearly from the subject area, it seemed appropriate to us to develop a new theory by collecting and analysing qualitative data. This theory-building had to be done inductively from the data. In line with the literature, we have chosen grounded theory with an interpretive approach as our research method to develop a theoretical understanding of the drivers and barriers of process automation of particularly sensitive processes in a critical care area according to our research question (Glaser and Strauss 2017; Wiesche et al. 2017).

We conducted a preliminary literature review to align our research with the literature. This review revealed that these phenomena of barriers and drivers for the use and development of RPA technology in sensitive processes have not yet been sufficiently theorized. In this situation, the use of grounded theory approaches is particularly well suited to gain new theoretical insights (Conlon et al. 2020). Grounded theory for gaining theoretical insights is widely used in IS research and is obtained through an intensive, data-driven analysis process (Wiesche et al. 2017). The nature of grounded theory requires iterative data collection and analysis.

In doing so, we divided our research design according to Chun Tie et al. (2019) as follows - data collection, initial coding, and intermediate coding, as shown in Figure 7-1 (Chun Tie et al. 2019).

Data collection includes interviews, the RPA-development documents, and RPA-test protocols. The documents (RPA-development documents and RPA-test protocols) were concurrently collected and analysed during the coding procedure of the interviews. The part of data analysis and coding is further explained in Section 7.3.2.

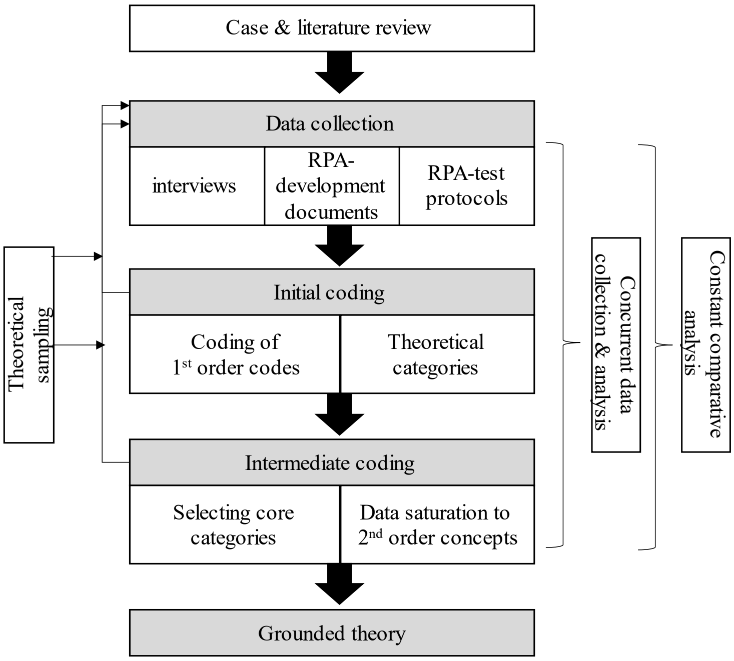

Figure 7-1: Research design

7.3.1 Case Setting

We conducted this study in collaboration with one of the largest German training centers for neonatology and intensive care medicine. Through the training center, we were able to recruit 5 nurses as participants. Each of the intensive care nurses worked in a different hospital, so we ended up studying 5 different ICUs in Germany. The nurses and their role in the ICUs are presented in Table 7-2 below.

Table 7-2: Overview participants roles

Participant	ICU	Expert's Role
Nurse 1	1	Pediatric nurse practitioner; pediatric intensive care unit; immunodeficiency outpatient clinic.
Nurse 2	2	Pediatric nurse practitioner; pediatric intensive care unit; special trauma surgery.
Nurse 3	3	Pediatric nurse practitioner; pediatric intensive care unit; child and an adolescent psychiatric hospital.
Nurse 4	4	Pediatric nurse practitioner; pediatric intensive care unit; surgical clinic.
Nurse 5	5	Pediatric nurse practitioner; pediatric intensive care unit; neurology clinic.

In addition to basic patient care, the tasks of intensive care nurses include monitoring vital functions as well as performing treatment care, administering medication, assisting with various minor procedures such as inserting a central venous catheter. The work tasks of intensive care nurses also include sensitive documentation tasks, such as the documentation of patient data. These processes represent the central information-based activity of nurses. Consequently, an ICU and the associated administrative activities can be regarded as an organisation with SBP through an inherently particularly critical work area. Inevitably, intensive care also includes IT-supported nursing documentation. The nursing documentation examined is the sum of all nursing-relevant data recorded for a patient, consisting of the nursing process, nursing planning, and service recording. It is regulated in Germany and serves as a memory aid, for communication, and as evidence of nursing interventions performed or not performed. All nursing and therapeutic measures and their effects on the patient are recorded and written down. This process can therefore be defined as an SBP.

The specialized training in anaesthesia and intensive care, which is conducted by the training center, includes theoretical instruction and nursing internships in various ICUs as well as the preparation of a technical paper and allows to take a closer look at a special, nursing-relevant topic. In the context of this training, part of the author team conducted a data collection with 5 participating nurses to record and investigate the usability of the development and use of RPA solutions for nursing documentation processes in different ICUs in Germany. The nursing documentation we studied, especially the IT-based part which had to be automated by RPA, is composed of different building blocks and is presented in Figure 7-2 below. The nursing staff enters the personal data of the person in need of care into a documentation system. In addition to name, address, and health insurance affiliation, the contact data of relatives is also recorded or taken from other software solutions, such as information on the patient's medical history. Based on the documentation of the family doctor or therapist on previous illnesses, the current diagnosis and the intake of medication are transferred from other electronic documents into the nursing documentation system. Besides detailed nursing reports as an electronic document that must be transferred, the known risk factors or isolated information on planned nursing activities, a detailed daily and weekly structure, and any rehabilitation measures that necessarily must be noted. At regular intervals, the data are transferred to the nursing report systems by the responsible nursing staff and compiled. These were structured differently in our data collection, either in the form of a nursing diary system or only as a continuous text or *Excel* document.

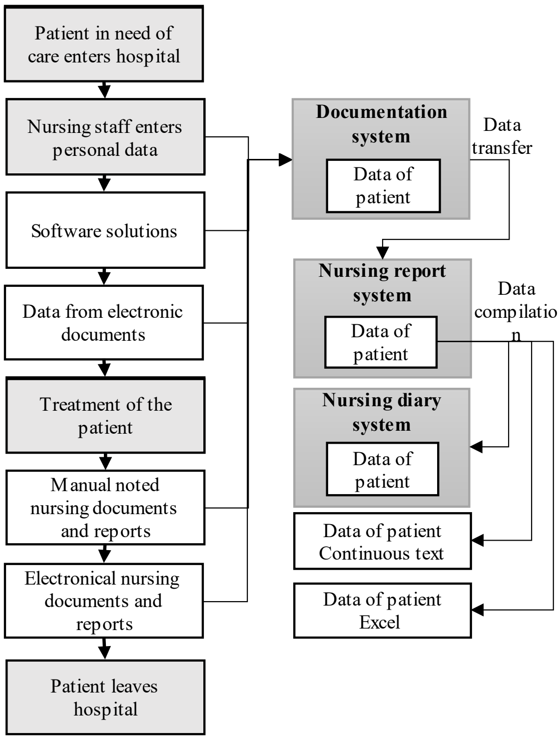

Figure 7-2: Nursing documentation process

Accordingly, these documentation processes were selected as the focus for our research on independent development and usage of RPA-solutions to gain further insights into critical success factors of RPA in the case of SBP. To ensure valid results and to create the organisational conditions for our theory building, 17 processes were implemented by RPA as an executable automation solution in five different hospitals to create a basis for comparison.

7.3.2 Data Collection and Analysis

To obtain a more comprehensive picture of the phenomenon of interest, the relevant literature recommends the use of multiple sources to study the unit of analysis (Buse et al. 2011; Kitchenham et al. 2002).

From August 2020 to May 2021, we collected data on processes that were highly sensitive and thus showed particular effects in the use of IT technology (in this case, RPA). We used a collection of different documents (RPA-development documents and RPA-test protocols), as shown in Figure 7-1, which we evaluated using qualitative content analysis according to Mayring et al. (2004) in an inductive process (Mayring 2004). From these, we extracted initial rudimentary conceptual constructs that we used as a guide in the employee interviews.

The RPA test protocols, which are generated by default by the development platform when RPA is executed, were analysed, and evaluated concerning the extension implementations used, runtimes and error types, exception handling, jumps, or other execution stops. In this way, technical barriers become clearer and provide initial insights into the respective emergence of RPA solutions.

The development documents consist of the status reports and the development histories. The status reports provide insight at the recurring development cycle level to provide more context about the content and potential usage barriers of each RPA solution.

Complementarily, the RPA solution development histories serve to better understand the changes to the RPA solutions and provide a slightly more detailed overview of revisions, additions, and restructurings. The history thus created also serves to better understand initial impacts and the effect of certain measures on user intent.

Table 7-3: Overview data collection

Designation	Data Sources
Nurse 1 - ICU 1	Interviews (3 x 25 min); Development documents (n = 3); Test Protocol (n = 6)
Nurse 2 - ICU 2	Interviews (1 x 65 min); Development documents (n = 10); Test Protocol (n = 22)
Nurse 3 - ICU 3	Interviews (2 x 60 min); Development documents (n = 1)
Nurse 4 - ICU 4	Interviews (5 x 30 min); Development documents (n = 12); Test Protocol (n = 25)
Nurse 5 - ICU 5	Interviews (3 x 65 min); Development documents (n = 1)

We conducted 14 unstructured, in-depth interviews with the participating intensive care nurses (n = 5), as mentioned above. The interviews were conducted with a total length of 10.1 hours.

Further, we analysed the RPA-development documents, in total 27, as well as test protocols, in total 53, of the developed RPA-solutions. The numbers of the analysed documents, as well as the detailed breakdown of interview times, are summarized by nurses and ICU in the overview of data collection in Table 7-3.

The goal of the interviews was to gain insights into the nurses' view of the usability and ease of use of the development and the developed RPA-solution for the different sensitive documentation processes. Since the nurses must work with the data entered by the RPA-solution and are responsible for the correct determination of the nursing data, it seemed crucial to let them assess the usability of the different RPA-solutions and thus the RPA-generated data sets.

The interviews were transcribed verbatim. The transcripts were then analysed using grounded theory coding techniques. Two of the authors as part of the team of authors first coded the transcripts. During initial coding, each line of the transcribed interviews was coded with the openness to aggregate theoretical categories. Throughout the whole coding procedure, the codes were systematically compared within and between the interviews and sorted into categories. They then compared and discussed their coding and developed a set of theoretical categories to group and conceptualize the codes (cf. Figure 7-1).

Intermediate coding was done more focused and applied to saturate the categories and led to core second-order concepts. To ensure methodological rigor, the two of the authors adopted a reflective and comparative view during analysis; additionally, discussions about category development evolution were done (Charmaz 2014). Figure 7-3 shows the result of the codes, the associated concepts, and the supported categories.

7.4 Results

7.4.1 Data Analysis and Results

The following section represents our data analysis and the identified results. Furthermore, we represent a comparison of our findings with the existing literature.

During the study period, 17 RPA solutions were used independently by the nurses surveyed. During the project, it was found that the RPA application performed the IT-based nursing documentation process in a more time-efficient manner: Time savings (measured as effort per nurse) compared to the traditional process of data entry by a nurse was up to 40%.

Concerning our RQ1, we can show that nurses who successfully used stand-alone RPA solutions for nursing documentation always did so with elicitable constraints and barriers in their intention to use.

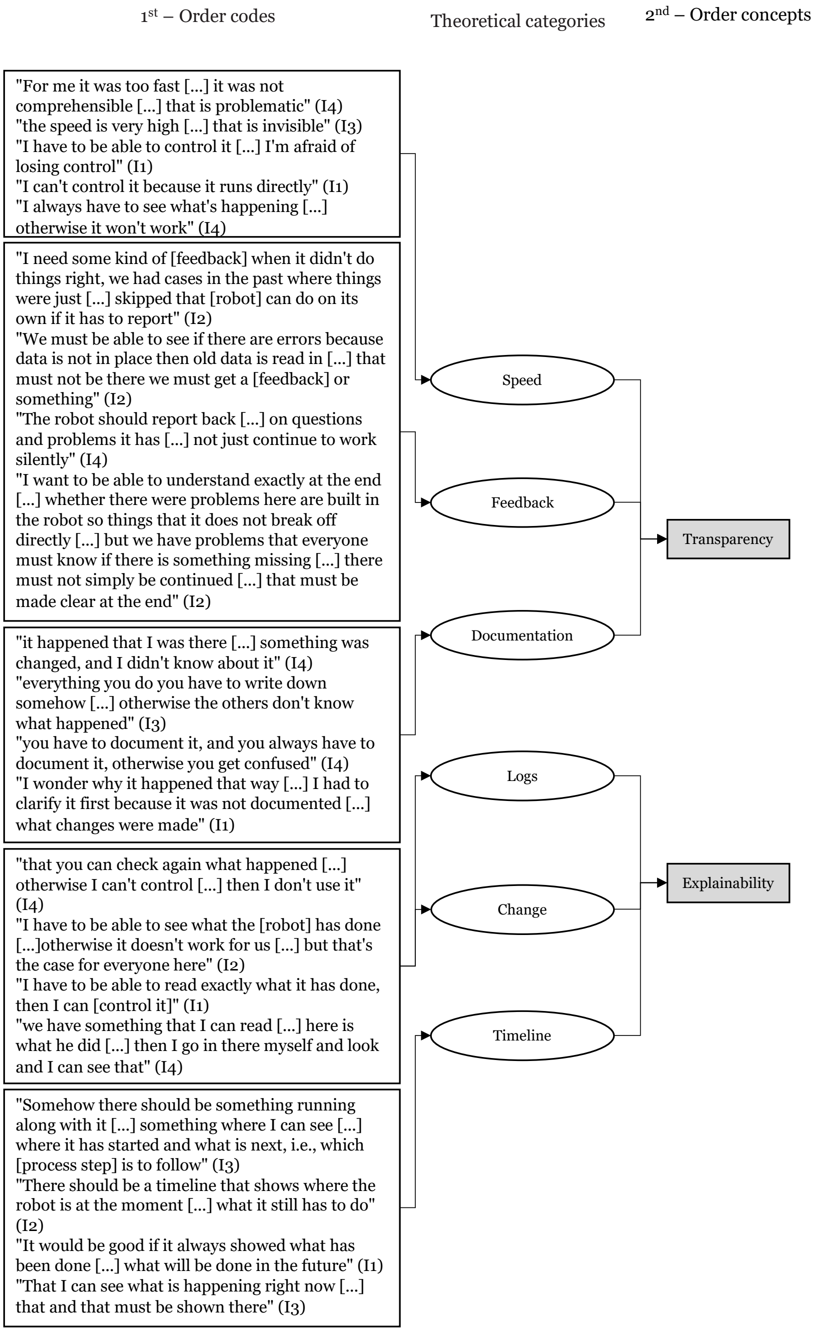

Figure 7-3: Data structure and coding results of grounded theory

Our results first show that the participating nurses consistently selected the same process types for automation. The selected processes do differ between the intensive care units studied in terms of systemic implementation, such as the order in which data is input or output. However, the general nursing documentation process itself as well as the inputs and outputs required for it do not differ or hardly differ between the intensive care units studied. These were the processes of extracting and compiling raw data, possible textual data transformations such as the exchange of patient data, and the transfer to a target system such as another documentation (diary) system. Archiving processes such as document creation and storage were also selected by all nurses.

As shown in Figure 7-3, our data analysis revealed that the derived theoretical concepts could be formed and aggregated into the six categories of *speed*, *feedback*, *documentation*, *logs*, *change*, and *timeline*. The superordinate constructs of „*transparency*" and „*explainability*" were then formed as second-order concepts (cf. Figure 7-3). These were increasingly addressed when using the RPA solution, such as „*the robot is going too fast, but I always have to look at what it is doing* [...] *it is going too fast for me, it should slow it down*" (nurse 2). It became clear that they „*don't want to use it if [they] don't understand it*" (nurse 1) and „*you don't understand it because it goes so fast*" (nurse 4).

Therefore, the RPA solution was artificially slowed down by the RPA specialist, which then resulted in the RPA solution „*running more understandable for all of us*" (nurse 1). It was also mentioned that collaborative RPA solutions often had the problem that they „*were not properly documented during a project*" (nurse 2) and that this often led to „confusion and uncertainty about further use when this (next RPA solution) suddenly looks different again" (nurse 3). As shown accurately in Figure 7-3, the use of RPA solutions was characterized by the observing nurses wanting to „*track exactly*" (nurse 2) how the RPA solution „*works, what* [the bot] *does next and what it has done so far*" (nurse 3) or that „*it becomes transparent and it goes so slowly*" (nurse 5) that „*the* [user] *can track that* [process execution]" (nurse 3).

None of the participants associated the scripting language provided by the RPA development environment with sufficient transparency, which was described as „*too complicated*" (nurse 1) and „*rather confusing*" (nurse 2). Here, it was observed that a sufficiently „*comprehensible documentation of the [mode of operation] of the bot is necessary*" (nurse 3).

On the other hand, the permanent feedback of the RPA environment was also noted, which should not only abort in case of possible errors but also inform the user about missing values or incorrect entries „*in an urban way*" and „*without gaps*" (nurse 1). According to the participants' observations, the traceability factor should be represented by logging the activities of the RPA solution, e.g., like log files, „*parallel to the process execution*" (nurse 1) in a „comprehensible and understandable form" (nurse 2), e.g., as a „*timeline*" (nurse 3).

7.4.2 Comparisons of the factors with those from the literature

Although the research field on RPA is still in its infancy, there are, by nature, some real-world studies on success factors or barriers that observe, analyse, and assess the implementation, deployment, and operation of RPA in different application contexts.

While a variety of industries have been studied here, SBPs such as the documentation processes in the ICU studied here, have not yet been considered as a unit of inquiry in this regard. The relevant literature consistently identifies the following factors as the most essential and prioritize the following drivers for the implementation of RPA: Top management support (Cooper et al. 2019; Lacity et al. 2015; Lacity and Willcocks 2016; Syed et al. 2020, 2020), adequate involvement of all stakeholders (Aguirre and Rodriguez 2017; Asatiani and Penttinen 2016; Lacity et al. 2015; Syed et al. 2020), especially IT, and the establishment of a proof-of-concept (Aguirre and Rodriguez 2017; Asatiani and Penttinen 2016; Lacity et al. 2015; Ratia et al. 2015; Syed et al. 2020).

As so, e.g., the factor of „*top management support*" is often mentioned as the cooperation and continuously guaranteed support of the management which enables the implementation of RPA (Cooper et al. 2019; Lacity et al. 2015; Lacity and Willcocks 2016; Syed et al. 2020, 2020). But this is not specific to RPA projects and applies in various consensus and projects (Khan and Keung 2016; Müller and Jugdev 2012). Whereby the use of „*proof-of-concepts*" (Aguirre and Rodriguez 2017; Asatiani and Penttinen 2016; Lacity et al. 2015; Ratia et al. 2015; Syed et al. 2020) includes the use of RPA before implementing RPA to assess insights about the values RPA could gain in the organisation (Lacity et al. 2015) and create learning experiences on the users' site (*How OpusCapita Used Internal RPA Capabilities to Offer Services to Clients* 2018).

Our results, presented here, show that we can assume with the existing literature of success factors for the implementation of RPA into business processes. These aforementioned success factors of RPA, in the form of „*management support*" (nurse 4), the use of proofs-of-concept and „*pilots*" (nurse 4), and the „*use of* [vendor] *support*" (nurse 1), are also found in our study but play a very minor role. The nurses did not mention these factors as inevitable.

However, it is noteworthy, that in contrast, the concepts we identified in this study of „*transparency*" and „*explainability*" have not yet been sufficiently mentioned or addressed in the literature as an important success factor at all. Previous factors also tend to focus on generalizable factors without a focus on the usability of the RPA-solution itself as well as the particular involvement of employees.

In the absence of comparative case study research in a similar scenario, this suggests that the „*transparency*“, as well as the „*explainability*“, are concepts and drivers in the case of SBP context. Especially the high amount of needed control in SBP explains these concepts as success factors for RPA in a critical care environment. As the main purpose of critical care areas is the saving and support of human life ensuring good documentation as well as data accuracy and data care is one of the most important parts of the treatment process of a patient. Therefore, every participant who is involved in this process wants to control this work, if it gets done by RPA, to guarantee trustful work.

7.5 Discussion

The focus of this work was on employee centric development of RPA solutions. From a practical perspective, our presented results offer implications for providers of RPA development environments. Regarding target group suitability, our work provides valuable insights that can be summarized under the term „*Explainable RPA*“. Here, not only is the self-explanatory visual development of RPA solutions important, i.e., that users do not write program code but use standardized visual modules, but also that the execution of these solutions is even more explainable and comprehensible to provide employees with complete transparency about the process they are responsible for, especially in sensitive processes.

The results of this study show that, in contrast to the hindering factors previously identified in the literature, the queried categories are primarily rooted in the designated „*transparency*“ and „*explainability*“ in the use of RPA technologies. We were able to show that it is possible to technically counteract the perception of loss of control by the employee when using RPA technologies. Our results contribute to the critical factors of RPA development and use in sensitive processes and environments where high requirements are given.

In the RPA projects examined, problems frequently arose due to the lack of transparency of changes to the RPA solution, which is of enormous importance, especially in sensitive processes. RPA solutions invite users to quickly make changes to the respective RPA solution themselves. However, when end users make changes themselves, they often do not know how these changes affect other users of the solution and in the process. Especially in sensitive processes, compliance and standardisation are extremely important, as even small changes can have a major impact. The involvement of human lives in this context also increases sensitivity and criticality. Changes must be precisely planned, communicated, or transparently visible to all those involved in the process. For this very reason, standard processes must be created for the implementation of changes to RPA solutions to document them in detail and create transparency between the various users of the RPA solution.

Among the limitations of this study, of course, is that the results may not be generalizable because only a small number of participants (n = 5) were studied for each of the five organisations. Also, we used only a single representative RPA development environment to derive our criteria; further pluralistic research will be conducted here in the future to obtain more valid conclusions. The use of perceptions through participant interviews always carries with it the limitation of strong subjectivity by them.

7.6 Conclusion

Following our aforementioned research questions, we were interested in understanding where the drivers and barriers to the development and deployment of the RPA solution in the SBP environment lie.

To this end, we conducted the grounded theory presented in this article to develop a theory based on empirical data. To collect this empirical data, we examined development documents and interviewed nurses who handle particularly sensitive business processes by independently developing and deploying the RPA solution. To do this, we conducted several interviews in addition to document analysis to determine what criteria influence nurses' intentions for using an RPA solution.

In doing so, we derived theoretical concepts that we summarized into six categories: speed, feedback, documentation, protocols, change, and timeline. We found that the aggregation of these six categories of RPA usage intent under study is related in two distinct, overarching ways. First, usage intent is strongly influenced by the „*explainability*“ of the RPA solutions used. One possible explanation is that nurses change from a passive role to an active role in the processes through RPA use. As part of the RPA development and use for their work, they are directly responsible for how, and thus how correctly, data is transferred and entered by the RPA solutions. As caregivers now develop and implement RPA solutions themselves to improve their system environment, they demand full traceability and controllability of RPA solutions to increase usage intent. This, especially in SBPs, is of great importance.

The second overarching aggregate factor was that all participants indicated that the barriers they encountered were related to the opaque program flow of the RPA solution, here the usage barrier could be summarized as a lack of „*transparency*“. This can also be explained, as the particular automated steps by RPA need to be transparent to the nurses in case of controlling the processes.

8 Beyond the Hype: RPA's Public Perception over Time

Table 8-1: Fact sheet publication P3

Titel:	Beyond the Hype: RPA's Public Perception over Time
Publication Type	Journal
Publication Outlet	Journal of Organizational Computing and Electronic Commerce
Ranking[1]	**C**
Authors	**Name** Kregel, Ingo Koch, Julian Plattfaut, Ralf
Status	Published
Full Citation	Kregel, I.; Koch, J.; Plattfaut, R. (2021): Beyond the Hype: Robotic Process Automation's Public Perception Over Time. In: *Journal of Organizational Computing and Electronic Commerce* 31 (2), S. 130-150. DOI: 10.1080/10919392.2021.1911586.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Beyond the Hype: RPA's Public Perception over Time

Abstract

The perception of emerging technologies such as Robotic Process Automation (RPA) goes through the phases of emergence, growth, and maturity. In the emergence phase, potential users of the technology naturally have unrealistic expectations of high performance. The expected positive impact of the technology drives the subsequent growth phase. Later, these exaggerated expectations increasingly give way to realistic assessments until a maturity phase is reached. The current academic debate on RPA argues that there is also a fear narrative that hinders wider adoption of this technology. In this article, we present an analysis of over 95,000 news articles on RPA published between 2015 and September 2020 to study the public perception of RPA. We employ sentiment analysis and topic modeling to evaluate positive/negative and subjective/objective views as well as major topics identified in news media. Based on this analysis, we demonstrate that RPA can now be considered a mature technology which seems to have passed a hype without enduring a large dip in expectations. Building on these insights, this article discusses some potential avenues for future research „*beyond the hype*".

Keywords: robotic process automation, sentiment analysis, hype cycle, polarity, news media

8.1 Introduction

Robotic Process Automation (RPA) is a comparably new technology to automate processes. It uses the graphical user interface and interacts with existing core systems just as a human employee would do. Both scientific research and news media outlets highlight the potential of RPA to increase process efficiencies. Exemplarily, Lacity and Willcocks report on an RPA project having „*a three-year return on investment of between 650% and 800%*" (Lacity and Willcocks 2016). Articles from news media outlets go into the same direction with headlines which suggest that RPA is able to generate „*97% time saving*" (Knutt 2020).

However, the topic of RPA technologies still causes fear among many employees. The current scientific discourse on job losses due to the advance of new technologies, to which

RPA also belongs, is also specifically concerned with the emotional presentation of these technologies in the media (Huysman 2020; Riemer and Peter 2020; Willcocks 2020). Here, it is the threat to jobs and the compulsion to trust new technologies that create resistance. The fear of losing control comes up and is often stimulated by the media with articles such as „*AI and RPA will absolutely, positively threaten your job*“ published by Forbes Online (Andriole 2018). The hype apparently brings negative perceptions with it. As such, the public perception of RPA appears to be somewhere between hype and fear.

There are multiple theoretical perspectives which aim at explaining the development of hype and adoption of new technologies over time. Exemplarily and often used in practice, there is the Gartner hype cycle which predicts a development of technological hype over time. A number of publications build upon this understanding and discuss the relevance to various technologies (Dedehayir and Steinert 2016; O'Leary 2008; van Lente et al. 2013). Next to the Gartner hype cycle, other theoretical perspective with a greater foundation in scholarly research exist. These include Bass' diffusion model which explains a rationale how current adopters and potential adopters of a technology interact (Bass 1969) and Rogers' diffusion of innovation theory (Rogers 2003), which describes a typical s-curve of technology adoption over time. Moreover, empirical analysis of the public perception of different technologies add to this fundus of scholarly research (van Lente et al. 2013). However, an empirical analysis of the public perception of RPA in light of different theories and a comparison with other technologies is yet missing.

A deeper understanding of the public perception of RPA would have several advantages. Firstly, prior research could show that the perception of RPA is a major influencing factor for the success of RPA programs in organisations. Exemplarily, Plattfaut (2019) named the focus of communication of the potential of RPA a major success factor for RPA projects. Recently, this argument was extended with Willcocks and subsequent authors deconstructing the hype-and-fear narrative with a focus on potential job losses which hinders success of RPA projects (Riemer and Peter 2020; Willcocks 2020). However, this hype-and-fear narrative is not empirically validated, yet. Building on these arguments, secondly, Syed et al. (2020) call for more research on drivers for RPA adoption. Thirdly, such a deeper understanding of the public perception of RPA would also open the doors to several fruitful avenues of future research.

Building on these observations, we aim at developing such a deeper understanding of the public perception of RPA and address the following research objectives. Firstly, we analyse the evolution of the public perception of RPA over time in a descriptive fashion (RO1). Here, we will employ four modes of data analysis to a set of published news articles on the topic of RPA. We will assess the (a) quantity of news articles over time,

(b) sentiment of these news articles in term of polarity, (c) sentiment of these news articles in term of subjectivity/objectivity, and (d) prevalent topics via topic modeling. Secondly, we compare the results of this descriptive analysis with existing technology lifecycle theories, prior analyses of lifecycles of other technologies, and scholarly literature on RPA (RO2).

The article is structured as follows. First, we summarize prior research on RPA and the different theoretical perspectives on technology lifecycle models. Afterwards, in section 8.3, we describe our methodological approach with regards to data collection, pre-processing, and our analyses as introduced above. The results of the data analyses are presented in Section 8.4 before we interpret and discuss them in Section 8.5. This section moreover lists limitations as well as potential avenues for future research. The article closes with a short conclusion.

8.2 Related Research

8.2.1 Robotic process automation

Robotic Process Automation (RPA) is a relatively new way to automate business processes. It extends the digitalisation lever of business process management as it allows easy development of computer programs, so-called bots, in a no-to-low-code environment (Lacity and Willcocks 2016; Penttinen et al. 2018; Plattfaut 2019; van der Aalst et al. 2018a). RPA bots are mainly employed in rule-based environments where they automate repetitive processes that have been handled by human employees before (Lacity and Willcocks 2016). Exemplary processes are swivel-chair tasks where a human employee is the interface between two different systems. The user needs to copy, manipulate, and paste data between one system and another. RPA solutions mimic the mouse and keyboard interactions of the user and thus automate the process. As RPA bot development does only require a low level of coding experience and comes with low implementation costs, it is suitable for a new set of processes that has been neglected by traditional means of process automation so far (van der Aalst et al. 2018a).

RPA has attracted a lot of interest in the business world with several examples of successful implementation. Lacity and Willcocks (2016) report on a successful implementation at a telecom provider where decision makers were in favor of RPA and expected high process efficiency gains. Plattfaut (2019) studied the implementation of RPA at a health insurance company and reported both on beliefs in high benefits and on difficult employee reactions with regards to jobs lost and jobs changed. Apparently, the opinion of the employees and corresponding successful change communication is a driver of overall RPA success (Lacity and Willcocks 2016; Plattfaut 2019).

The mentioned difficult employee reactions are potentially also based in a hype-and-fear narrative of public media. This argument was recently discussed heavily in the Journal of Information Technology where different perspectives on the effect of rising automation by the general public were subject of multiple debate articles (Klein and Watson-Manheim 2020; Riemer and Peter 2020; Willcocks 2020). Willcocks argues that the general belief in the unlimited possibilities of technology, which could only fully develop in the future, is associated with massive job losses, although this imaginary development of technology is only a hypothesis and is by no means certain (Willcocks 2020). In contrast, Riemer and Peter (2020) argue that it is not the quantifiable factors, such as net job loss, that drive such public discernment and inclusive discourse, but rather the qualitative factors and impacts, such as the expected effects on the quality of working life and the intrinsic value of work. However, an empirical analysis of this postulated hype-and-fear narrative is yet missing.

8.2.2 Technology life cycles

There are numerous discussions in science about the transfer, adoption, and diffusion of new technologies over time. Corresponding models and theories essentially assume that the diffusion and life cycle of new technologies can be described by a growth and saturation process (Bass 1969; Foster 1986; Rogers 2003). While the core of the adoption models is represented by the independent variable time, the dependent variables are different in nature. Both Roger's model and Bass' model use the adoption rate, alternatively represented as relative market share. The popular hype cycle model of Gartner instead uses the hype term to represent the (too) high expectations generated around a new technology (Linden and Fenn 2003): This model „*can be implemented to explain users' expectations that differ from the conventional life cycle, which reflects users' purchasing behavior*“ (Jun 2012). What all models have in common, besides the same independent variable of time, is that their dependent variables are always directly controlled and influenced by public opinion and perception (Dedehayir and Steinert 2016; Jun 2012).

A diverse set of measurements has been used in the past to create technology life cycles (Watts and Porter 1997). Suitable data is not easy to collect and to interpret; its source also depends on the specific technology, industries, and further contextual variables (Järvenpää and Mäkinen 2008). Scholars already focused their research on archetypes of dynamics and patterns and summarized several types of life cycles, including linear, exponential, and s-curve models (Kriechbaum et al. 2018; Routley et al. 2013; Ruef and Markard 2010).

The diversity of life cycles models can also be found in the number of different methods to explore their stages. These methods include mathematical modeling, bibliometric analysis, principal component analysis (PCA) and hierarchical clustering (Mikova 2016). In this context, sentiment analysis is highlighted as one of the emerging methods besides web scraping and ontology modeling (Mikova 2016).

Even though the web offers a variety of useful news information (Albert et al. 2015; Kayser et al. 2014; Kayser and Blind 2017), one of the typical sources when looking for technology life cycle indicators are newspaper articles (Mejia and Kajikawa 2017; Watts and Porter 1997). Several scholars rely on the archives of The New York Times (NYT) to count the number of articles mentioning a particular technology (Melton et al. 2016). Exemplarily, van Lente et al. (2013) empirically analyse the life cycle patterns of gene therapy, high-temperature superconductivity, and internet telephony (Voice over IP, VoIP). As visualized in Figure 8-1, gene therapy shows a slow but steady growth starting in 1980 and reaching a clear spike in 2000 before the number of articles significantly decreases again. High-temperature superconductivity in comparison, starts with a strong peak in 1987, the second year ever that it was mentioned. The topic loses its importance very quickly after that and is mentioned for the next twenty years in only a few articles. As a third example of van Lente, Spitters, and Peine (2013), VoIP shows a pattern different again from the first two examples. With peaks in 2000 and 2004, this topic apparently went through two phases of high popularity.

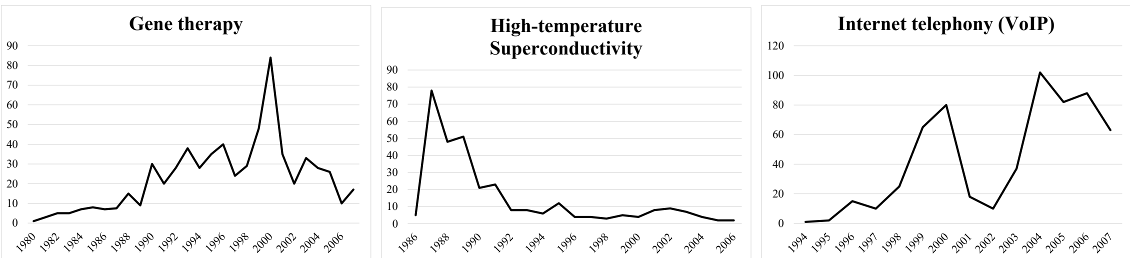

Figure 8-1: Number of articles in NYT for three technologies selected by van Lente et al. (2013)

One possible explanation of this observation is the theory of double-boom cycles (Peters et al. 2012; Schmoch 2007). This term summarizes a first „*boom*" of a technology due to new scientific or technological developments and inventions that is followed by a second „*boom*" when the market adopts the new technology on a large scale. Schmoch (2007) describe this phenomenon as a *science push* that is followed by a *market pull*. In between these two booms, a period of stagnation can occur.

According to prior research, public debates mark the start of any technology adoption curve. An adoption curve therefore does not start with the introduction of a new technology per se but with the corresponding media attention (Jun 2012; Linden and Fenn 2003). This public perception can also influence the development and speed of a hype, the technology adoption rate, and eventually the success or failure of a technology (Jun 2012). The typical hype cycle visualisation of Gartner can be found in Figure 8-2 and shows the development of expectations in the course of time. According to Gartner, a technology or innovation goes through the following five stages of the hype cycle in chronological order (Fenn and Blosch 2018):

(1) *Innovation Trigger*: A first event starts the hype cycle of a new innovation / technology. This event can be of many forms, such as a public presentation, a scientific article, a news article or commentary, or a registered patent.

(2) *Peak of Inflated Expectations*: The innovation reaches a high point of public discussion, optimistic expectations, and positive predictions of its future.

(3) *Trough of Disillusionment*: The level of expectations eventually decreases again. Very positive predictions of an innovation's potential will usually be reduced and become more realistic. Negative news, surprising setbacks, and a slow adoption rate of the innovation can accelerate this development until a new low point is reached and the expectations eventually rise again but will not reach their former peak.

(4) *Slope of Enlightenment*: The innovation has left a hyped stage and reaches a point of grown maturity. The experiences (and mistakes) made by early-adopters led to more knowledge about the innovation's added value and use cases. This can convince a broader audience to apply the innovation.

(5) *Plateau of Productivity*: The innovation's adoption rate further increases, and it becomes widely known and applied. In earlier publications (Linden and Fenn 2003), Gartner also added a last phase, the post-plateau where the adoption rate eventually would drop again.

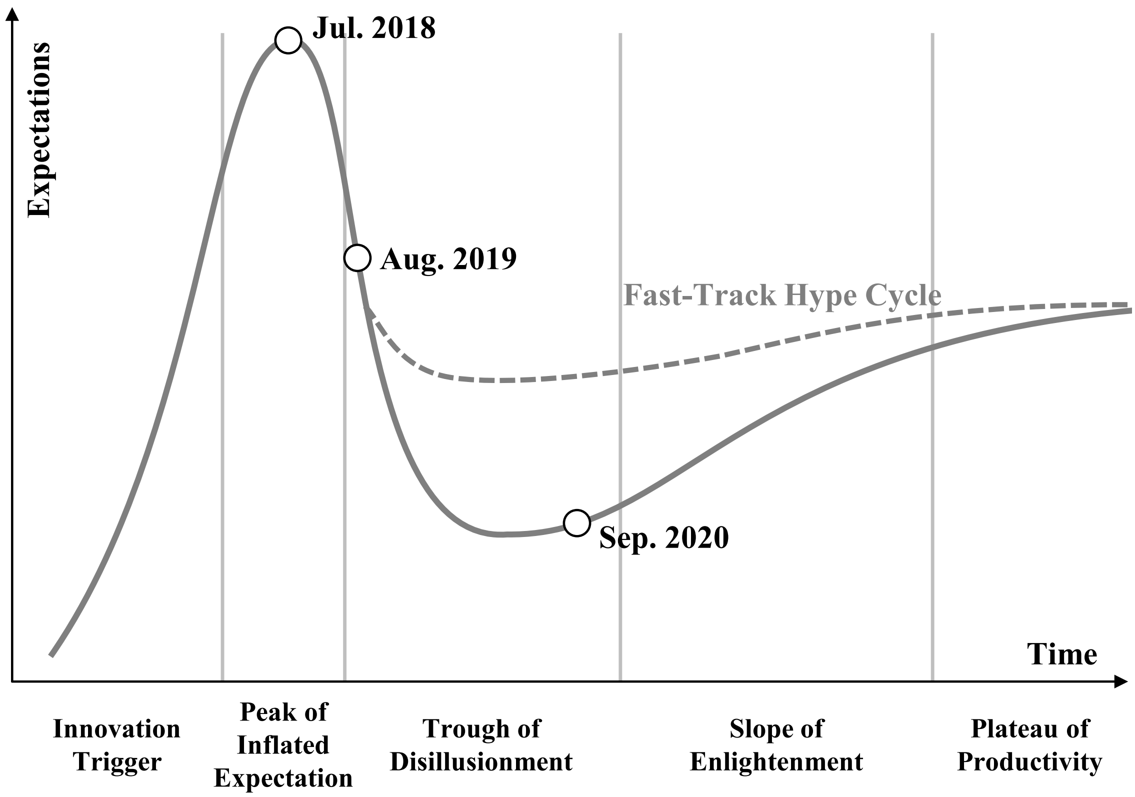

Figure 8-2: RPA in Gartner's hype cycle over time

The Gartner model actually is a combination of a hype level with an engineering or business maturity (Dedehayir and Steinert 2016; Fenn and Blosch 2018). The more apart both factors are, the larger the „*trough of disillusionment*" becomes, when a sharp flattening of the hype level does not meet an advanced engineering or business maturity. In turn, however, there are also „*fast track hype cycle*" technologies where an early maturity leads to a „*negligible through*" after the hype is over (Fenn and Blosch 2018, see dotted line in Figure 8-2).

Even though Gartner's model originally is a commercial product, it has been frequently researched during the last decades (Dedehayir and Steinert 2016). Scholars worked on creating hype cycle models out of quantitative data (Järvenpää and Mäkinen 2008, 2008b) and by analysing the content of news media (Alkemade and Suurs 2012; Konrad et al. 2012). Gartner started their model with expressing a technology's levels of „*visibility*" over time (Linden and Fenn 2003) and changed this label to „*expectations*" in 2009: „*The current label more accurately reflects the deeper root cause and nature of the buzz as the innovation progresses. For example, an innovation may be in the trough yet still visible in the form of negative press*" (Fenn and Blosch 2018). Their argumentation therefore would favor a sentiment analysis over simply counting the number of news articles. Sentiment analyses can also better reflect the „*overenthusiasm*" of users and media, which is part of Gartner's model (Dedehayir and Steinert 2016; Linden and Fenn 2003).

Gartner regularly publishes hype cycle analyses for several different groups of topics. The entry „*Robotic Process Automation Software*“ first appeared in Gartner’s Hype Cycle for Business Process Services and Outsourcing in August 2017. Surprisingly, its initial positioning moved from sliding into the trough back to the peak in 2018 before it entered the trough again a year later and was placed just before leaving it in 2020 (Thyagarajan 2020). Gartner changed the name after 2017 and removed the „*outsourcing*“ part which might have resulted in the different technology evaluation at the beginning. The company also positioned RPA in their 2018 Hype Cycle for Artificial Intelligence at the *peak*, before entering the *trough* a year later (Goasduff 2019). In 2020, it was no longer listed in this particular hype cycle. Instead, it appeared in Gartner’s 2020 Hype Cycle for Legal and Compliance Technologies, where its position matched the result from the Business Process Services hype cycle of the same year (van der Meulen 2020). After the exception in 2017, all further published RPA life cycle statements therefore were in agreement and are summarized in Figure 8-2.

8.3 Research Methodology

8.3.1 Overview

Our research process consisted of the three phases data collection, pre-processing, and analysis (see Figure 8-3). We firstly collected news articles on the topic of RPA. Secondly, we pre-processed the data to allow further analysis. Lastly, we employed four different modes of data analysis to achieve our research objectives. Here, we analysed (a) the quantity of articles over time, (b) the sentiments in the articles in terms of polarity, (c) the sentiment in terms of subjectivity, and (d) relevant topics derived via topic modeling. All these steps are described in the following Subsections 8.3.2-8.3.6. Results are presented in Section 8.4.

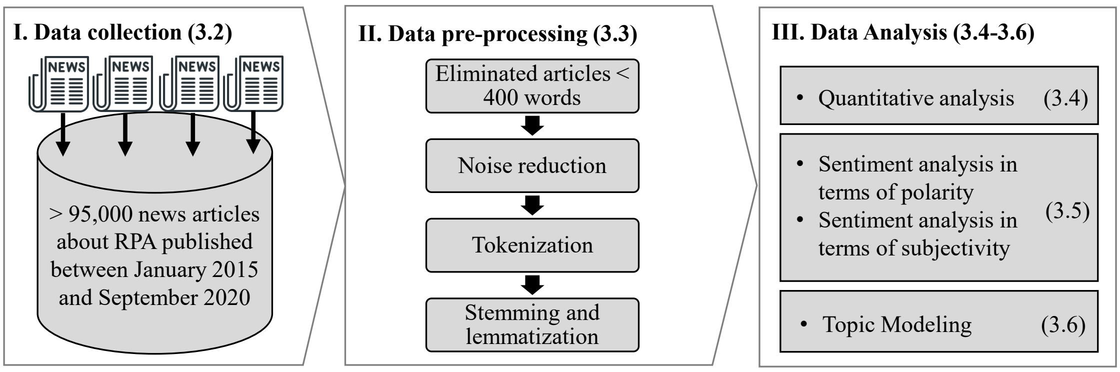

Figure 8-3: Process of data analysis

8.3.2 Data collection

To achieve the presented research objectives, we first collected news articles. To this end, we applied specific search operators on the most comprehensive news search engine of Google News. Since we approach the topic of RPA from a technical perspective, we included technological substitutes that reflect similar technical characteristics in our search. These alias search terms were compiled from the literature in advance (Fung 2014b; Koch et al. 2020; Lacity and Willcocks 2016) and are listed in the following: *„RPA“ OR „Robotic Process Automation“ OR „Robotic Desktop Automation“ OR „Business Process Automation“ OR „Human-Computer Interface Automation“ OR „Intelligent Process Automation“ OR „Cognitive Process Automation“*. Google News has the advantage of eliminating news articles that are not the main source through an algorithmic evaluation of thematic duplications in the content. Thus, identical news articles duplicated by press distribution services or so-called „*content farms*“ for search engine manipulation can already be excluded by the search engine's pre-filtering of results (Jun et al. 2018). In addition, we performed a check for the exact news title to detect and exclude any duplicates. For each of the remaining articles, we scraped the corresponding results so that the dataset included the news title, description, and unique URL of each entry. More information and descriptive statistics of the retrieved dataset will be presented in the results section.

8.3.3 Text pre-processing

To enable the analysis of the news articles in the dataset, we performed appropriate pre-processing of the collected text data. For this purpose, we used the algorithms of the *Natural Language Toolkit (NLTK)* and *TextBlob*, both based on the Python programming language (Loper and Bird 2002; Loria 2020).

As the first step of text pre-processing, we eliminated articles that were less than 400 words long. We did this to ensure that we had sufficiently large text corpora for analysis. Beyond that, however, the length of news articles does not matter for the weighting in the overall context, as the length of a news article per se does not allow any conclusions to be drawn about its importance, significance, or status in a collection of news articles.

The second pre-processing step was to apply noise reduction to the text to normalize the data. Unwanted text components such as URLs, e-mail addresses, JavaScript, PHP, or HTML code were removed.

The next step was tokenisation, which is also called text segmentation (Ravi and Ravi 2015). It breaks down a sequence of sentences into individual components such as words, phrases or symbols called tokens. We used the *TreebankWordTokenizer* which is part of the NLTK. This state-of-the-art method aims to solve the problem of word contractions by using regular expressions. Larger blocks of text can thus be converted into sentences, phrases can be converted into words, and so on. Further processing is generally carried out after a piece of text has been given a token. During tokenisation, some characters, such as punctuation marks, are also discarded. This step was followed by stemming and lemmatisation, where affixes were removed from words to obtain the word stems.

8.3.4 Descriptive analysis of publication quantities

Our first mode of data analysis was to descriptively analyse the development of publication quantities over time. We will present these numbers aggregated per half year and as a distribution of articles per month. However, in line with prior research (van Lente et al. 2013), the distribution of articles per month needs to be analysed very carefully as single occasional spikes are not smoothed out.

8.3.5 Sentiment analysis in terms of polarity and subjectivity

Our second and third modes of data analysis were to analyse the sentiments in the articles in terms of both polarity and subjectivity. Sentiment analysis follows in the tradition of literary, cultural, and social science research approaches that deal with the connection between language and emotions (Vinodhini and Chandrasekaran 2012). It focuses on the automatic computer-aided analysis and recognition of opinions, evaluations, and trends in natural language texts. In its simplest form, this technique is based on a predetermined list of positive and negative words. The respective expression or sentence is then checked to see how often these words occur in it (Pang and Lee 2008).

Sentiment analysis of news articles has been widely used by scientists to investigate public opinion and perception (Cambria et al. 2013; Cambria et al. 2017; Mäntylä et al. 2018; Zhang et al. 2018). Thus, sentiment analysis can also be used to analyse the evolving publicly expressed expectations of technologies over time (Straub 2009). With the growth of online news sources, researchers increasingly use text mining and natural language processing tools to analyse online texts (Ghiassi et al. 2016; Mousavi et al. 2020). Scholars who focus on the sentiment in news articles are particularly interested in the polarity of these articles, i.e., whether they convey a positive or negative attitude to the topic of discussion (Mäntylä et al. 2018; Shapiro et al. 2020).

In our second mode of data analysis, we are interested in news data's polarity which can be defined as „*classifying an opinionated document as expressing a positive or negative opinion*" (Liu 2010). Polarity allows scholars to measure and classify the contents of the examined texts on a continuous scale from very negative to very positive. Moreover, sentiment analysis can also be used to analyse the subjectivity of each article (our third mode of data analysis): „*An objective* [text] *expresses some factual information about the world, while a subjective* [text] *expresses some personal feelings or beliefs*" (Liu 2010).

To this end, we calculated the Term Frequency-Inverse Document Frequency (TF-IDF). The TF-IDF indicates how important a word is within a document. This technique is often used as a weighting factor for word frequencies (Aizawa 2003). The weight of a word increases in proportion to the frequency with which a word occurs in the document but is offset by the frequency of the word in the corpus. This offset helps to control the fact that some words generally occur more frequently than others. In this paper, we follow the lexicon-based approach for our sentiment analysis and use the lexical dictionary of SentiWordNet (3.0). SentiWordNet was designed to support sentiment analysis applications by providing an annotation based on three numerical sentiment values of positivity, negativity, and neutrality. For this purpose, these measures were obtained from the individual words of each news article, their values were summed, and the corresponding average was calculated. News articles with an emotional value of -1 are considered purely negative and those with an emotional value of +1 are considered purely positive. Moreover, SentiWordNet also allows to assign a continuous value for subjectivity (ranging from 0 as purely objective to 1 as purely subjective) of a text (Baccianella et al. 2010). SentiWordNet is the most established dictionary for performing media resonance analysis within textual content such as news texts (Mäntylä et al. 2018; Ravi and Ravi 2015). It has been used and proven in academia, especially in the area of financial market news and its impact on stock prices (Denecke 2008; Sohangir et al. 2018). As a source for new words, SentiWordNet uses glossaries and word relations which it obtains from WordNET, the most popular digital dictionary of the English language (Baccianella et al. 2010). With these existing word relationships, new words could be identified on an ongoing basis, which would then be assigned the appropriate same or similar tonality. Therefore, in our case, SentiWordNet was used with a word sense disambiguation (WSD) algorithm to identify the most significant word meaning and lower the risk for misinterpretation (Navigli 2009).

8.3.6 Topic modeling methodology

After our first three modes of data analysis, we aimed at examining the prevalent topics in the news articles over time. To this end, we employed probabilistic topic models to discover topics in each year. The main goal of this analysis method is to obtain an exploratory view of the content of our news text corpus (Blei 2012; Wallach et al. 2009). Topic modeling analyses content structures exclusively from the studied pre-processed texts, which also means that the method does not require external dictionaries or training data, unlike the sentiment analysis presented in Section 8.3.5.

Topic modeling is widely used in various scientific applications such as classification, categorisation, summarisation, and segmentation of documents (Liu and Zhang 2012; Mimno et al. 2011; Wallach et al. 2009). It has become one of the most widely used applications in computational natural language processing and is the leading analysis method in research disciplines such as scientific literature analysis, social network analysis, software engineering, and bioinformatics (Blei 2012; Jelodar et al. 2019).

We evaluated several unsupervised machine learning algorithms and chose latent Dirichlet allocation (LDA) as the preferred method. LDA is the most well-known and successful approach, especially for news articles, to discover common topics hidden in a collection of documents (Jelodar et al. 2019; Song et al. 2009). LDA is at its core a Bayesian approach in which a document, in our case the news article, is modeled as a mixture of topics (Blei et al. 2003). A topic modeled in this way can be viewed as a group of similar words characterized by a distribution over a fixed vocabulary. By analysing each news article, a distribution of this fixed vocabulary is modeled according to their frequency (Blei et al. 2003). The generated topics then represent clusters of co-occurring words based on an analysis of the distribution of these words and the generated topics for each news article (Agrawal et al. 2018). The results of topic modeling are thus multiple extracted topic terms with their associated statistical expressions. To analyse differences in generated topics by year, we split our news text corpus by year. This allows exploratory insights into key news topics at the respective year level.

The forms of representation and quality criteria that we used to evaluate the topic model are described in more detail in the appendix.

8.4 Results

8.4.1 Descriptive analysis of publication quantities

In total, we collected 97,402 news articles over a timespan of a little more than five years.[4] The first available news data came from six articles on 2015-08-08. Since then, every week resulted in at least 21 articles, every month in at least 128. Figure 8-4 visualizes the

[4] The condensed dataset can be requested from the authors.

number of published articles per month: The highest numbers of articles were published in May 2019 (3611 articles), March 2018 (3549 articles), and May 2020 (3308 articles). These three peaks already show that there is no clear linear increase of quantities.

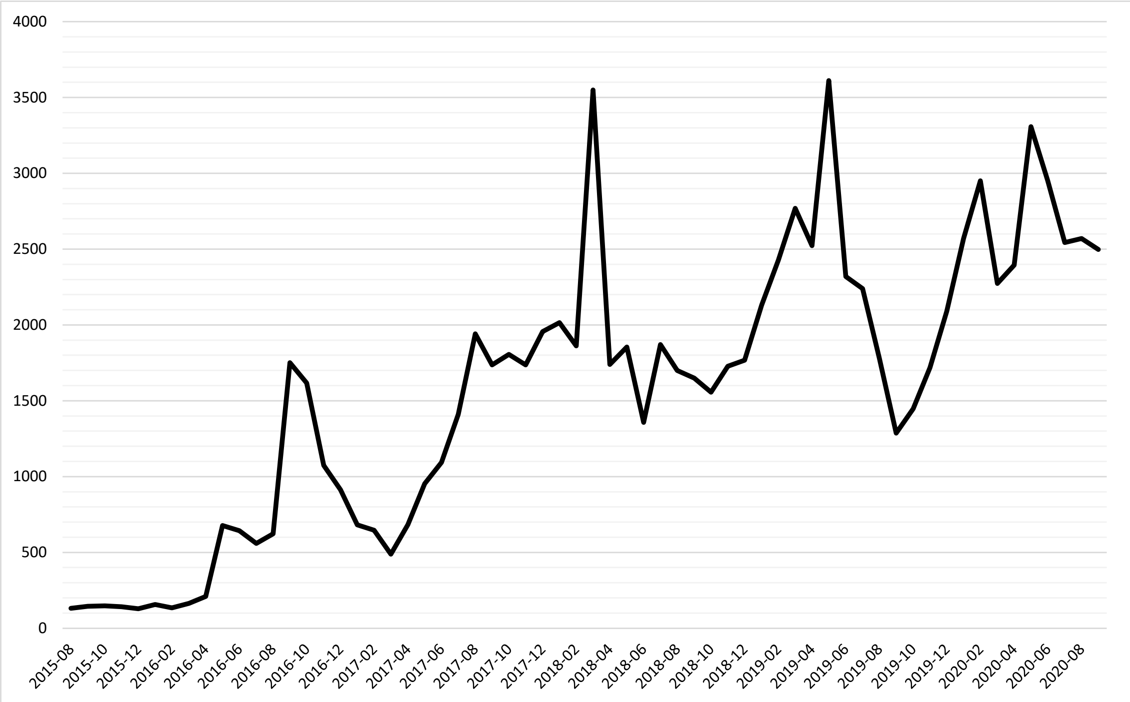

Figure 8-4: Number of RPA-related news articles per month

For a long-term comparison of periods, Table 8-2 summarizes the number of articles for each half-year since 2015. The number of articles in these periods grew until the first half of 2018 and since then showed a pattern with fewer articles published in the second half than in the first half of each year. 2020 started with only 4.2% more articles than the previous-year period. Our data collection stopped at September 30, 2020. We therefore did not include a value for the second half-year of 2020.

Table 8-2: Number of RPA-related news articles per year / half-year

Year	Jan-Jun	Jul-Dec	Sum
2015	-	693	693
2016	1,986	6,537	8,523
2017	4,545	10,589	15,134
2018	12,377	10,272	22,649
2019	15,783	10,562	26,345
2020	16,447	-	-

8.5 sentiment analysis in terms of polarity

The polarity and subjectivity analyses are visualized using box plots. These diagrams allow analysing the combination of discrete and continuous data. In our case, the discrete data is the separation of each month of our dataset. The continuous data is the set of polarity / subjectivity values belonging to the respective month. In such a diagram, the data distribution is divided into its four quartiles. The second and third quartile form the „*box*", the first and last quartile are usually visualized by lines („*whiskers*"). Due to the high number of months in our analysis and to keep our figures clearer, we omitted the whiskers. We therefore visualized the two middle quartiles of each month's data with boxes and added the month's median as a big dot. The box plot in Figure 8-5 visualizes the polarity from August 2015 to September 2020.

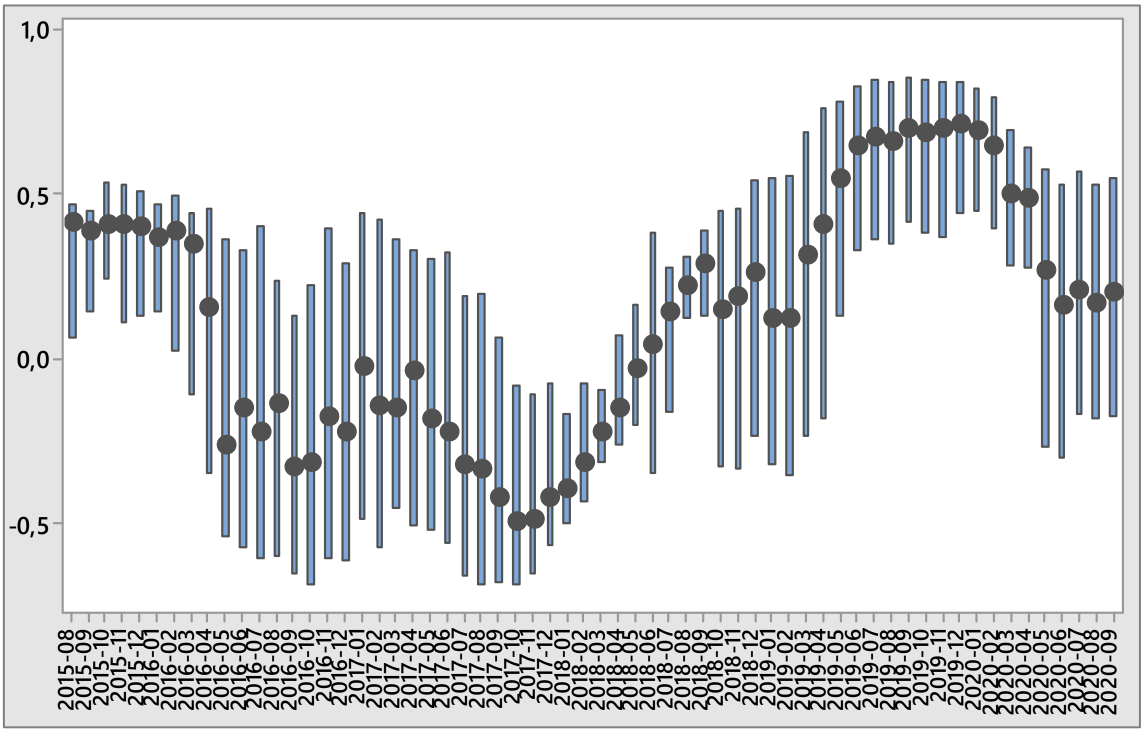

Figure 8-5: Polarity box plot per month

The sentiment analysis in terms of polarity shows some development. In the first months from August 2015 until April 2016, the mean polarity stayed above zero. This implies that the majority of news articles were speaking positively about RPA. Between May 2016 and May 2018, the general narrative stayed negative. However, strong variations in news article polarity occurred. From June 2018 onwards, the polarity improved until it peaked around the turn of the year 2019/2020. Since then, we observe a reduced positivity and comparably steady polarity values in the last five months.

8.5.1 sentiment analysis in terms of subjectivity

The subjectivity measures in Figure 8-6 on a first look seem to be relatively even with a nevertheless slow but steady decrease in subjectivity from 2015 until May 2020. In the last few months of our observation, from June until September, the subjectivity values vary stronger and show a significant drop. Here, a low subjectivity value refers to more objective news articles. Possible reasons for the subjectivity development over time are discussed in section 8.4.

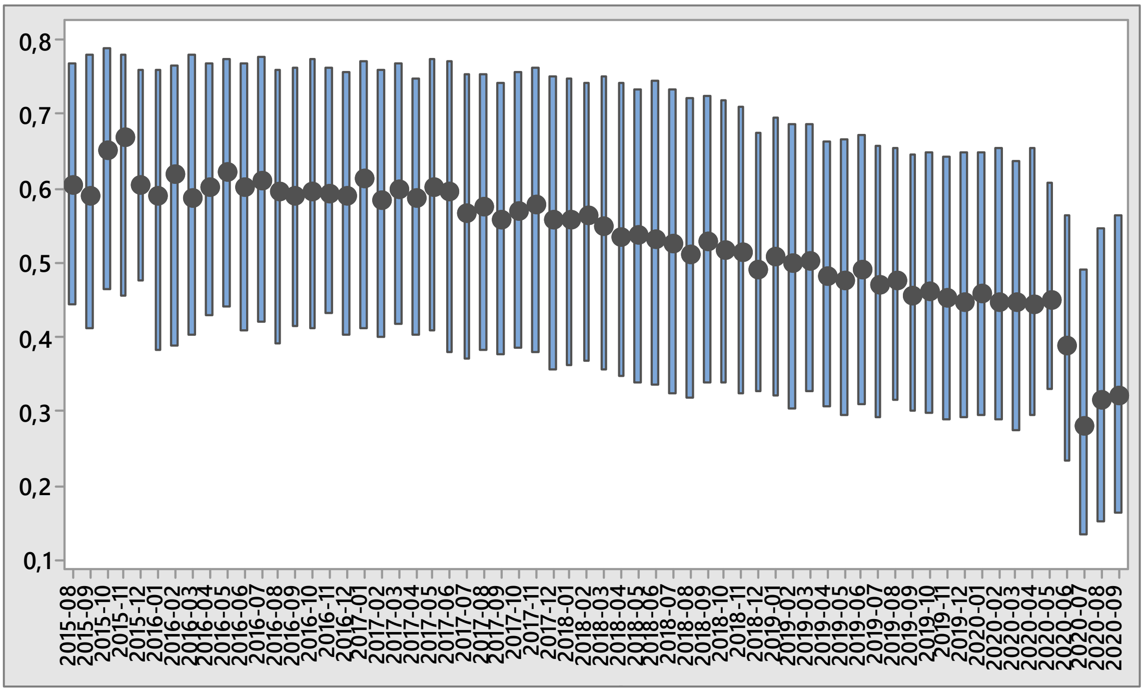

Figure 8-6: Subjectivity box plot per month

8.5.2 Topic modeling analysis

Lastly, we employed topic modeling to identify prevalent topics in the collected news articles per year. Table 8-3 describes the 10 most prevalent topics in each year from 2015 to 2020. Please note that, as stated above, both 2015 and 2020 do not cover the full calendar year. More details on the topics and their quality can be found in the appendix.

The results show that especially in the beginning news articles focused on explaining and defining RPA with topics such as accuracy, rule-based, work task, etc. Over time, the advantages and expectations of RPA were more heavily discussed, e.g., cost reduction, future of work, and digital labor. In the last year, the Covid-19 pandemic also dominated news articles on RPA. Apparently, RPA can be seen as one way for organisations to react on the transforming nature of Covid-19.

Moreover, the results also show a shift in the provider landscape. In early years, Blue Prism was the dominant provider mentioned n news articles. However, from 2018 on, UiPath overtook BluePrism in terms of prevalence in public perception.

Table 8-3: The modeled topics on an annual basis in descending order of priority

#	2015	2016	2017	2018	2019	2020
1	ACCURACY	COST REDUCTION	HUMAN RESOURCES	RULES BASED	UIPATH	COVID-19
2	RULE-BASED	BLUE PRISM	ACCURACY	UIPATH	FUTURE OF WORK	UIPATH
3	WORKFORCE	FINANCIAL ACCOUNTING	RULE-BASED	COGNITIVE	REDUCE COST	COST SAVING
4	CONSULTING	CUSTOMER SUPPORT	FUTURE OF WORK	NATURAL LANGUAGE	NATURAL LANGUAGE	FUTURE OF WORK
5	FUTURE OF WORK	CONSULTING	WORK TASK	HUMAN RESSOURCES	ARTIFICIAL INTELLIGENCE	HUMAN RESSOURCES
6	BLUE PRISM	ARTIFICIAL INTELLIGENCE	WORKFORCE	ARTIFICIAL INTELLIGENC E	COMPUTER VISION	USER INTERFACE
7	HUMAN RESOURCES	ENTERPRISE SYSTEM	USER INTERFACE	FUTURE OF WORK	SAP	WORKFORCE
8	NATURAL LANGUAGE	FEAR	CONSULTING	BLUE PRISM	FINANCE ACCOUNTING	DIGITAL TRANS-FORMATION
9	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	HUMAN RESOURCES	NATURAL LANGUAGE	DIGITAL LABOR	HUMAN RESSOURCES	SAP
10	WORK TASK	FUTURE OF WORK	COMPLIANCE	CONSULTING	BLUE PRISM	RULES BASED

8.6 Discussion

8.6.1 The evolution of public perception of RPA

Analysing the quantity of news articles on RPA shows that the topic is still booming with publication numbers on a high level. This level was relatively stable in the last 2 years of analysis. There is so far no indication for a drop in RPA’s media attention. Apparently, the pure media buzz is still high.

A deeper look on the quantity of news articles on RPA over time shows some spikes. However, these are not driven by scientific publications but rather by published reports of consultancies or market research agencies or by major mergers and acquisitions. To the best of our knowledge, the first scientific article using the term RPA was published in 2014 (Fung 2014b). Afterwards, several very popular and highly cited research articles came from the „*Outsourcing Unit*“ of the London School of Economics. In 2015, they started publishing working papers that finally resulted in articles in MIT Sloan Management Review (Lacity and Willcocks 2016) and MIS Quarterly Executive (Lacity and Willcocks 2016). In the two following years, RPA-related teaching cases have been published (Asatiani and Penttinen 2016; Willcocks et al. 2017). All these research articles of the first years have in common that they are practice-oriented and were published in outlets aligned accordingly. A deeper look into the news dataset shows that news output and the research publications mentioned above do not have a strong link. Many peaks in media presence quantities were caused by the publication of studies and surveys of large consulting firms such as Deloitte, KPMG, and Gartner. These firms also use press services to gain the best possible coverage and scale in the search engine results. Individual acquisitions of companies or business figures are, because of their focus on financial and stock market effects, shared in many stock exchange news sources and thus lead to an increased number of results, too.

Analysing the polarity of the news articles shows that RPA media coverage started out very positively at the beginning. From 2016 to mid-2018, the polarity became negative, before switching back into positive territory for the last two observed years. Apparently, the public perception went through a phase of a narrative with stronger connotations of fear. In the same period, the articles became more and more objective when their subjectivity values decreased linearly over time. The strong drop at the end of our period of analysis (i.e., from June to September 2020) could be explained with the effects of Covid-19.

This development is underlined by the results of our topic modeling analysis which focused at the beginning on explanation, then on expectations, and, in the last years, on more general topics such as the Covid-19 pandemic. Apparently, the perception of RPA is that of a more mature technology that can now be employed to tackle major problems both of organisations (e.g., future of work) and of society at large (e.g., impact of Covid-19).

In sum, the analysis has shown that there is a strong range of variation within the polarity/objectivity sentiments over time. We could, however, not identify any relationship between the quantity, polarity, and objectivity of the articles.

Building on the four analyses of article quantity, polarity, and objectivity as well as the results form topic modeling, we can nevertheless argue that the public perception of RPA is now more realistic and beyond an initial very contrasting hype and fear narrative that Willcocks (2020b) observed.

8.6.2 Comparative analysis with related research

Prior theoretical perspectives argued for a growing media buzz (hype) at the beginning of each technology life cycle (Bass 1969; Linden and Fenn 2003; Rogers 2003). Our results confirm this understanding as they show a steady rise of media attention. We cannot yet observe a decrease in publications quantity over time. Thus, we assume that although

RPA can be considered a mature technology, it is not yet adopted by the majority of organisations around the globe. The pure publication quantity cannot be described by any standard pattern such as linear, exponential, and s-curve developments (Routley et al. 2013).

We could identify some proximity of the perception of RPA to technology cycle theories such as the Gartner hype cycle by using insights from the sentiment analysis. This is especially true with regards to polarity. Following the positioning of RPA on Gartner's hype cycle (see Figure 8-2 and Section 8.2.2), public perception was very positive while RPA was considered to be on the peak of inflated expectations. However, we should not assume *cum hoc ergo propter hoc*, i.e., we can only show a correlation between the positioning of RPA on the hype cycle of Gartner and the polarity of the media perception. Whether a cause-effect relationship exists cannot be extracted from the data. Moreover, as we currently do neither see a real drop in polarity nor a decline in publication quantity, we might postulate that RPA will reach the plateau of productivity without going through a real trough. The hype cycle for RPA therefore might be fast-tracked as visualized in Figure 8-2 (Fenn and Blosch 2018).

Surprisingly and not matching with any of the discussed theoretical perspectives, the polarity data shows a significant drop between April and May 2020. In the months up to September, the end of our data collection, the polarity though remains on a very constant level. This observation could have different potential reasons. As mentioned above, one of them could be the effects of the Covid-19 pandemic. In many industries, automation and robots can be used to remain active without endangering the health of employees. Furthermore, many digital technologies are discussed differently since the beginning of the pandemic (Ågerfalk et al. 2020). Not only in healthcare, RPA has been discussed with particular interest in these unstable times (Mardani et al. 2020; O'Leary 2020b).

When we compare the public perception of RPA in terms of publication quantity with the prior analysis of (1) gene therapy, (2) high-temperature superconductivity, and (3) VoIP by van Lente et al. (2013), we can firstly observe that RPA does not follow the curve described by gene therapy. In contrast to the slow rise of the perception of gene therapy, media buzz of RPA showed a comparable quick start with a currently stable plateau. Secondly, we are unable to predict whether RPA will follow the curve of VoIP, i.e., will go through a double boom (Peters et al. 2012) with two peaks of popularity. So far there is no indication of a comparable dip in publications over time. Thirdly, it is also too early to compare the public perception of RPA to the perception of high-temperature superconductivity. Potentially, RPA could now lose importance quite quickly and be neglected for the next decades. However, this would be in stark contrast to the prevalent scientific consensus (Plattfaut 2019; Syed et al. 2020; Willcocks 2020).

This scientific discourse on RPA underlines our interpretation that RPA is now beyond the hype and can be considered a mature technology. Exemplarily, Plattfaut argues that „[i]*t is widely regarded as proven that RPA is able to deliver basic promises, the technology is established, and it works in multiple environments*“ (Plattfaut 2019). Following these arguments, Syed et al. (2020) and Wewerka and Reichert (2020) argue that scholarly research should now focus on giving real advise instead of providing mere case descriptions.

8.6.3 Deriving research questions for RPA scholars

Building on the discussion of our results considering prior theoretical perspectives on lifecycles, prior empirical analyses of the public perception of other technologies, and published research on RPA, we propose some potentially fruitful avenues for future research.

Firstly, our research shows that the public opinion of RPA appears to be more objective now than it has been before. Prior research also argues that the technology is now proven but needs to be applied at scale (Plattfaut 2019). As such, a deeper empirical analysis of the perceived benefits of RPA for public and private-sector organisations - after the hyped expectations - seems to be possible. This is in line with the call for a more quantitative analysis of the effects of RPA (Wewerka and Reichert 2020). It is generally common for new technology research to use methodologies such as case studies during the early phases of the hype cycle before the maturity of the technology enables more comprehensive methods (O'Leary 2008).

Secondly, based on our results, researchers can also understand in how far RPA adoption in specific and technology adoption in general might be influenced by public media perception of a technology. Adoption theories on individual level often acknowledge for these „*secondary sources influence*“ (Brown and Venkatesh 2005) but studies on an organisational level might be fruitful. This is especially true taken into account the general differentiation between early adopters/innovators and later adopters (Bass 1969; Rogers 2003).

Thirdly, scholars can revisit prior interpretative research on RPA. Especially in qualitative studies, researchers often rely on interview data. However, this interview data might be under the influence of the general public perception. Exemplarily, interviewees in 2017 might had a more negative opinion of RPA than those interviewed in 2019 (see also Figure 8-5).

Fourthly, it is unclear in how far RPA can support the organisational and societal reactions on the current Covid-19 pandemic. Our topic modeling shows that in the last analysed year the pandemic was the single most important topic in news articles on RPA. However, scientific research seems to be lacking behind with only few articles discussing this relationship.

Lastly, the identified topics also show a divergence in goals of RPA that are perceived by the public media. On the one hand, there are publications which put cost saving into the focus. On the other hand, publications perceive RPA as one tool in the future of work. More research on the effects of RPA on society could be fruitful.

8.6.4 Limitations

Our analysis of course also has limitations. Firstly, computerized sentiment analysis has generally problems recognizing figures of speech such as sarcasm and irony, some negations, jokes, and exaggerations (Bosco et al. 2013; Olteanu et al. 2019; Reyes et al. 2012). If those elements are not recognized, the results and interpretations of sentiments can become biased. However, as we have analysed news articles, we assume that this limitation does only apply to a minor extent. Secondly, the length of the news articles was not considered. Short pieces of text were weighted the same way as longer articles (except for very short news articles with less than 400 words which have been excluded). Longer articles might have a heterogeneous sentiment as several context sensitive words could be found and considered. However, longer news articles are not given more weight in the text collection than shorter news articles (Baroni et al. 2014). Therefore, and because of the large number of articles considered, we believe our results are valid. Thirdly, our results are limited as we collected data from one single search engine. Moreover, the algorithm of this engine is non-transparent and not accessible to us. Especially the historisation and availability of old news articles is not guaranteed. However, we regard Google and Google News as state-of-the-art search engines with a very comprehensive data base. Fourthly, there might still be some duplicated articles in our data set. While we removed duplicates based on the article title and made use of the indexing algorithm of the Google News search engine, which should effectively eliminate duplicate content, there is, theoretically, still the possibility of duplicates. Exemplarily, a news article could still be published multiple times, even over several weeks, with similar content on other news sites if the content were changed to a sufficient extent. This pluralism of news publication possibilities, however, also demonstrates the real-world representation of public engagement with a topic/technology. Lastly, no weighting of sources' reputation and seriousness was made. Blogs considered as news by the algorithm were therefore weighted the same way as established newspaper websites.

8.6.5 Conclusion

We examined the public perception of RPA by analysing the quantity of news articles, sentiment in news articles with regards to polarity and subjectivity, and major topics within these news articles (using topic modeling algorithms). We relied on over 95,000 published articles on RPA which were indexed by Google News. These articles were published between the technology's upturn in 2015 and September 2020. The implications of the observed public perceptions have been discussed in light of existing lifecycle theories, observed public perception cycles of other technologies, and prior publications on RPA. Based on these discussions we can support the claim that RPA is now a mature technology with a prospective further growth of adoption. We presented five potentially fruitful avenues for future research.

9 Looking for Talent in Times of Crisis: The Impact of the Covid-19 Pandemic on Public Sector Job Openings.

Table 9-1: Fact sheet publication P4

Titel:	Looking for Talent in Times of Crisis: The Impact of the Covid-19 Pandemic on Public Sector Job Openings
Publication Type	Journal
Publication Outlet	International Journal of Information Management Data Insights.
Ranking[1]	**n. R.**
Authors	**Name** Koch, Julian Plattfaut, Ralf Kregel, Ingo
Status	Published
Full Citation	Koch, J.; Plattfaut, R.; Kregel, I. (2021): Looking for Talent in Times of Crisis - The Impact of the Covid-19 Pandemic on Public Sector Job Openings. In: *International Journal of Information Management Data Insights* 1 (2), S. 100014. DOI: 10.1016/j.jjimei.2021.100014.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Looking for Talent in Times of Crisis - The Impact of the Covid-19 Pandemic on Public Sector Job Openings

Abstract

The current Covid-19 pandemic has tremendous effects on labour markets worldwide. While we observe a rapid change to work from home, an increase in unemployment is expected, too. This research article reports on results of a research project on the effect of the pandemic on the public sector labour market. We systematically study public sector job openings in Germany with a focus on the development of certain job types. For this purpose, we used the central German provider for e-recruiting in the public sector as a unique database that documents the current personnel demand. We comparatively analyse snapshots of this database using quantitative text analysis and descriptive statistics. Our results show that public institutions, besides a significant increase in work from home jobs, have a substantial demand for IT jobs, but that these IT vacancies do not have a focus on work from home technology.

9.1 Introduction

The Covid-19 (Coronavirus, SARS-CoV-2) pandemic has, as of October 2020, a massive impact on both the number of jobs and the way we work. Since the appearance of the novel corona virus Sars-CoV-2 in China in early January 2020, the virus has spread worldwide. The WHO classified the spread of the corona virus on 11 March 2020 as a pandemic (i.e., a global epidemic, World Health Organisation 2020). It has been confirmed as of September 2020 that more than 31 million people are infected with the corona virus and more than 1 million people have died in connection with the virus (European Centre for Disease Prevention and Control 2020). At the end of January 2020, there was the first confirmed infection with Corona virus in Germany. On month later, the states of Baden-Württemberg and North Rhine-Westphalia also reported the first confirmed cases, with other states following by mid-March 2020. In early March 2020, the first deaths within Germany occurred in North Rhine-Westphalia and the number of infections rose to more than 1,000 nationwide. At the same time, a lockdown began that included the closure of retail stores, theatres, sports venues, and concert halls, as well as widespread contact bans. Universities, schools, and day-care centres were also closed. Checks had inner-European borders were implemented together with wide-ranging travel and entry bans. At the beginning of May 2020, the German states began to gradually ease the restrictions (Desson et al. 2020). However, in October 2020, the number of new infections throughout Germany exceeded 10,000 within one day for the first time which indicated the second wave. On November 2, a second nationwide lockdown began, with renewed restrictions in the retail, social, and recreational sectors (Bundesministerium für Gesundheit 2021).

However, countries like Germany, which reacted in time with drastic measures, are apparently getting through the corona crisis comparably better (Bennhold 2020; Fairless 2020; Wieler et al. 2020). In Germany as in an increasing number of countries, public and economic life was shut down to slow down the spread of the coronavirus. A large number of organisations switched as many jobs as possible into working from home (Brynjolfsson et al. 2020; Fadinger and Schymik 2020). These changes resulted in many challenges both for workers adapting to their new environment and for organisations to technically enable the employees to work remotely. But it also led to cancelled or at least changed recruiting activities (Bartik et al. 2020; Montenovo et al. 2020).

On the one hand, we observe job losses around the world due to the pandemic. On a global level, gross domestic product is expected to shrink by 3%, „*much worse than during the 2008-9 financial crisis*“ (International Monetary Fund 2020). The International Labour Organization (ILO) estimates nearly half of the global workforce in danger to lose their livelihoods and hundreds of millions of companies confronted with bankruptcy (International Labour Organization 2020). In the United States, within the first six weeks since President Trump declared a national emergency, a total of 30.3 million newly filed unemployment claims were registered (U.S. Department of Labor 2020). Similar retractions on the job market are already observable in Europe: A recent analysis by McKinsey & Company sees 59 million jobs at risk in the European Union and the United Kingdom (Chinn et al. 2020).

On the other hand, we see that more and more people work from home (Venkatesh 2020; Waizenegger et al. 2020). Organisations react on the Covid-19 pandemic with investments into information technology (IT) (Dwivedi et al. 2020). Video conference solutions are in huge demand, as schools and universities invest in distance learning techniques and companies rely on working from home and have to cancel business trips (He et al. 2021; Iivari et al. 2020; Neate 2020). The usage of the internet changed and simultaneously intensified (Koeze and Popper 2020). To avoid network problems, regulators in Europe urged providers of the most traffic-causing online applications such as Netflix and Amazon to temporarily decrease their used streaming quality and bandwidth (Kang et al. 2020).

In this article, we evaluate in how far the Covid-19 pandemic had impact on public sector job openings in Germany. We specifically aim at answering the following research questions:

RQ1: How did the German public sector job market react on the Covid-19 pandemic?

RQ2: How did the German public sector job market for IT professionals react on the Covid-19 pandemic?

With these research questions we aim at analysing the current state. However, in line with prior suggestions (Kar and Dwivedi 2020), we also want to move beyond this descriptive analysis of „*what is*“ and thus discuss implications for theory that might be observable in public sector job markets in general when exogenous shocks occur.

To answer our two research questions, we build upon a dataset of all public sector job openings in Germany that we collected in August 2019 („*time point 0*“) through advanced web mining using robotic process automation (RPA). We repeated this data collection weekly since the start of the Covid-19 crisis (March 2020) and compare the results both with our time point 0 and over time until September 2020.

The remainder of the article is as follows. First, we present some theoretical background on the Covid-19 pandemic in the IS domain and hypotheses on its effect on public sector job openings. Second, we explain our research methodology with respect to data collection and analysis. Third, we describe our findings. We end with a concluding discussion.

9.2 Literature Review and Hypotheses

9.2.1 German Job Market until the Corona Pandemic

The long-term trend in new jobs created in Germany had been positive for more than 10 years. Since 2007, a total of 5 million additional jobs have been created in Germany. In 2018, there were nearly 580,000 new jobs and in 2019, nearly 450,000 new jobs (Bundesagentur für Arbeit 2021). Before the start of the Covid-19 pandemic, at least 200,000 additional jobs were expected to be created in Germany in 2020 (European Commission 2019). The number of unemployed in Germany before the start of the Covid-19 pandemic in March 2020 had fallen by 30,000 to 2.396 million compared with January, implying an unemployment rate of 5.3 percent and 23,000 more unemployed than in the same period in 2019 (Bundesagentur für Arbeit 2020c). Possible effects due to the consequences of the coronavirus outbreak are explicitly not yet included here. The seasonal decline in February was thus stronger year-on-year, which is attributable to the somewhat weaker economy in Germany at this time. Economists had last revised their growth forecasts for the German economy downwards accordingly in December 2019

(Institut der deutschen Wirtschaft Köln e. V. 2019). In contrast to the slight decline in the overall supply of jobs, Germany was already struggling with the consequences of the shortage of skilled workers before the Corona pandemic began. Nationwide, around 1.41 million positions could not be filled in the fourth quarter of 2019 (Bundesagentur für Arbeit 2020c). This was 55,000 more than in the third quarter of 2019 and 48,000 fewer than in the same period of 2018 (Bundesagentur für Arbeit 2020a). Demand for staff had fallen, particularly among larger companies with more than 250 employees. In contrast, demand for staff remained high in the SME and service sectors (Bundesagentur für Arbeit 2020a).

9.2.2 Covid-19 Pandemic in IS Research and Related Fields

Covid-19 represents a massive challenge to the medical systems of countries worldwide. It has been compared to natural disasters that effect both societies and organisations (Sakurai and Chughtai 2020). Understandably, Covid-19 also triggered a large wave of pandemic-related medical research. The world health organisation (WHO) listed 4,079 registered clinical trials as of July 05 (HeiGIT 2020). The huge effects of Covid-19 were also reflected in research calls in many scientific disciplines, not only including medical domains. Special issues explicitly related to Covid-19 have been announced from outlets such as International Review of Economics & Finance, Risk Analysis, Journal of Operations Management, Production and Operations Management, and Decision Sciences Journal. Multiple articles deal with contact-tracing apps which try to predict, observe, and minimise the spreading of a virus (Riemer et al. 2020; Rowe et al. 2020; Urbaczewski and Lee 2020). Another area that is studied with regards to Covid-19 is the working from home or remote e-working (Barnes 2020; Dwivedi et al. 2020; Iivari et al. 2020; Sein 2020), something that is also highlighted by other studies on the impact of Covid-19 on IS research and education (van der Aalst et al. 2020). Studies on the effects of Covid-19 on the labour market focus predominantly on survey, e.g., using the Nielsen panel (Coibion et al. 2020). Next to the effect on the labour market, the public sector is furthermore also challenged by several additional aspects such as public order, effective crisis communication, and citizen engagement (Chen et al. 2020; Hodder 2020).

9.2.3 Hypotheses

The worldwide development also leaves its mark on Germany. The social distancing measures led to the lockdown of most businesses for weeks and endangered a large number of jobs. The unemployment rate increased from 5.1% in March to 6.4% in August (Bundesagentur für Arbeit 2020b). Foreseeing this effect, the German government reacted. With the help of subsidising short-time work („*Kurzarbeit*“), the government hoped to ease the ascent of unemployment just like during the financial crisis ten years ago. In early May 2020, the Bundesrat (Federal Council) approved numerous draft laws of the Federal Government in this context during the crisis. Among other things, corona tests and reporting requirements for laboratories and health authorities were expanded on a large scale (Bundesagentur für Arbeit 2020b). Also, numerous social benefits were expanded, including short-time work, parental and unemployment benefits. During the first two months, applications for these short-time work subsidies were received for already 10.1 million employees, whereas during the complete year of 2009 applications for only 3.3 million employees were registered (Bundesagentur für Arbeit 2020b). In mid-May 2020, in connection with the ongoing corona development, the Federal Government adopted the law to protect the population in the event of an epidemic situation of national importance (Bundesministerium für Gesundheit 2020). The aim of the law was to provide the best possible protection for people at particular risk from infection with the corona virus and to gain a better insight into the course of the epidemic. To this end, numerous restrictions and limitations were imposed, focusing on social distancing in the workplace. The core of the law was that the almost 400 public services were the linchpin in the fight against the coronavirus. The modernisation of the public health service will therefore be supported with a funding programme totalling 50 million euros. In mid-July, an enormous relaxation of infection protection is again in force throughout Germany (Han et al. 2020). Nearly all retail and gastronomy businesses have been allowed to open again as normal. For example, visits to nursing homes and larger family celebrations were possible again.

Based on existing literature and observations of the current development we can hypothesise that the Covid-19 pandemic has and will have a large impact on the German job market. Even though we do not expect a strong decrease in existing public sector jobs, we hypothesise a reduction in job openings in line with the observations from the private sector (Bundesagentur für Arbeit 2020b). We assume that our data shows that with the Covid-19 pandemic less positions are opened and public sector hiring slows down. Therefore, we propose H1 as follows:

The total number of job openings will be reduced over the course of the pandemic

We know from public responses to the pandemic that in most countries people are encouraged to work from home (WFH) when possible (Carillo et al. 2021). However, several studies indicate that the general trend toward WFH, which began in the private sector years before the pandemic outbreak with the introduction of flexible work models, had barely taken hold in the public sector and public administration at the time of the Covid-19 pandemic (Melian and Zebib 2020; Milasi et al; Palumbo 2020). We therefore assume that the underlying conditions (remote access to IT systems, equipment with portable computers, etc.) are not yet in place or only sparsely. (Office for National Statistics 2020). From this, we infer that we should expect longer turnaround times in the recruitment processes for the positions studied due to the Covid-19 pandemic. This is particularly the case in the processes that require a high level of communication intensity, such as the applicant management process in connection with applicant pre-selection, interviews, and applicant assessment. Therefore, we propose our second hypothesis:

The pandemic is explicitly mentioned to account for longer processing times during the crisis

Building on H2, we moreover assume that WFH possibilities and corresponding technology is increasingly mentioned in public sector job openings. First, we base this assumption on the announced sales and revenue figures of suppliers of WFH technology. Second, past research shows that job security is an important factor for public sector employees (Clark and Postel-Vinay 2009; Lewis and Frank 2002). Especially in times of the pandemic, WFH possibilities can signal a higher degree of job security. Third, WFH has become a necessity to operate during the pandemic (Waizenegger et al. 2020). We therefore propose the following hypothesis H3:

During the pandemic, positions allowing for home office and/or mention working-from-home (WFH) technology will increase

The pandemic led to an increased willingness to digitalise and automate processes and services over all industries (World Economic Forum 2020). In this context, the German state invested in the expansion of digital infrastructure and in public sector digitisation initiatives. One example is the troubling Online Access Act („*Onlinezugangsgesetz*“, OZG) of April 2017, which obliges the federal states to offer their administrative services electronically via administrative portals by 2022 and to connect them to a digital portal network. The economic stimulus package launched in June 2020 to combat the consequences of Covid-19 now provides for the additional investment of three billion euros for OZG's implementation (Bundesministerium des Innern, für Bau und Heimat 2020). It is obvious that the partly massive investments of the German state to maintain service delivery and specially to accelerate the implementation of service digitalisation in the public sector should also be used to nationwide build up human resources. Hence, H4 is proposed as follows:

New positions (except job offers in the health sector) will be created during the pandemic to specifically react on the new circumstances

Closely related to H4 we especially expect new positions in public healthcare. We expect public administrations to create additional job openings for doctors, nurses, laboratory staff, and other clinical professionals (Shulzhenko and Holmgren 2020). Early during the pandemic, the media was reporting on volunteer recruiting of medical professionals as well as of fast-tracks for medical students (e.g., Kottasová 2020, Noveck et al. 2020). Several studies point to the unmistakably higher demand for healthcare professionals during the Covid-19 pandemic (Cutler 2020; Fuchs 2020; Liu et al. 2020a). In April 2020, the German government indicated that it would support the national health sector with a total of ten billion euros, with a focus on the public health service, but also on hospitals and medical research (Hallam 2020). Therefore, we expect that new positions relevant to the health sector will be created by public institutions to respond to the pandemic. Based on this, we hypothesise to see a rise in demand for healthcare professionals:

Especially at the start of the pandemic, recruitment for healthcare professionals will increase

Following the arguments for H4, we also expect a rise in IT and digitalisation positions in the public sector. Prior research has shown that organisations reacted on the Covid-19 pandemic with investments into IT (Dwivedi et al. 2020). Especially video conference solutions rose in demand as schools and universities invest in distance learning techniques (He et al. 2021; Iivari et al. 2020; Neate 2020). Moreover, the usage of the internet changed and simultaneously intensified (Koeze and Popper 2020). We assume that these rising investments into IT also lead to a rising demand for IT professionals in the public sector. Hence, we hypothesise the following:

The share of new IT/digitalisation positions among all positions will rise during the pandemic

Moreover, these new IT/digitalisation positions will be, especially in the beginning of the pandemic, less in completely new technologies requiring corresponding future skills such as artificial intelligence, user experience, blockchain, or internet of things (Carter et al. 2011; Kirchherr et al. 2018) and more in maintenance and support of existing systems as well as support for WFH technology. As such, H7 and H8 are proposed as follows:

Especially at the beginning of the pandemic, public organisations will focus their IT professionals recruiting on support and maintenance of IT

Considering H3, the positions that allow home office and/or mention working-from-home (WFH) technology will increase particularly strongly within the group of IT jobs (H6)

9.3 Methodology

The application of diverse analytics methods of big semi structured data for the purpose of behavioural analysis of the public sector, especially based on time series data, is a scientifically established field (Chintalapudi et al. 2021; Grover and Kar 2017). In this research project, we employ a quantitative text analysis approach to achieve our research objective and test our hypotheses. Especially when analysing unstructured, large amounts of data by means of information extraction, data mining or knowledge discovery, one should explain the context, i.e. be decisive why a found phenomenon occurs (Kar and Dwivedi 2020; Kumar et al. 2021). We build upon data collected in August 2019 and contrast this to data continuously collected since the beginning of the „*lockdown*“ as a reaction to the Covid-19 pandemic. Figure 9-1 provides a brief overview of our methodology which is detailed in the following.

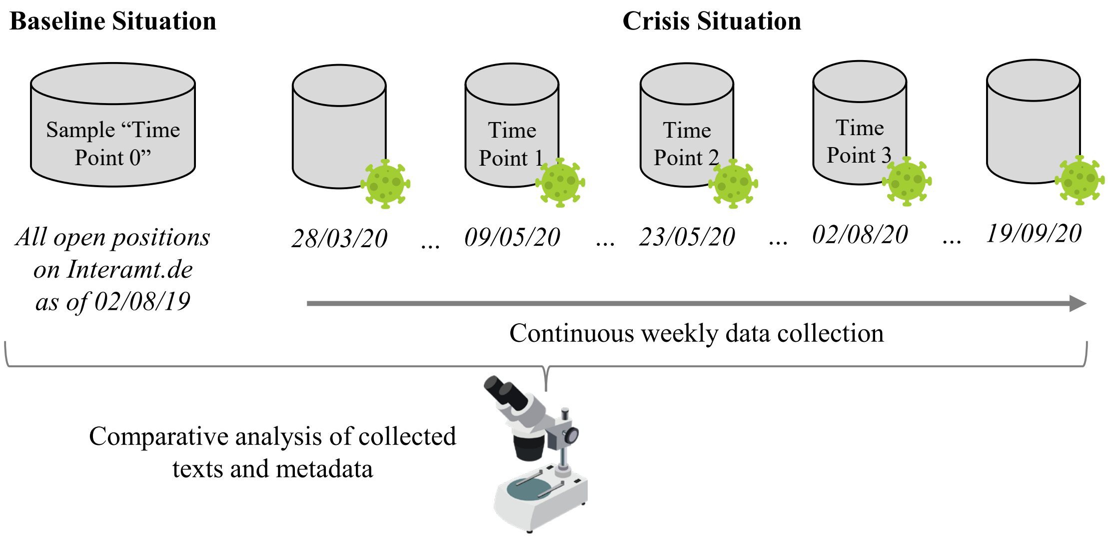

Figure 9-1: Research Approach: Data Collection and Analysis

9.3.1 Data Collection

Data was collected from the Interamt.de website. Interamt is the official central job platform for the public sector in Germany and claims to be the largest provider of job ads in this field. It provides e-recruiting services for public administrations and includes about 50,000 ads per year from federal, state, and local institutions. Typical job providers are ministries, state offices, city governments, and public sector associations. To facilitate data collection, we employed an RPA software bot. This bot was developed to simulate human access to the websites to avoid being locked out by technical crawling detection functionalities.

The bot has been used for an initial research project in August 2019, when all 6,661 job advertisements open by this time were collected from Interamt. This sample will be considered our baseline (or data point 0). Based on our learnings we then optimised the bot and started a data collection from Interamt on March 28, 2020 following the announcement of a country-wide shut down by the German chancellor Angela Merkel on March 22. The bot is started every second day and collects all job openings from Interamt. Every Saturday, the data of the week is consolidated with closed and newly opened job positions. We have continued this data collection and thus are now able to analyse 26 weeks in 2020 to describe the developing impact of the pandemic on public sector job openings.

9.3.2 Pre-Processing

Collected job advertisements are saved in text format together with their metadata and pre-processed before the data analysis: HTML tags, URLs, and e-mail addresses as well as disclaimers and imprints in the footer of the job descriptions are removed using regular expressions (Batra et al. 2021). The German pre-processing of the texts differs from the English pre-processing, as there are special characters with umlauts that must first be converted. To do this, the German umlauts are normalised and all special characters, such as non-alphabetic characters, question marks, and bullets, are also removed. Pre-processing also includes normalisation of alphanumeric data, removal of punctuation marks and numbers, normalisation of spaces, and conversion to lowercase.

We evaluated several German stop word lists. Both *NLTK* and *Scikit-Learn* as often used standards for text analysis have built-in sets or lists of German stop words that serve as a set of words that we clean in our data (Pedregosa et al. 2011). Hence, we use both *NLTK* and *Scikit-Learn* one by one to get the best result (Bird et al. 2009; Loper and Bird 2002). Subsequently, we use the *German Snowball Stemmer* for German stemming to remove word prefixes and suffixes (Bird 2006). Finally, we employ the *spaCy* library for lemmatisation to break the words down into their basic forms (ExplosionAI GmbH 2021).

9.3.3 Data Analysis

The collected text is analysed by using quantitative text analyses that are the most frequently cited methods in the academic literature for analysing job advertisement data (Aken et al. 2010; Debortoli et al. 2014). In order to generate relevant research results in a comprehensive way, a combination of keyword searches is applied. A keyword list is created for each of the hypotheses H2-H8. Based on these lists, every job position that includes a keyword is marked as having the corresponding feature (Aken et al. 2010;

Chintalapudi et al. 2021; Gardiner et al. 2018). These markers are used to calculate frequency of the features. Our collected data will allow us to analyse the development of these frequencies over time. In order to validate the keyword collection as a central selection tool with regard to suitability, consistency and completeness, we proceeded in two steps. Since we assume a domain-specific nomenclature in the public sector, we used the specifications for job descriptions that are updated annually by the Federal Office of Administration (Bundesverwaltungsamt) (Bundesverwaltungsamt 2020b). Within the German public sector, these serve as the basis for the classification and remuneration of employees according to collective agreements. In a first step, we used the catalogues for employees in information technology to extract corresponding job description terms based on the job descriptions presented there with explicit job characteristics and job evaluations (Bundesverwaltungsamt 2018, 2020a).

In a second step, we discussed, eliminated, added to, modified and refined the collection of terms. This controlled opinion-forming process ran for three cycles before we made a final human decision on the necessary terms. Table 9-2 shows the German keywords used and the associated quantities in conjunction with the mapped English terms.

Table 9-2: Keyword mapping from German to English

	English Translation	**German Keyword**	**(Additional) identified positions in Combined Sample**
H3 WFH	Telework	TELEARBEIT	4339
	Remote work	MOBILES ARBEITEN	3763
	Home office	HOME OFFICE	2000
	Working from home	HEIMARBEIT	693
	Other keywords with less than 90 identified additional positions include Skype, Zoom, Webex, etc.		
H5 Health	Doctor	ARZT*	2954
	Health insurance	KRANKENKASS*	1116
	Medicine	MEDIZIN*	159
	Care & Health	PFLEGE* & *GESUNDHEIT	142
	Health*	GESUNDHEIT*[1]	125
	Hospital	KRANKENHAUS*	84
	Other keywords with less than 20 identified additional positions include pharma*, clinic, etc.		
H6 IT	Informatics	*INFORMATIK*	7004
	Information technology	INFORMATIONSTECHN*	3932
	Software develop*	SOFTWAREENTWICKL*	1370
	Integrat* & system*	INTEGRIERT* & SYSTEM*	1347
	IT system management	IT-SYSTEMMANAGEMENT	1230
	Other keywords with less than 90 identified additional positions include application development, system integration, etc.		

H7 IT-Ops	IT infrastructure	IT-INFRASTRUKT*	4613
	IT support	IT-SUPPORT*	2089
	IT processes	IT-PROZESSE*	1207
	SAP administration	SAP & ADMINISTR*	1086
	Data maintenance	*DATENPFLEG*	566
	IT security	IT & SECURITY	372
	Other keywords with less than 60 identified additional positions include helpdesk, service desk, problem management, etc.		
H8 WFH-Tech	VPN	VPN	869
	Remote access software	FERNWARTUNG* & SOFTWARE	652
	Virtual teams	VIRTUELL* & TEAMS	621
	Other keywords with less than 30 identified additional positions include Skype, Zoom, Webex, etc.		
Keywords were iteratively ordered based on number of uniquely identified positions. For each keyword we calculated additional positions identified on top of those identified by higher-rank keywords.			
[1] In the data analysis, terminology relating only to employees' health benefits was filtered out and not taken into account.			

For H2 and H4 this list includes „*Corona*“, „*Covid-19*“, and „*SARS-CoV-2*“ as the virus and corresponding illness. Where there was a match within the description text of the vacancy notice, an additional manual screening for H4 was carried out to determine whether the vacancy was a job created specifically because of the pandemic. Coding and qualitative assignment were accomplished in a one-step process by a single researcher. The job advertisements had an average of 254 words (in the unadjusted state). Therefore, it was possible for the researcher to quickly and unambiguously assess whether a job advertisement arose from the Covid-19 pandemic - i.e., explicitly refers to the pandemic situation in terms of content - or whether a job advertisement uses the keywords elsewhere, e.g., to justify delayed processing procedures in the application process or response times. For H2, an additional validation was carried out to see if the terms „*additional*“, „*expanded*“, „*extended*“ in combination with „*processing time*“, „*response time*“, „*reply time*“, „*processing time*“ or „*delays in the process*“ could be found within the same body text section in the „*organisational information*” section of the job advertisement. In German public administrations, working from home (ad H3) works in two different models. First, employees can have a permanent workplace at home (telework, „*Telearbeit*“). Second, employees can be allowed to work remotely at selected times (remote work, mobile work5, „*Mobiles Arbeiten*“). Based on these two keywords and corresponding synonyms as well as WFH technologies (such as Skype, Zoom, Webex, etc.) a keyword list was compiled (see Table 9-2). With regards to jobs for

[5] In this context, mobile work is a special term from German labour law. Mobile work can be understood as working from home (or anywhere), but without certain technical and legal conditions. In general, it is easier for organizations to allow mobile work than to offer permanent workplaces at home.

healthcare professionals (ad H5), we created keywords based on a differentiation between healthcare payers and providers. Payers are health insurances while providers include inpatient care (hospitals), outpatient care (doctors), nursing or geriatric care, or pharmacists. To identify IT jobs (ad H6), we used keywords based on vocational training and university courses. As such, we focused on computer science and informatics, information technology, and software development and added further related keywords to the list, e.g., application development or system integration.

To assess hypotheses H7 and H8 we looked for specific keywords within the identified IT jobs. As such, job positions here require to be marked as IT jobs (matching corresponding keywords from the list created for H6) as well as other keywords specifically created for H7 and H8. The list for H7 (IT operations) originated in both ITIL processes (e.g., IT support, helpdesk, service desk) and other operative tasks (e.g., SAP administration). The list for H8 (WFH-technology) includes selected technology for WFH. Most prominently, this is remote access software, software for virtual teams and virtual private networks (VPN) in general. Other software such as Skype, Zoom, or WebEx led to only very few additional matches.

To analyse the development over time we use simple regression analysis and present corresponding graphs. Moreover, we take three striking points in the development of Covid-19 in Germany and compare the state at these time points with time point 0 (2 August 2019). Time point 1 is set at 9 May, approximately when the Corona Protection Ordinance was largely implemented in an executive capacity (Landesregierung Baden-Würtemberg 2020). In March, Germany enacted a comprehensive set of measures, such as the „*restriction of social contacts*“: Among other things, a minimum distance in public spaces of at least 1.5 meters was introduced, the stay in public spaces was only allowed alone or with another person of the own household. Catering and numerous other service establishments were closed. With the May 2020 decision, the federal states were given extensive autonomy to relax the measures now further on their own. At the same time, it was decided for the first time at the beginning of May that stricter infection control measures would apply in counties or independent cities with a particularly high incidence. A few weeks later, restrictions in Germany were further tightened with the Second Covid-19 Population Protection Act (Bundesministerium für Gesundheit 2020) (time point 2, 23 May). The last time point is exactly one year after our time point 0 and at a time when the existing corona protection regulation has been largely softened. (2 August 2020).

9.4 Results

In total, we collected 33,643 unique job postings. Out of these, 6,661 were collected in August 2019 and 26,982 were collected from March to September 2020. In all weekly samples, the number of open positions is between 5,276 and 8,324.

Regarding our first hypothesis, we could observe a gradual reduction of the number of open positions at the beginning of the pandemic. However, beginning with the first harsh legislator reactions (time point 1), we can see an increase in open job positions. With the relaxations of the restrictions (time point 3) this number arrived at a stable plateau with a small downwards trend. Figure 9-2 shows this development over time. Next, Figure 9-3 shows only the newly opened job ads over time.

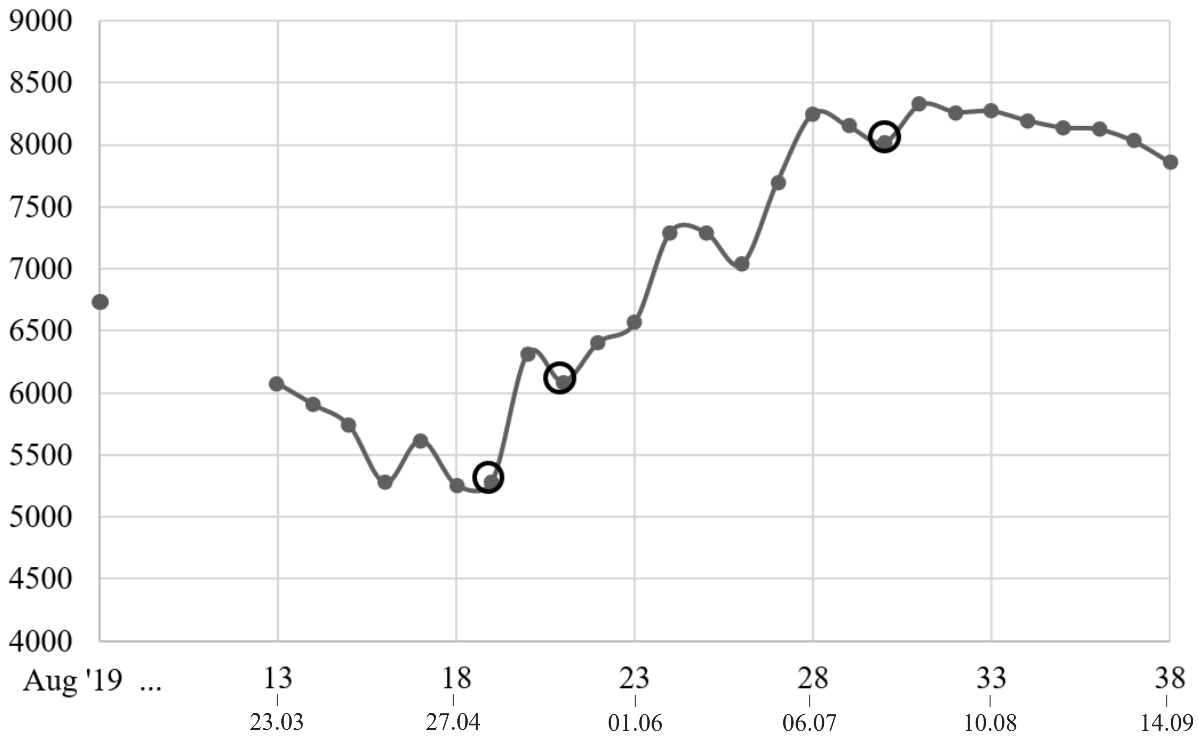

Figure 9-2: Analysis of hypothesis H1: Open positions over time

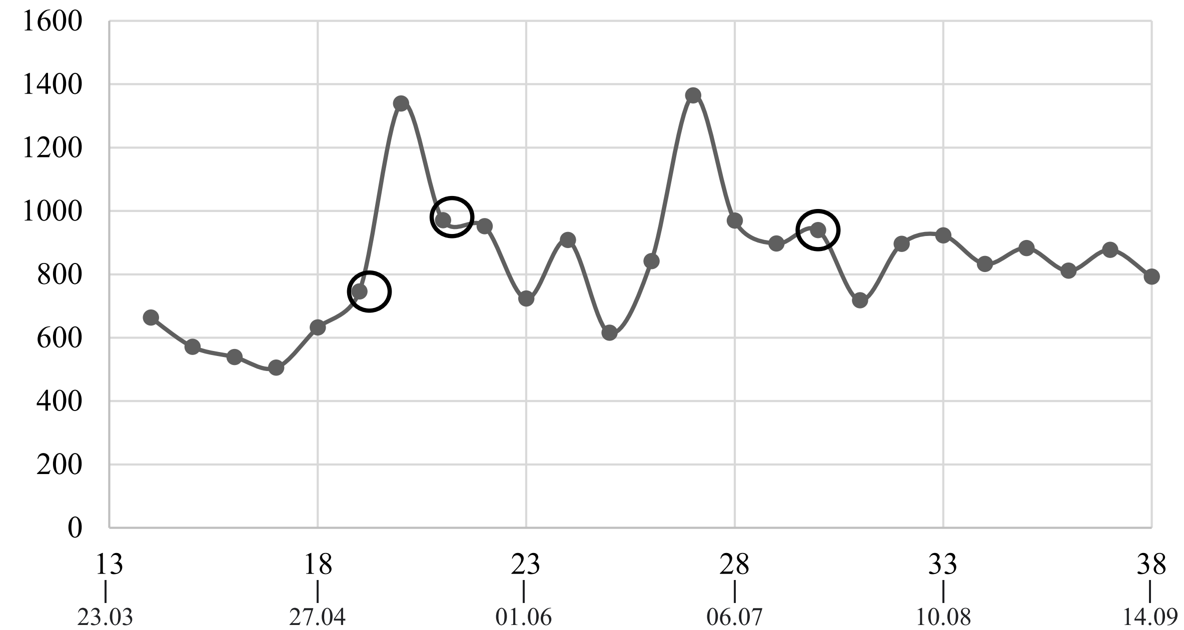

Figure 9-3: Analysis of hypothesis H1: Newly opened job advertisements over time

To test the other hypotheses H2-H8, we identified the frequency of job advertisement features based on the described keyword lists. With regards to H2, we could identify 1896 job advertisements that prepared potential applicants for longer processing times and mentioned the Covid-19 pandemic. As was to be expected, the corresponding relative frequency has increased over the period of the pandemic (see Figure 9-4).

H2: Longer processing times due to pandemic

	Abs.	Rel.	p
t0	0	0%	n/a
t1	150	2.83%	0.00
t2	290	4.76%	0.00
t3	750	9.35%	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

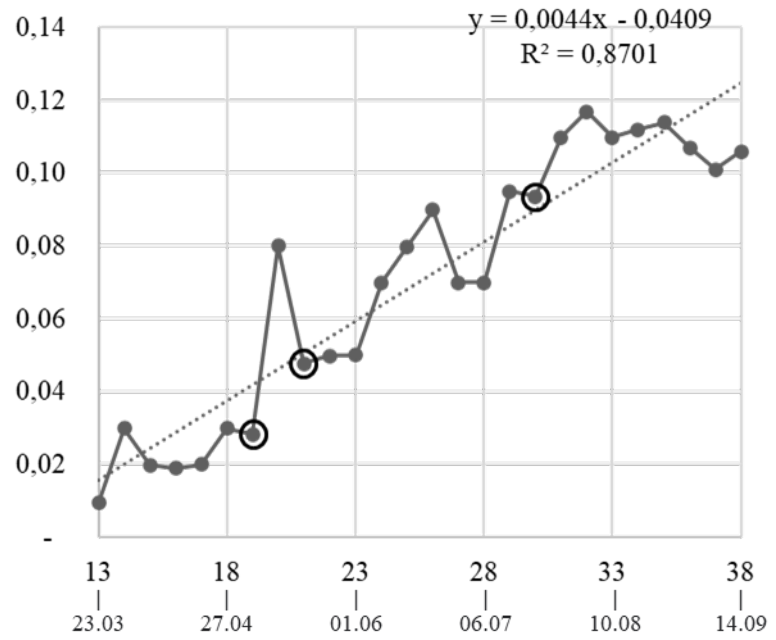

Figure 9-4: Analysis of hypothesis H2: Longer processing times due to pandemic

To further investigate on our hypothesis H2 we analysed the duration between initial job posting and announced application deadline (e.g., „*please send your application until deadline*“, Figure 9-5). This can give us insights whether public sector organisations account for a potentially longer processing time and, thus, reduce the time for the applicants to prepare their documents.

Additional analyses to test hypothesis H2

	Days between job posting and deadline	Std. dev.	p
t0	23.14	8.07	n/a
t1	22.05	6.58	0.00
t2	25.11	13.41	0.00
t3	18.06	9.01	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

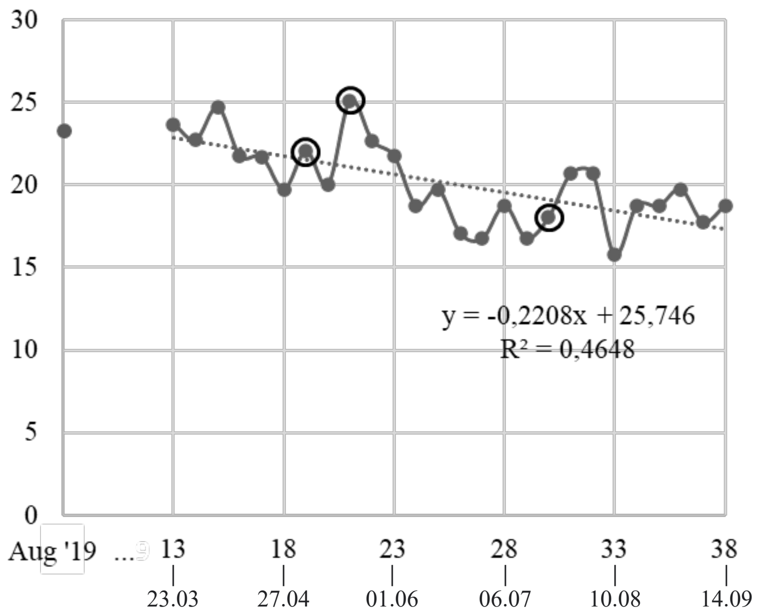

Figure 9-5: Additional analyses to test hypothesis H2

The average application period at time point 0 was 23 days. This application period is reducing with the pandemic. Apparently, while some job openings now warn applicants that processing times of their applications might be longer (see above), applicants are expected to send their applications faster. Through this, organisations could ensure that the total time between job opening and hiring does not change that much.

Regarding H3, we could observe that in in the original data set (time point 0), only 15.1% of the positions mentioned WFH. This share increased significantly and comparably steadily to 37.9% in time point 3 (see Figure 9-6).

H3: WFH mentioned

	Abs.	Rel.	p
t0	1007	15.11%	n/a
t1	1211	22.92%	0.00
t2	1921	31.54%	0.00
t3	3039	37.90%	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

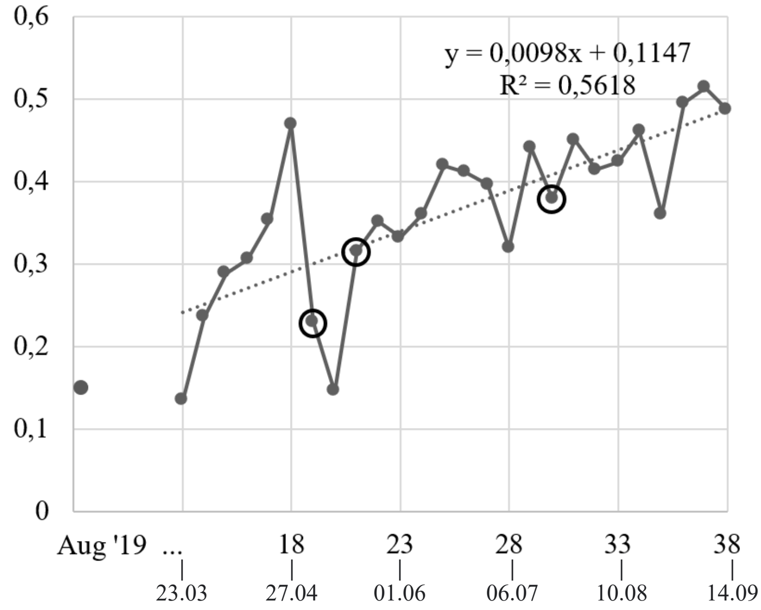

Figure 9-6: Analysis of hypothesis H3: WFH mentioned

We were able to identify only a few positions that were created specifically to deal with the pandemic and that were not explicitly related to the health sector in terms of content (ad H4). Most positions did not include texts such as „*To fight the ongoing coronavirus pandemic, the city of x is looking for*“. While the corresponding curve shows a maximum during the height of the pandemic in Germany, the low proportion of jobs (less than 3% of all jobs at maximum) allows for no real conclusions (see Figure 9-7).

H4: New positions explicitly due to pandemic

	Abs.	Rel.	p
t0	0	0%	n/a
t1	6	0.02%	0.00
t2	71	2.06%	0.00
t3	69	1.59%	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

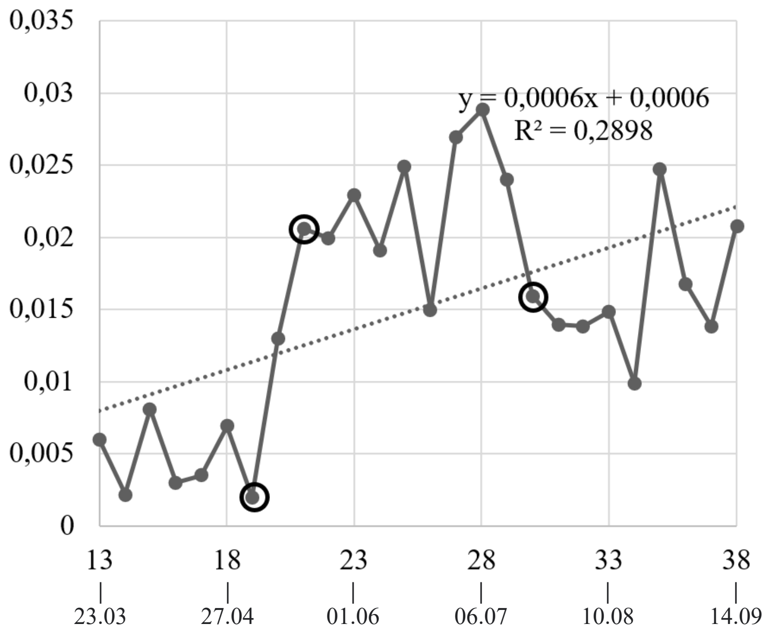

Figure 9-7. Analysis of hypothesis H4: New positions explicitly due to pandemic

Building on this, we can see a significant increase in healthcare positions (ad H5), especially at the beginning. However, this number is normalising over time towards the reference point in time 0 (see Figure 9-8).

H5: Additional Healthcare Positions

	Abs.	Rel.	p
t0	540	8.10%	n/a
t1	1211	22.92%	0.00
t2	626	10.28%	0.00
t3	781	9.74%	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

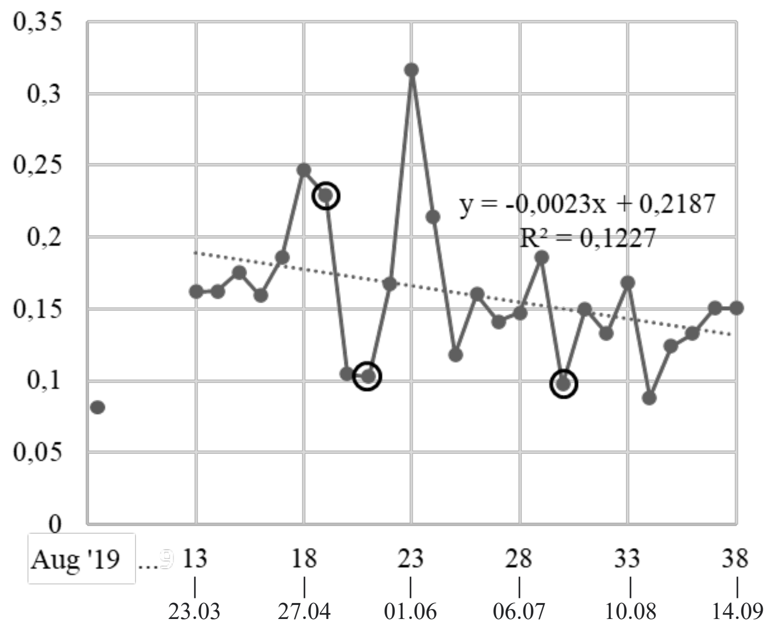

Figure 9-8: Analysis of hypothesis H5: Additional healthcare positions

The development is clearer for IT positions (ad H6) with a significant increase from 30.19% to 40.14%. While in August 2019 3 out of 10 positions were IT positions, this number increased to 5-6 out of 10 positions in time of the Corona crisis (see Figure 9-9). It will become interesting whether the dip in the last observed week (calendar week 38) is an outlier or the return to a pre-pandemic state.

H6: Additional IT positions

	Abs.	Rel.	p
t0	2390	36.00 %	n/a
t1	3036	57.46 %	0.00
t2	3445	56.57 %	0.00
t3	4334	54.05 %	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

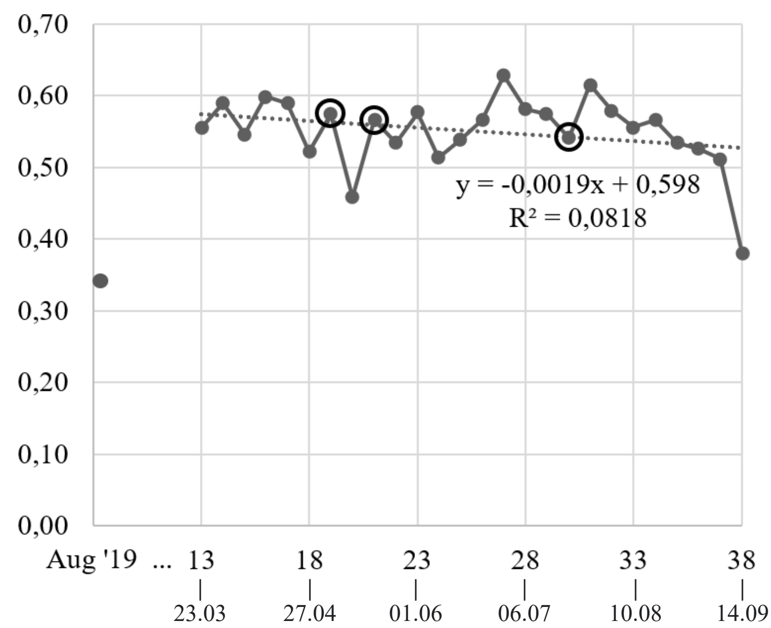

Figure 9-9: Analysis of hypothesis H6: Additional IT positions

A comparable increase can be seen with regards to IT operations positions. During the pandemic, the German public sector is looking for more IT operations than IT change positions. Compared with the prior-year period, the number of IT operations-based job vacancies increased by more than 25% on average. However, over the course of the pandemic, including the last calendar week 38 we looked at, there were no major movements in job requirements. From calendar week 38 onwards, the number of IT operations-based jobs on offer visibly declined (see Figure 9-10).

H7: Higher share of IT operations positions

	Abs.	Rel.	p
t0	1180	58.67%	n/a
t1	2265	74.61%	0.00
t2	2778	80.64%	0.00
t3	3278	75.63%	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

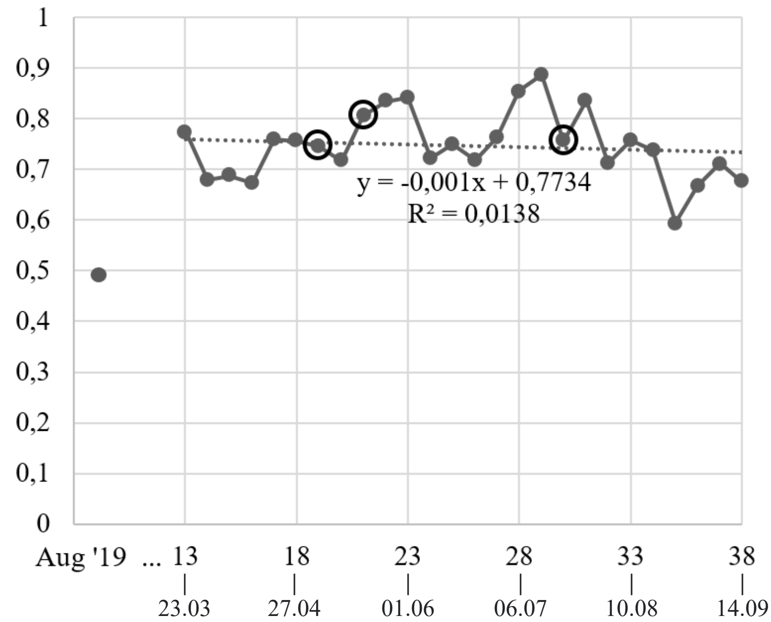

Figure 9-10: Analysis of hypothesis H7: Higher share of IT operations positions

However, our analysis shows with regard to H8: Although the general share of job advertisements with designated WFH opportunities increased comparatively strongly during the observation period (H3), the share of job advertisements with designated WFH technology focuses within the group of IT jobs decreased from 7.41% to 4.46% (see Figure 9-11).

H8: Higher share of IT positions with WFH-technology focus

	Abs.	Rel.	p
t0	126	6.27%	n/a
t1	129	4.24%	0.00
t2	168	4.87%	0.01
t3	152	3.50%	0.00

Abs. = Absolute number of occurrences

Rel. = Relative proportion of occurrences

p = Significance of difference to t0

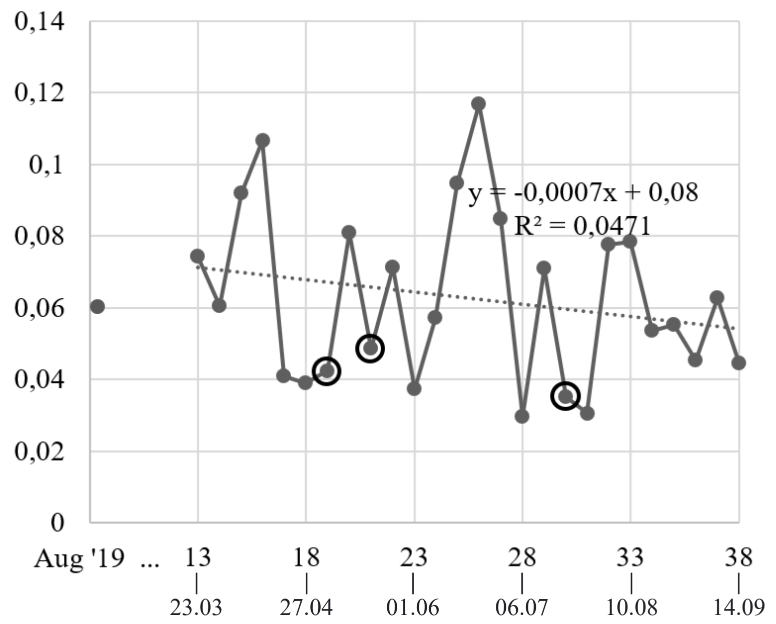

Figure 9-11: Analysis of hypothesis H8: Higher share of IT positions with WFH-technology focus

9.5 Discussion

9.5.1 Theoretical Contribution

Our results have several contributions to theory. Next to the description of the what (see Section 9.4) we can reflect on our hypotheses (section 9.2) and, thus, give insights into the why (Kar and Dwivedi 2020).

With regards to our first hypothesis, we do not observe a clear reduction of job openings over the course of the pandemic. As such, H1 needs to be rejected. A potential reason can be found in the stimulus packages the German federal government has issued (Jennen 2021). Moreover, issues of seasonality might exist which cannot fully be analysed with the data set at hand.

In contrast to this, our data supports the second hypothesis. We observe a consequent increase of the number of job advertisements mentioning longer processing time and, at the same time, a significant decrease of the application deadlines mentioned. As such, we can argue that public organisations try to accommodate for internal process inefficiencies through more pressure on future applicants.

Thirdly, we can indeed see that during the pandemic significantly more job openings allow for WFH than before the pandemic. As such, we believe that the trend to work from home that was observed in the private sector also holds true for the public sector.

Our data also supports the fourth hypothesis. There are some new positions that are specifically opened to counter the effects of the pandemic. However, this number is on a low level with about 70 open job postings per week.

Fifthly, our data indicates a significant increase of healthcare professionals needed by the public sector. Apparently, to battle the health effects of the Covid-19 pandemic, German public administrations hire significantly more healthcare professionals than before the pandemic.

With regards to our sixth hypotheses, the data indicates support, too. The share of IT professionals among all positions rose significantly. The digitalisation trend that could be observed in the private sector [16] also holds true for the public sector.

Moreover, our data also supports H7. Public organisations hire significantly more IT support and maintenance professionals than before the pandemic. Apparently, while digitalisation was fuelled due to the Covid-19 pandemic, this includes the increasing use of existing solution even more.

Lastly, our eight hypothesis needs to be rejected. Although we could show that more positions now allow WFH, corresponding IT jobs are not in higher demand than before the crisis.

A tabular overview of a verification and falsification of our hypotheses can be found in Table 9-3.

Table 9-3: Overview of hypothesis and verification/falsification

#	Hypotheses	Results
H1	The total number of job openings will be reduced over the course of the pandemic	Rejected
H2	The pandemic is explicitly mentioned to account for longer processing times during the crisis	Not rejected
H3	During the pandemic, positions allowing for home office and/or mention working-from-home (WFH) technology will increase	Not rejected
H4	New positions to specifically react on the pandemic will be created during the pandemic	Not rejected
H5	Especially at the start of the pandemic, recruitment for healthcare professionals will increase	Not rejected
H6	The share of new IT/digitalisation positions among all positions will rise during the pandemic	Not rejected
H7	Especially at the beginning of the pandemic, public organisations will focus their IT professionals recruiting on support and maintenance of IT	Not rejected
H8	Considering H3, the positions that allow home office and/or mention working-from-home (WFH) technology will increase particularly strongly within the group of IT jobs	Rejected

Prior research has indicated that organisational routines need to change due to the Covid-19 pandemic (Borghoff and Plattfaut 2021). Our results support this notion and indicate that, on the one hand, organisations now change their hiring strategies and, on the other hand, the corresponding hiring processes take longer than before. As such, we contribute a better theoretical understanding of the impact of the pandemic on public sector organisations. Whether this impact also holds for other types of exogenous shocks is up to future research (see also Section 9.5.4).

9.5.2 Practical Implications

The results of this study also have implications for practitioners. With regards to applicants, our results indicate that especially healthcare and IT professionals can make use of an increasing demand and, as such, rising market values. Moreover, applicants can also more likely demand to have options to work from home. With regards to public sector decision makers, our results indicate that the competition for qualified IT professionals is higher than before. As our literature review showed, private sector organisations increasingly invest into digitalisation during the Covid-19 pandemic. Our results support the same picture for the public sector. As such, public sector decision makers should find the right value for their current and future IT professionals.

9.5.3 Limitations

Our findings are limited to the German public sector job market and its accessible data. For comparison we rely on a snapshot from August 2019. While we are unaware of any special developments in this specific month/week, it could nevertheless be influenced by such environmental factors. Due to the shortness of the time series used, we cannot completely exclude the possibility that we contain, at least in part, seasonal components. Accordingly, we must assume the risk that there is, in part, a structure in the time series that repeats itself seasonally. Specifically, for the case of labour markets, we know that there is often an annual pattern in the frequency distribution of the data, such as the decrease and increase in the unemployment rate between summer and winter months (Policy Department for Economic, Scientific and Quality of Life Policies 2020; Rinne and Schneider 2019). We therefore cannot yet completely exclude such seasonal effects from our analyses.

It would be useful to continue the study presented here over the course of the pandemic to obtain a more reliable picture of the postulated needs of the public sector and to track their evolution over time. In our data analysis, job advertisements were used to identify needs, skills and competencies sought, and frameworks offered. We hypothesise that job advertisements from the domain-exclusive database presented here will act as a reliable source of human capital needs in the public sector and provide us with insights into the existing labour market situation and the skill requirements needed. The limitation, however, is that examining job advertisements in general may not always reflect the true requirements of an employer. Employers may require more skills than can reasonably be expected of a candidate or use additional non-specialised vocabulary to phrase job advertisements in a way that is attractive to the broadest possible group of candidates (Gardiner et al. 2018). Such biases are present in our data, but we believe that the number of job ads we examined should be sufficient to minimise the bias's effect (de Mauro et al. 2018). Processing such a broad, quantifiable data source as used in this study gives our chosen approach an advantage over other research methods, such as interviews, because it reduces the risk of bias from specific contextual backgrounds (Batra et al. 2021; Chintalapudi et al. 2021; Debortoli et al. 2014). Our results are further limited to the German public sector labour market, as we cannot properly map multilingual sources with the chosen methods of analysis. Our study is inductive and exploratory; future confirmatory research (e.g., surveys) is therefore necessary to test and refine our findings (Chintalapudi et al. 2021; Kobayashi et al. 2018).

9.5.4 Future Research

Future research could focus on similar data from other countries, e.g., India, the U.S., and Australia using similar public sector job platforms. Moreover, future research could also try to assess the effect of the described developments on public sector performance. We are so far only able to report on open positions and their properties. It would be interesting to see in how far IT recruiting strategies influence service provision and satisfaction during the pandemic. Furthermore, when we submitted this article, the pandemic unfortunately was not over. Therefore, further effects could be observed and the effects of the pandemic could include several phases. Another field of interest could be the long-term effects even years after the pandemic. Lastly, future research could investigate the effects of other exogenous shocks on public sector job markets. It could be safe to assume that the effect on demand of healthcare professionals is only high in case of healthcare crises. However, especially the effects on demand for IT professionals appear to be worth studying.

9.6 Conclusion

In this research project we analyse public sector job profiles from the Interamt platform before and during the Covid-19 crisis. We are able to show the development of job profiles over time. Our results indicate a reaction of the public sector on the crisis. First, the results indicate an increased planning uncertainty. We could observe that increasing number of job postings (while on a low level) prepare applicants for longer processing times. However, in general, the time between job posting and application deadline was significantly shorter than before the crisis (with the exception at the height of crisis at time point 2). One reason could be the increased urgency to occupy a position. Second, results also indicate that the importance of WFH has increased in advertisements for jobs. Moreover, as expected, the job profiles examined here do show a significant increase in IT-operations-oriented skills. Apparently, IT occupations that are primarily concerned with network infrastructure, operational security, and service availability have experienced a significant increase in the crisis. Regarding IT operations, there seems to be a need for an increased number of employees at present, potentially due to the current high level of utilisation of IT systems and the fact that many employees work from home. Job advertisements with a healthcare background also grew less strongly than expected. While they were very high especially at the beginning, they are now more and more normalising towards the pre-pandemic level. A reason for this may be that most healthcare professionals are not employed by public sector organisations per se, but are self-employed (e.g., medical doctors) or employed by privately owned and operated hospitals or nursing homes.

10 Digitalisation in the Public Sector: A Job Mining Perspective

Table 10-1: Fact sheet publication P5

Titel:	Digitalisation in the Public Sector: A Job Mining Perspective
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 26th Annual European Operations Management Association Conference
Ranking[1]	**n. R.**
Authors	**Name** Kregel, Ingo Koch, Julian Coners, André
Status	Published
Full Citation	Kregel, I.; Koch, J.; Coners, A. (2019): Digitalisation in the Public Sector: A Job Mining Perspective. In: *Proceedings of the 26th Annual European Operations Management Association Conference*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Digitalisation in the public sector: A job mining perspective

Abstract

The digital revolution will significantly transform organisations, their strategies, processes and needed competencies. As the central German provider for e-recruiting in the public sector, the online job portal *Interamt* provides a unique database that documents the current personnel requirements of public institutions. We summarise a snapshot of current digitalisation-related recruitment in Germany by applying text mining algorithms and statistical analyses to 800 web-crawled job postings. Our results show that public institutions are not recruiting next-generation IT experts but rather focus on current, more modest digitalisation steps. We recommend directions for further research and job market analyses.

10.1 Introduction

Public sector operations are massively challenged by the digitalisation. New products and services have to be developed and new expectations from citizens and organisations arise (Dunleavy et al. 2006). The management of change and transformation are of major importance, including process management and technological innovation (Benner and Tushman 2003). Many jobs through all industries will be significantly transformed or replaced by digital technologies soon. Frey and Osborne (2017) did not specifically focus on the public sector, but summarise for the overall economy that 47% of all jobs in the USA could be replaced by intelligent robots or software in the next 10 to 20 years. This development is also rapidly increasing the demand for highly qualified work. But there are also many chances connected to digitalisation. In the past years, especially organisations with in IT-intensive or highly competitive industries could benefit from the adoption of big data and analytics (Müller et al. 2018) as major elements of digitalisation. Digitalisation in the public sector is not only about performance and efficiency. Customer requirements and ways of contact between the citizens/customers and public institutions are also significantly changing (Lindgren et al. 2019).

Most of previous research focuses on the potential of digitalisation and on describing the future. We are taking a closer look on the current situation. The term digitalisation and its idea grew in the last decade (Dunleavy et al. 2006). We are taking a job market perspective to summarise current digitalisation trends and answer the following research question:

Which conclusions can be drawn from analysing currently advertised positions in German public sector institutions regarding their digitalisation efforts?

While parts of this article include topics from information systems research, it also contributes to the domain of public service operations management, which is a rather underrepresented research field (Radnor et al. 2016). Text mining as a method for big data analysis also represents an innovative and growing method for operations management research (Cohen 2018; Guha and Kumar 2018). We present the first large-scale analysis of public sector digitalisation jobs in Germany and thereby follow the literature about the resource-based view on organisations and their operations strategy (Coates and McDermott 2002; Paiva et al. 2008). We are building theory about the current personnel management of public organisations and their digital transformation strategies and contribute to current developments of evolving operations research in the era of big data (Feng and Shanthikumar 2018).

10.2 Research Background

In public discussions nowadays, digitalisation could be replaced by the term *digital revolution*, comprising all aspects of transforming life and work into a more digital environment. In the academic literature, Legner et al. (2017) define it as follows:

„*While digitisation puts emphasis on digital technologies, the term digitalisation has been coined to describe the manifold sociotechnical phenomena and processes of adopting and using these technologies in broader individual, organisational, and societal contexts.*“

Researchers use various search terms when looking for digitalisation topics. Buer et al. (2018) selected terms like „*industry 4.0*“, „*smart factory*“, „*cyber physical system*“, „*big data*“. Most of these terms have a manufacturing context and will not be equally useful in the context of public administration.

The analysis of competencies related to information technology (IT) has a long history (Bassellier et al. 2001; Murawski and Bick 2017; Todd et al. 1995). To use text mining technology though, has only been popular (and technically easier) for the last ten years. In the field of technology and processes, some job mining articles already analysed profiles. Müller et al. (2016) created competency profiles for business process management professionals and Kregel et al. (2019) for lean professionals. Examples for IT-related analyses are the comparison of business intelligence skills with big data skills (Debortoli et al. 2014) and the analysis of digital competencies in lean-related job profiles (Kregel and Ogonek 2018). As the public sector is known to be text-intensive, research about text mining in this domain is particularly recommended (Hollibaugh 2019).

Due to the sharp increase of available online data in recent years, the task of extracting the most relevant information has become a novel and evolving process. As a result of this data push, job portals and websites that are very domain-specific, have experienced an increase in scope, quality, and performance. Their advantage for both jobseekers and employers is the concentration of domain-specific jobs. Given the increasing relevance of the topic of digitalisation and respective skill shortages in public sector institutions, these data collections provide a great opportunity to study current digitalisation-related recruiting.

10.3 Research Process and Methodology

We crawled and analysed job advertisements from the website *Interamt*, which claims to be the largest job exchange platform for German public services. About 50,000 ads per year come from federal, state or local level institutions. Typical job providers are ministries, state offices, city governments and associations.

We used a Robotic Process Automation (RPA) software bot to crawl the website frequently for several months to receive all job ads matching the search term *digi**. These search results therefore include words like digital, digitise, and digitalisation in various meanings and contexts. We did not use classical web crawling, as the *Interamt* website used internal frames and did not provide an individual page address for each job posting. The RPA bot was developed to simulate human access to the websites to avoid being locked out by technical bot detection functionalities. The website's structure and source code significantly changed several times during the data collection period so that we needed to reconfigure the bot accordingly.

The collection of the raw job posting data was followed by several data processing steps as well as qualitative research workshops where we discussed, categorised and clustered data properties. The following Figure 10-1 summarises the elements of our research process and is divided into the job analytics flow addressing the data processing, and the researcher workshop flow representing the researchers' influence on the data analysis and the respective results.

The *research workshops* were used to set goals and steer the quantitative job analysis. First, the crawled jobs in a raw form were sighted to discuss the general data base and identify typical reoccurring contents. We decided to form four main job categories for a coding of all crawled postings. More details are given in the results section. At the end of the job analytics flow, the researchers again had to sight the processed data especially for the topic modelling to discuss and summarise the main findings of the data-driven research steps.

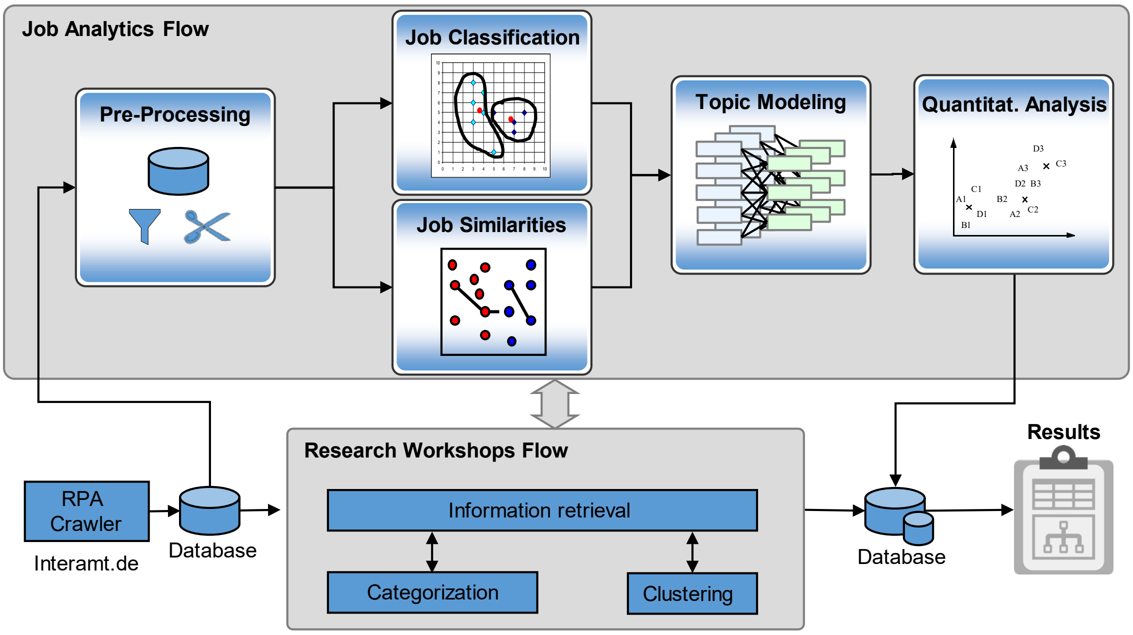

Figure 10-1: Research process and methodology

The *pre-processing* of the raw data builds the typical first step of a big data analysis. Here, the categorisation, cleansing and allocation of the individual job advertisements of the data set is a necessary condition for effective use of our data-driven research approach. Using raw and unedited job ads for modelling could lead to incorrect results. In our research process, an analysis was required to extract structured information from partially structured or unstructured job advertisements. This included the correction of missing values, job advertisement normalisation, and discretisation, and text pre-processing to remove and replace embedded characters that may affect the analysis content.

The elimination of irrelevant *stop words* also took place in the pre-processing step. We aimed on reducing text corpus of terms that occur frequently but are not adding to the informative value. In the German job advertisements, these are mainly articles, pronouns and some adjectives. For this processing step we created an extensive stop word list containing 897 terms, covering about 40-50% of the total text content.

During a research workshop, we decided to *manually categorise* all job ads into four disjunct groups. The allocation was executed manually by assistants following a written set of rules. All job information was transformed into the following elements: Job ID, check for duplicates, check for relevance, job posting organisation, job tasks, job requirements, „*nice to have*" requirements, job title, minimum pay scale group, maximum pay scale group.

We also applied categorisation algorithms. In our research design, we considered the k-nearest neighbours algorithm and Naive-Bayes, which have been intensively discussed in the literature (Islam et al. 2007; Smith et al. 2002). Both variants were examined for their suitability for job classification. The probabilistic classifiers summarise terms of the same frequency, since otherwise inquiries deliver only general results. Due to the summary, the classifier has an average frequency of occurrence and can therefore be regarded as a suitable attribute for the individual class descriptions. In order to use frequently occurring terms for classification, compound terms consisting of several individual terms are formed. This makes them more specific and produces better results. If the words are evenly distributed across the job advertisements, it can be concluded that very frequently occurring words are not suitable for classifying job assignments. This is because they appear in almost every job assignment, making it impossible to distinguish between them. At the same time, some words occur so rarely that they are not certified to be separable. Following these considerations, only words that occur with medium frequency are left for classification. Especially challenging for the classification of job advertisements is to find the correct threshold values for differentiation.

Job similarities were the object of investigation in our next step. We used the clustering of job advertisements to quickly find similar ads and a macrostructure for our job collection. We also used this to detect possible duplicates. In contrast to the previous classification, clustering does not use a predefined set of terms or taxonomies used to group job ads. Instead, groups are created based on job characteristics that are found in the set of documents. We applied hierarchical clustering techniques, which clustering groups of job ads according to a similarity measure in a tree structure. Instead of finding only one cluster that best matches a job advertisement, hierarchical cluster algorithms group the job advertisement iteratively into larger clusters. At the beginning, each job ad is arranged in its own cluster, which represents a leaf in a cluster tree. In the next step, two clusters that are as similar as possible are combined. This process continues until all small clusters are finally assigned to a single large cluster of all job advertisements.

Our next step was *topic modelling,* a method with rising popularity in research in the last years (Schmiedel et al. 2019). Topic modelling describes a group of statistical procedures which allow conclusions to be drawn about the thematic structure of the individual job advertisement in the collection of advertisements. Algorithms also determine the thematic relevance of the respective job advertisements. In contrast to keyword tools, the topic modelling used does not only reveal keywords and topics that appear in the job advertisements. Rather, it shows us the semantic relevance and context of words and phrases. In this step, we apply the Latent Dirichlet Allocation (LDA) topic modelling technique (Blei et al. 2003) to domain-centred job data along with other feature engineering methods to define characteristics of a job posting and a requested job profile. We chose the LDA algorithm, because it can generate higher-dimensional topics than other common algorithms (Masada et al. 2008). The algorithm is based on a repeated random selection of text segments, each of which captures the statistical clustering of word groups within these segments. The algorithm thus calculates the topics of the text collection, the topic portions in the individual texts and which words belong to the respective topics. Our design is natural language controlled, enriched with n-grams and latent topics as features. Several techniques such as latent semantic indexing, natural language processing, and semantic matching are performed on the job data.

The similarity value is then calculated and further normalised by min-max transformations. In this way, a similarity matrix is obtained, which determines the proximity of a digit* display to a range of values. The system of job capture and processing mentioned in this paper is therefore inspired by the necessity to use text mining algorithms to explore different needs for personnel within the public administration - by means of job advertisements - through a constructive mechanism on their relevant content contribution to the concept of digitalisation. This not only enables accurate and relevant information filtering, but also reduces time and human effort throughout the process.

10.4 Results

After a first pre-processing and duplicate removal, we could analyse 800 job ads crawled by the RPA bot from the *Interamt* website. More than half of them (432) describe jobs far away from shaping digitalisation activities. Instead, those ads only use *digi** randomly for describing secondary information technology (IT) aspects of current jobs. Examples for those hits are sentences like: „*combine classical marketing activities with digital marketing activities*“, „*file management of the audit office is completely digitalised, experience in Word and Excel is required*“, and „*the ability to meet the requirements of modern digitalisation, e.g. become acquainted with new IT systems*“. In some cases, the term only described application processing or similar side aspects: „*Please note that your application will be digitised for internal processing*“.

The content analysis of the remaining hits resulted in three major job categories. Ads could be categorised as addressing IT specialists, IT generalists, and project managers without specific IT skills. A qualitative manual analysis of the job ads showed that IT specialists typically create and implement digitalisation concepts and advise managers and employee regarding new technologies. IT generalists have a stronger focus on maintaining IT infrastructure and systems and to assist employees with digitalisation-related requests. The category of project managers without specific IT skills is needed for the general management of digital transformation, change, and process improvement.

Since we described our method and research path to our findings in the last section in detail, we will focus on five modelled topics identified by the introduced algorithms. The originally German data tables have been translated into English for this article.

The first modelled topic summarises terms related to flexible time management and home office (see Table 10-2). The effects of digitalisation on work organisation are inconsistent and sometimes contradictory in our data. Overall, it is becoming apparent that digitalisation within the public administration is leading to a disentanglement, more flexible and decentral of work. This results in new demands on the communication, cooperation and management of employees. A distinction can be made between internal and external work flexibility. External flexibility is reflected in the creation of jobs outside full-time work for an indefinite period. This includes fixed-term employment contracts (52.70% of all cases) and various forms of part-time work (87.41%). This type of internal project economy is most common in the areas of general local government, construction and housing, transport and economic development. This change has an impact on the qualification requirements, the function-related task structures and activities of the employees as well as the organisation of work, on the one hand as a structuring of tasks and activities based on the division of labour in horizontal and hierarchical terms.

Table 10-2: Modelled topic „Flexible Time Management / Home Office“

TOPIC: Flexible Time Management / Home Office		
ORDER: 11	**COHERENCE**: 0.984	**FREQ**: 1455
KEYWORDS: Home office; teleworking place; teleworking; teleworking; free; teleworking; work environment; flexible; personal responsibility; motivation; alternating teleworking; flexible work environment; free time management; alternating teleworking; flexible work environment; free time management;		

The future and performance of the public administration therefore do not necessarily require specific expertise. This is because the core competencies of many classic administrative professions are shifting more and more into breadth in the future and are also becoming detached from the classic job profiles. For example, the job advertisements very often demand considerable new- and further- qualification affinity. As the changes in job profiles are assumed to increase in the future, a continuous professional development gains importance (see Table 10-3).

Table 10-3: Modelled topic „Professional Development“

TOPIC: Professional Development		
ORDER: 24	**COHERENCE**: 0.286	**FREQ**: 198
KEYWORDS: Professional development; diverse; possibilities; corresponding; participation; corresponding professional development; individual support with your wish; participation in internal professional development; diverse possibilities for professional development; readiness for professional development;		

The next modelled topic has a high overlap with the previous topic. Not only technical skills are listed in the job ads, also human abilities are formulated clearly. The ability to guide and coordinate, critical thinking and persuasiveness are just as much in demand as communication skills at various hierarchical levels, resilience, flexibility, problem-solving skills and emotional intelligence. We summarise this topic with „initiative (Table 10-4), as independency and autonomy of employees are highlighted.

Table 10-4: Modelled topic „Initiative“

TOPIC: Initiative		
ORDER: 40	**COHERENCE**: 0.297	**FREQ**: 673
KEYWORDS: Way of working; personal initiative; high personal resilience; capacity for teamwork; service orientation; distinct; independent; autonomous; independent action; structured; cooperation; commitment; high measurement; high measurement of ownership; ownership responsibility; high load capability; independent method of working; high application; high commitment; high measurement of responsibility; high measurement of self-responsibility; high measurement of owner initiative; owner responsibility of work; high strength; self-responsibility; high responsibility; high commitment; high measurement of responsibility; self-responsibility and own responsibility;		

Communication skills are a standard element in many job ads of different sectors. In the analysed set of digi* jobs though, a focus lies on virtual communication (Table 10-5). Communication and collaboration systems are a classical element of information systems research for many years and it is not surprise, that they also form a key element of digitalisation-related recruiting. Requirements amongst others list cooperation, leadership, virtual teams, and teamwork as important terms of this topic.

Table 10-5: Modelled topic „Virtual Communication“

TOPIC: Virtual Communication		
ORDER: 13	**COHERENCE**: 0.458	**FREQ**: 783
KEYWORDS: Virtual; contact; personal; cooperation; communication skills; analytical; teams; information; leadership; conceptual; internal; application; communication; team; skills; communication skills; collaboration; ability; teamwork; analytical skills; conceptual skills; analytical and conceptual skills; analytical skills as well as communication skills; application of internal platforms; functioning virtual communication; ability to communicate clearly; leadership in virtual teams; colleagues information; contact and communication technology; contact and communication live communication; personal communication; text-based communication tools; virtual teamwork; virtual collaboration; virtual collaboration and communication; virtual teams; collaboration and communication; pronounced analytical; teamwork; pronounced analytical and conceptual skills; cooperation with different stakeholders; organisational and analytical skills;		

Before starting the data processing and statistical analyses, we discussed which technologies we expected to find in the data. In a literature review about digital technologies affecting the public sector, we identified the following developments amongst others: Artificial intelligence and machine learning specialists (Nam and Pardo 2011), big data and process automation experts (Kim et al. 2014), user experience and human-machine interaction designers, (Gil-Garcia et al. 2014), information security analysts, robotics engineers and blockchain specialists (Swan 2015). Our evaluation indicates that there is still no significant demand for many completely new specialist roles. However, employers underscore the importance of skills to understand and analyse problems (Table 10-6). Combined with professional development (Table 10-3), this brings the opportunity to develop specialised knowledge after the recruitment.

Table 10-6: Modelled topic „Understand Complex Issues“

TOPIC: Understand Complex Issues		
ORDER: 14	**COHERENCE**: 0.212	**FREQ**: 218
KEYWORDS: Issues; complex; ability; complex; familiarise; complex issues; grasp quickly; analytical skills; conceptual skills; analytical and conceptual skills; virtual teams; analytical skills as well as;		

10.5 Discussion and Conclusion

According to our analysis, the public administrative culture faces major challenges. The concept of digitalisation is determined above all by the closely interwoven IT investment decisions of the public sector, the amount of available information, the dynamic development of policy fields and technological change. The digitisation requirements of the administration are developing at a rapid pace, making flexibility and lifelong learning the most important factors for its modernisation. Derived from the job advertisements, the personnel policy of the public administration formulates the requirements in this context as efficient processes, networked procedures and proactive behaviour.

Thus, workflows and standards do not change visibly. New IT procedures are taken into account, also in order to make work easier in the future. This not only serves the employees, but also leads to a high communication orientation to external parties. The use of IT procedures, in turn, is intended to influence quantitative and qualitative job planning in many areas through faster and cross-departmental processes. The new employees should support and implement these changes and should therefore be able to implement the new requirements in a targeted manner, usually in a project context. At the same time, it is clear that personnel should participate in and contribute to change. To this end, particularly the intensified personnel development was identified. It includes continuing education, training, supervision and coaching. But there is also a clear need to create an open administrative culture in which staff are encouraged to get involved as their engagement and commitment is wanted and needed.

At the same time, most of the ads can be summarised showing a trend for supporting and accompanying digitalisation. However, the majority of postings does not describe a very concrete or pioneering role or mindset. It could be the case, that the most innovative impulses and changes are given in Germany by expert groups and central agencies. Most of the analysed institutions seem to follow trends, role models / pilot institutions, or simply laws and regulations. In summary, our results leave two major ways for interpretation. The data analysis shows that German public sector institutions either do not actively plan far ahead and do not seem to have a clear vision and strategy for digitalisation-related recruiting. Or they intentionally recruit for a short-term vision and are in an early stage of digitalisation where the identified key developments are known but more modest steps must be taken first.

10.6 Limitations and Further Research

Our research of course has its limitations. We only interpreted a snapshot of job postings between November 2018 and March 2019 from one single platform representing public sector jobs in Germany. Also, text mining methods would be more effective, if much more data would be available. Furthermore, more detailed job profiles are possible, if the data set would be more homogenous. These limitations leave a lot of space for future research.

The method and its details leave many possibilities for modifications in the future. Although knowledge discovery was applied quite early in the history of computer science, text mining has received a boost in the era of social networks and employment websites. Job Mining has thus become a central field of research. While studying the related literature, the research challenges such as information overload, correct model choosing to represent the found knowledge, content economy, use of RPA technology, etc. represent an innovation for job mining. As a result of these new developments, topic modelling algorithms were the most interesting research area and especially all application areas led to a mixture of classical data mining and topic modelling algorithms.

No research branch is currently working in this area of public administration with content-based analysis on such data stock. But there is potential for further improvement through machine learning and natural language processing techniques. Kobayashi et al. (2018) suggested LDA as the best decision to use topic modelling, especially when exploring larger text collections in the areas of employee satisfaction, performance motivation, leadership and communication quality, and their interrelationships and possible adjustments. The non-parametric machine learning algorithms proposed by (Rosa and Ebecken 2003) essentially use genetic algorithms in combination with a k-nearest neighbours approach in the context of the assignment of text content. González-Briones et al. (2019) and some years before Lu et al. (2013) proposed a case-based and agency-based recommendation system for job seekers and recruiters. It uses a hybrid approach that combines content-based recommendations and machine learning for natural language processing approaches to improve result accuracy and provide a more accurate information extraction. They control two models based on probabilistic hybrid information extraction by combining machine-selected job segments based on latent features of individual preference.

In the future, we could also continue our study by interviewing recruiting specialists of public institutions, discuss our findings and their view on digitalisation-related recruiting. Interesting could also be to narrow the data set down and look for specific job titles like digitalisation project manager or big data analyst do analyse their requirements and remits. Researchers could also take the digitalisation job mining on to other countries. How are the open positions in countries characterised, which are known for their comparably mature digitalisation status? Another intriguing idea could be to transform the *Interamt* analysis into a longitudinal study. This would allow to regularly compare different snapshots e.g., once per year with each other to identify changes and trends in public sector jobs related to digitalisation. Another aspect is the comparison of public sector recruiting with the private sector. Analysing the differences and communalities regarding in their digitalisation efforts leaves many opportunities for future research.

11 Critical Success Factors for Robotic Process Automation - Analysing Multiple Case Studies

Table 11-1: Fact sheet publication P6

Titel:	Critical Success Factors for Robotic Process Automation - Analysing Multiple Case Studies
Publication Type	Journal
Publication Outlet	Computers in Industry
Ranking[1]	**C**
Authors	**Name** Plattfaut, Ralf Borghoff, Vincent Godefroid, Marie Koch, Julian Trampler, Michael Coners, André
Status	Published
Full Citation	Plattfaut, R.; Borghoff, V.; Godefroid, M.; Koch, J.; Trampler, M.; Coners, A. (2022): Critical Success Factors for Robotic Process Automation - Analyzing Multiple Case Studies. In: *Computers in Industry*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

The Critical Success Factors for Robotic Process Automation

Abstract

Robotic Process Automation (RPA) is a comparably new phenomenon in process digitalisation and automation. Prior research has identified a clear need to analyse Critical Success Factors (CSF) for RPA. In this study, we set out to derive a corresponding framework. Based on a structured review of the literature and an analysis of 19 expert interviews, we identify 32 CSFs which we subsume in several contextual clusters. Building on prior literature on CSF, we critically discuss how far the success factors we found are RPA-specific or hold for other process automation technologies or process improvement efforts in general, too. Based on this, we highlight implications for both theory and practice and areas for future research.

11.1 Introduction

Robotic Process Automation (RPA) is a comparably new phenomenon in process digitalisation and automation. It is now increasingly adopted by organisations around the globe (from telecommunication firms (Lacity et al. 2015) and insurance companies (Lamberton et al. 2017) to soccer clubs (Plattfaut and Koch 2021)) and has received a lot of media attention (Kregel et al. 2021). According to a recently published study by Forrester, almost 50% of companies worldwide will increase their use of RPA due to the COVID-19 pandemic (Oesterreich and Avasthy 2020). RPA is a low-code way of automating business processes using the graphical user interface of underlying applications. It is very versatile and can increase efficiencies for a wide range of computerized business processes. As RPA mimics the behaviour of end-users, the corresponding transfer from human processing to robotics can be done quickly (Aguirre and Rodriguez 2017; Asatiani et al. 2019). As such, RPA projects can be executed in a short time and very cost-efficient (Lacity et al. 2015; Schmitz et al. 2019). Success stories, especially by RPA tool providers, report tremendous effects RPA can have on process efficiency and effectiveness (Automation Anywhere 2020; Blue Prism Limited 2020; UiPath Inc. 2020). However, other reports indicate that RPA projects and efforts are not always as successful as hoped (ABBYY 2020; Lamberton et al. 2016; Lamberton et al. 2017; PricewaterhouseCoopers 2019; Rutaganda et al. 2017).

Many researchers have studied the implementation of RPA; however, there are still gaps in understanding the exact factors that determine success or failure. According to Syed et al., future research should therefore also focus on empirical studies in the area of Critical Success Factors (CSF) for RPA (Syed et al. 2020). Such empirical studies should then lead to scientifically grounded findings on how organisations use the various methods, tools, and techniques in robot-supported process automation in a way that is critical to their success (Syed et al. 2020). These insights can form the basis for a better understanding of the requirements to be met, the principles and practices applied, and their impact on project success (Kieser and Nicolai 2005). Scholarly researchers have already created a great knowledge base of success factors, lessons learned, or considerations for RPA but to date no structured framework of these success factors is available. As such, we set out to compile a structured list of CSFs for RPA. Acknowledging that RPA is different from other technologies (e.g., because of its low-code nature), we also set out to contextualize this list relating the CSFs to factors those prior studies have identified for other technologies, or (information technology; IT) projects in general. Hence, we set out to answer the following two research questions:

RQ1: What are CSFs for RPA, how can these be categorized, and how do they interrelate?

RQ2: How do these CSFs for RPA differ from the generally accepted CSFs of other process-related technologies or process improvement approaches?

To fulfil these objectives, we employ a four-staged approach. Firstly, we conduct a systematic review of the literature on RPA, in which we identify and analyse 34 empirical articles. Secondly, we quantitatively analyse data from 19 expert interviews to confirm and supplement the literature-derived findings (Yin 2018). Based on these findings, we build a structured framework of CSFs for RPA (which are contextually clustered). Thirdly, we discuss this framework considering existing literature, especially lists of CSFs for other process automation techniques, and distinguish factors that are well known and true for many project settings (e.g., top management support) from those that are more RPA-specific (e.g., creation of a centre of excellence which concentrates resources and knowledge). Fourthly, we cluster these CSFs based on conceptual proximity.

After this introduction, we continue with our theoretical background on RPA and CSFs (Section 11.2). Section 11.3 shows the research methodology. Section 11.4 presents the results and provides further details on each success factor. We discuss these results in section 11.5, where we also highlight implications for theory and practice. Section 11.6 presents conclusions and limitations as well as suggestions for future research.

11.2 Background

11.2.1 Robotic Process Automation

RPA is a widely discussed topic, both within practice and academia, especially within the Information Systems and Business Process Management (BPM) community (Cooper et al. 2019). Although researchers can observe an increased attraction of RPA solutions in practice (Kregel et al. 2021), a holistic academic perspective on RPA and especially on CSFs for RPA is still missing (Syed et al. 2020). While there are various sources examining success factors for implementation and operation (Lande et al. 2016; Müller and Jugdev 2012b; Niazi et al. 2006; Niazi 2015; Ram et al. 2013), there is no such framework in the field of RPA (Syed et al. 2020).

RPA mimics user interactions on existing underlying systems to manipulate data according to preset rules (Cewe et al. 2018; Lacity et al. 2015). Therefore, we can describe RPA as a non-invasive automation approach in contrast to traditional automation solutions, requiring no major changes to existing systems (Willcocks et al. 2018). RPA relies on techniques from the field of artificial intelligence and machine learning but cannot be considered intelligent itself (Tsaih and Hsu 2018; vom Brocke et al. 2018). Instead, researchers see RPA rather as a transition technology towards a fully intelligent automation solution (Alles and Gray 2020). Regarding its applicability, RPA is most suitable for automation of repetitive, rule-based, and mundane tasks, where no human cognitive action is needed (Aguirre and Rodriguez 2017; Urbach et al. 2019; Willcocks et al. 2018). Unlike other technologies, RPA is not designed to optimise existing business processes (Aguirre and Rodriguez 2017; Denagama Vitharanage et al. 2020). Rather, a software robot reproduces the manual tasks exactly as they are, i.e., with all the inherent inefficiencies and imperfections (Osmundsen et al. 2020; Syed et al. 2020). While the development of traditional automation solutions requires advanced IT skills, which lie in the responsibility of the IT department, RPA is relatively low-level concerning development skills (Hallikainen et al. 2018; Madakam et al. 2019). Hence, RPA projects often lie outside the responsibility of the IT department on the business side (Osmundsen et al. 2020).

To complement and extend this context, single RPA projects usually follow a lifecycle consisting of the six phases: context analysis, process analysis, process development, bot deployment, testing, control, and operation and maintenance (Jimenez-Ramirez et al. 2019). These six phases can guide the analysis of CSFs for RPA further as not all CSFs are relevant throughout the lifecycle. Building on these six phases, we analyse CSF for RPA from three perspectives: (A) Firstly, we consider CSFs that enable the organisational success of RPA and are overarching in nature. (B) Secondly, we aim at identifying CSFs that drive the success of an RPA project and the corresponding implementation. (C) Thirdly, we set out to identify CSFs that deal with the post-implementation maintenance of the RPA solutions and, thus, enable the long-term success of RPA.

11.2.2 Critical Success Factors

We can define CSFs as the few critical areas for the success of an organisation, a project, a newly introduced technology, or another corresponding unit of analysis. Research on CSFs has a long tradition in management science. Researchers originally developed the concept to identify what organisations need to do well to be successful (Rockart 1979). In the 1980s, research defined CSFs as the key business activities that, if achieved, would ensure an organisation's competitive performance in the marketplace (Bullen and Rockart 1981). They are the few key areas where things have to be done right for the organisation to be successful. If the results in this area are not sufficient, the organisation's efforts during this period will remain behind expectations (Bullen and Rockart 1981; Rockart 1979). As such, they are the relatively small number of really important topics on which managers should focus their attention (Bullen and Rockart 1981).

The concept of CSFs has also been used extensively in information and communication technology research. In the manifold research on computer science, IT management, or even IT service management, scientists started early to understand the key factors that influence the success of organisations (Delone and McLean 1992). Several articles address the identification of CSFs within these multi-faceted research disciplines (Munro and Wheeler 1980; Pfeffers et al. 2003).

Despite this strong research theme of CSFs, it is still unclear which CSFs directly impact organisational success with respect to RPA (Syed et al. 2020). However, CSFs already exist for other forms of process automation technologies, e.g., for the implementation of Enterprise Resource Planning (ERP) systems (Dezdar and Sulaiman 2009; Finney and Corbett 2007; Nah et al. 2003; Ram et al. 2013) or other non-technology driven business process improvement initiatives (Jurisch et al. 2012).

With regards to generalizability, CSF analyses often exhibit a set of common weaknesses. When analysing CSFs, researchers typically use a qualitative methodological approach with a very small sample of respondents; therefore, the data quality of the surveys or interviews is crucial (Alias et al. 2014; Bullen and Rockart 1981; Remus and Wiener 2010). Another problem with CSFs is the inevitable restriction of respondents to a specific group of people, which can lead to bias and the inherently limited willingness to provide information as soon as, for example, questions focus on failure factors at the employee level (Chow and Cao 2008; Pfeffers et al. 2003; Pinto and Prescott 1988). Furthermore, in some cases, the identification of critical factors can be complicated by the interconnectedness of factors (Lim and Mohamed 1999; Ram et al. 2013). For example, there are usually correlations between CSFs such as „*top-level management support*“ and the available project budget, which without context would lead to misinterpretations (Alias et al. 2014; Bullen and Rockart 1981; Remus and Wiener 2010).

11.3 Methodology

11.3.1 Research Approach

To achieve the research objective and answer our two research questions, we followed a four-staged sequential research approach (Figure 11-1). Each phase used a distinct methodological approach to compensate for inherent weaknesses of individual methods on the one hand (Khandelwal and Ferguson 1999) and provide a coherent picture of factors that promote success on the other (Morse 2007; Remus and Wiener 2010). Through this, we were able to counteract some of limitations that come with CSF research mentioned above.

The first stage consisted of a systematic literature review on empirical journal articles available in leading databases, which aimed at identifying relevant CSFs for each of the three perspectives on the RPA lifecycle. We based the second stage on a qualitative analysis of expert interviews (from prior case studies of the authors and published interview transcripts (Helm et al. 2020)). We used the expert interviews for confirmation and supplementation regarding the prior identified CSFs. As our research lens, we employed the RPA lifecycle proposed by Jimenez-Ramirez et al. (Jimenez-Ramirez et al. 2019). We used the three different perspectives depicting the six phases of the lifecycle as introduced above: A) CSFs for RPA in an organisation, B) CSFs for RPA Development, and C) CSFs for RPA Operations. In the third stage, we cross-validated the identified CSFs for RPA with other CSF frameworks from the literature (e.g., for other technologies or IT projects in general) to investigate each factor's uniqueness for RPA purposes. In the fourth and final stage, we clustered the CSFs according to the contextual information retrieved in the prior stages.

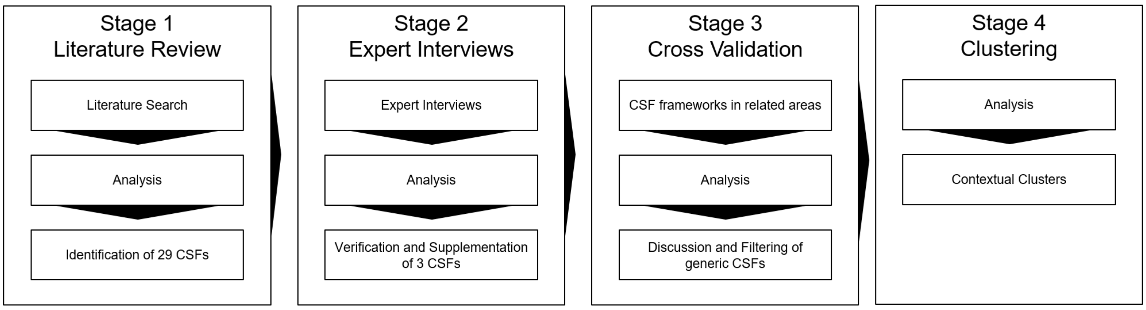

Figure 11-1: Research design

11.3.2 Stage 1 - Literature Review

We followed a structured and systematic approach to review the literature (Rosemann and vom Brocke 2015; Webster and Watson 2002). After a systematic search of suitable literature, we analysed the results in a structured way. To ensure not missing relevant papers, we used the search term „*robotic process automation*“. The search term was allowed to appear in all accessible fields, e.g., title, abstract, keywords, and text. We included research from 2015 onwards, starting with the first major publications on RPA.

Within our literature analysis, we followed a broad approach to cover all relevant papers. We focused on empirical studies on RPA to derive CSFs from the presented data. Hence, we searched within multiple sources beginning with the AIS Electronic Library covering major journals and the proceedings of renowned conferences. Furthermore, we used the AIS Senior Scholars basket of journals to include further high-quality research. To broaden the scope to research streams like BPM, computer science, and information systems engineering, we additionally included Elsevier Science Direct, IEEE Xplore and the ACM digital library as literature outlets.[6]

[6] The exact search procedure in stages 1 and 3 was available to the reviewers in the review process. Please contact the authors for more details.

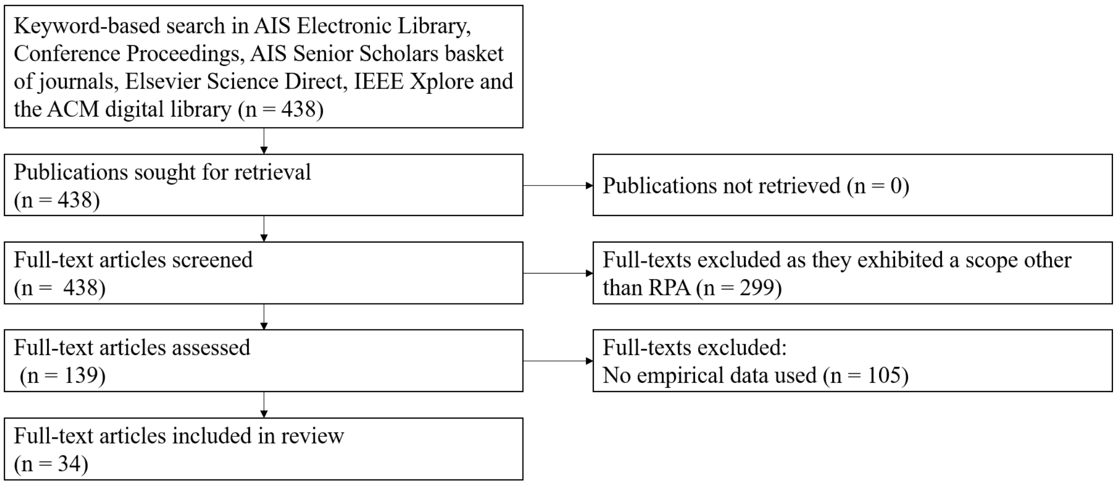

Figure 11-2: Overview of the literature identification and classification process

We evaluated the identified papers based on their relevance for our research and used method (Iden and Eikebrokk 2013; Kitchenham et al. 2009). We excluded all papers only mentioning RPA in passing, where RPA was not an integral part of research or where it was just as a potential technological solution for other problems. As a next step, we also excluded non-empirical papers (e.g., purely conceptual) to ensure solid grounding of the CSFs. For this purpose, all papers were read and classified as empirical or non-empirical based on the data used and procedure described in the respective methods section. Figure 11-2 provides an overview of the conducted literature identification and classification process. From the initial 438 identified papers, we found 139 with a relevant share of RPA content. With regards to empirical studies, 34 papers remain as our focus of analysis. All articles were read and coded regarding potential CSFs, following the three perspectives on the RPA lifecycle as a grounding framework. Within this body of literature, we were able to identify 29 potential CSFs.

11.3.3 Stage 2 - Expert Interviews

On the one hand, to validate our results and, on the other hand, to supplement the CSF framework derived from stage 1, we analysed the rich data of 19 expert interviews in stage 2. This approach allowed us to collect direct firsthand information and to understand the validity of the before-built framework (Yin 2018).

As a basis, we revisited qualitative expert interview data from three organisations (O1 to O3) originating from three distinct sectors. O1 is a statutory healthcare payer, O2 a leading private sector insurance company, and O3 a sports and entertainment organisation. We had accompanied the individual organisations during the introduction and operation of specific RPA projects. We conducted 13 semi-structured interviews with employees on different hierarchical levels and from different departments involved within the respective RPA projects. Table 11-2 gives an overview of the interviewees and their roles.

The statutory healthcare payer is one big player within the European health sector. In the face of a wave of retirements within the organisation's staff, the organisation will reduce the workforce continuously. The organisation used RPA as part of a larger process optimisation and digitisation program. The private sector insurance organisation is part of one of the largest insurance groups in the world, with more than 20,000 employees in administration alone. The organisation is one of the leading providers of cover for corporate operational risks of companies and property and casualty, life insurance, and private pension schemes with multiple affiliated subsidiaries. The sports and entertainment organisation is one of the most successful professional sports clubs globally, both from a sport and economic perspective. With over 150,000 club members, it is one of the world's top ten largest sports clubs. The head office employs more than 350 people who work in the respective subsidiaries in sports, e-commerce, event management, travel management, and media broadcasting.

In addition, we used a publicly available data set of interview transcripts as a further data source within stage 2 (Helm et al. 2020). This dataset consists of six structured interviews conducted and transcribed as part of a research project with an RPA focus. The focus of the original study was on developing a consolidated framework for the implementation of RPA (Herm et al. 2020).

Table 11-2: Overview of the interviews used for analysis

Organisation	Sector	Interviewee	Role
O1	Statutory healthcare payer	O1.1	Business Lead
		O1.2	Head of Communications and Change Management
		O1.3	Technical Program Manager
O2	Private sector insurance company	O2.1	Software Developer, Division Manager SAP Project System (PS)
		O2.2	Division Manager Product Technology & Inventory/AE, Product & Operations
		O2.3	SAP Consultant Success Factors IT
		O2.4	Software developer
		O2.5	Group & Segment Controller
O3	Sports and entertainment company	O3.1	Key account manager
		O3.2	Senior developer
		O3.3	Head of digital
		O3.4	Content manager
		O3.5	Managing director
Data Source		**Interview**	**Interview in [Helm]**
		H1	Interview A

Interview transcripts from published open data [45]	H2	Interview B
	H3	Interview C
	H4	Interview D
	H5	Interview E
	H6	Interview F

For the analysis, each interview was read and coded separately by a team of two researchers to ensure rigor. Each researcher was coding based on the list of CSFs identified within the prior literature study (stage 1). Moreover, each researcher aimed at identifying additional factors. After the individual coding procedure, we compared the results. In case both researchers declared the same findings, we considered the results to be valid. If we reached no consensus, we consulted a third researcher to solve the stalemate via discussion until we achieved consensus. Newly identified CSFs were discussed within the whole research team to ensure validity. Moreover, we discussed whether the individual input can be understood as an aspect of an already identified CSF (which led to a revision of the corresponding CSF) or whether the input needs to be considered as a new CSF. Within the expert interviews, we confirmed 28 CSFs from the literature. The only CSF we could not confirm with interview material was C4 (Ensure compliance with existing governance as solutions scale and adapt tools and processes). We were able to confirm nearly all CSFs with data from at least two different organisations. C5 (Plan for continuous improvement for automation solutions) appeared only in the data from one organisation (Interview O2.1). However, we could identify three additional CSFs from our analysed qualitative expert interview data. These did not appear in the original published literature. Moreover, in five cases, we also appended the literature-based CSFs with additional facets based on the rich findings of our qualitative data. All CSFs were allocated to one of the three lifecycle-based perspectives (A - success factors for RPA in the organisation in general, B - success factors for RPA development, and C - success factors for RPA operations). As all interviews were conducted in German, interview quotes used in the following have been translated.

11.3.4 Stage 3 - Cross-Validation

In the third step, the identified CSFs were cross-validated with success factors from related areas such as ERP systems and general frameworks in the field of process automation and other relevant literature. For this purpose, we analysed existing review papers in the field of CSF research and articles on other process automation technologies or process change methodologies and extracted the containing CSFs. We concentrated on well-published and cited work, especially concerning ERP systems, management information systems, and BPM. To this end, we employed a broad search term across multiple databases.

We identified a total of 77 publications, which we narrowed down to 12 in two iterations. We analysed the publications according to the following three exclusion criteria: The success and failure factors presented in the sources did not address 1) an implementation, operations, or management issue related to IT-based or at least IT-related business processes or 2) the introduction, maintenance, and enhancement of new technologies or innovations. 3) The publications did not show a certain originality in the success factors and did not predominantly relate their presentations to already identified sources.

This prior literature includes articles on CSFs for organisational transformation (Dikert et al. 2016), ERP introduction and implementation (Finney and Corbett 2007; Françoise et al. 2009; Nah et al. 2003; Ram et al. 2013), software development projects in general (Khan et al. 2009; Khan and Keung 2016; Niazi et al. 2006; Niazi 2015; Rainer and Hall 2002), process improvement projects and BPM (Lande et al. 2016; Trkman 2010), and general project management (Müller and Jugdev 2012b). Using these articles and other literature, we assessed the specificity for our 32 CSFs for RPA, following the approach by Kan et al. (Khan et al. 2009). As such, we analysed each of the 12 publications regarding the occurrence of CSFs also identified within our research. This analysis helped us to determine the specificity and validity of the CSFs for RPA.

11.3.5 Stage 4 - Clustering

Informed by the qualitative insights from both literature and expert interviews, we were lastly able to cluster the CSFs for contextual proximity. To this end, authors individually clustered the CSFs based on their content and context. Differences in interpretation were discussed and resolved among the team. This led to the creation of a holistic CSF framework for RPA (see Figure 11-3). In the following chapter, all 32 CSFs are introduced in their respective contextual clusters. Here, we will especially focus on those CSFs that are specific for RPA. A complete overview of these CSF with exemplary quotes can be found in the appendix.

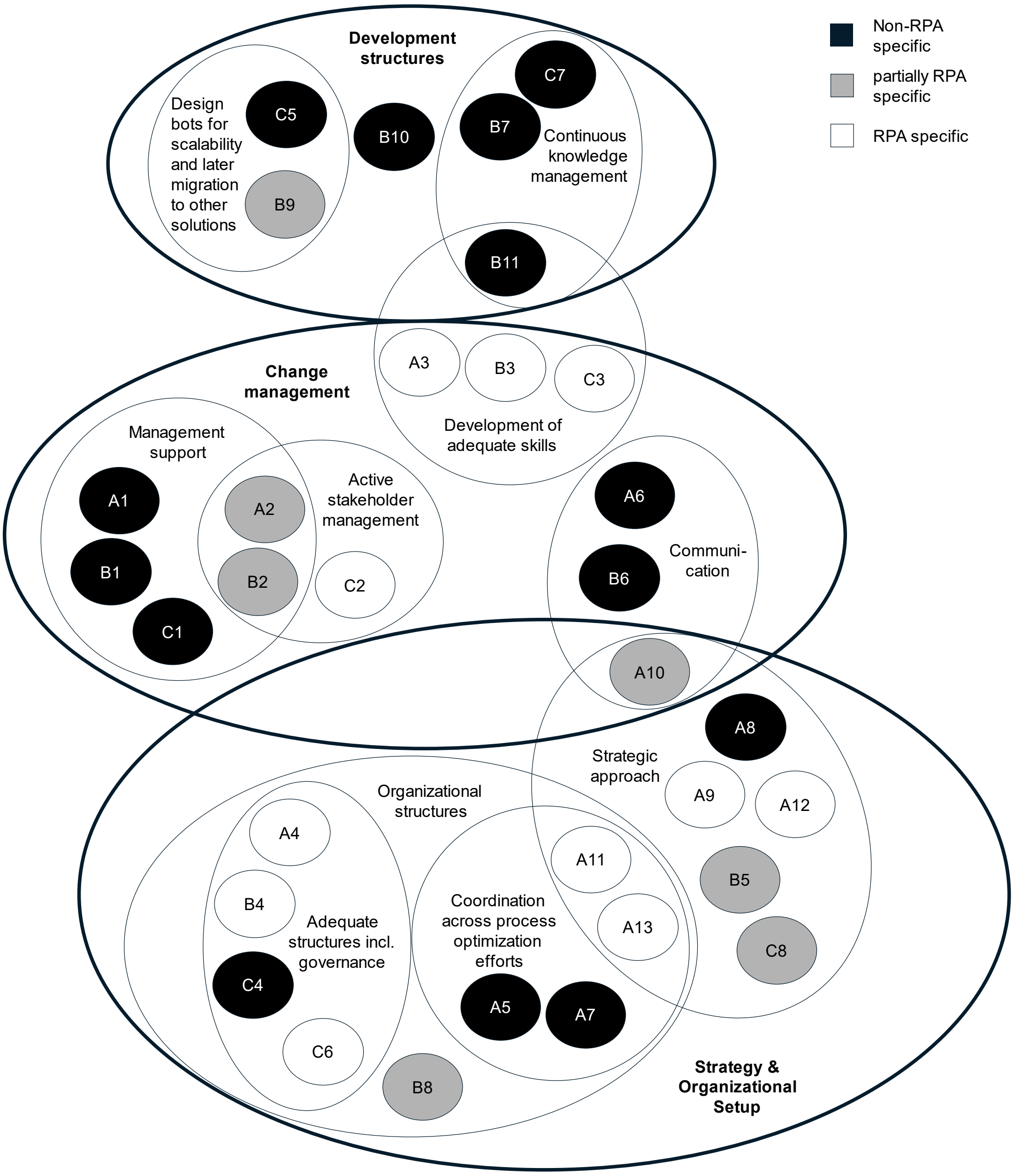

Figure 11-3: Contextual clusters and level of specificity of CSFs for RPA

11.4 Results

11.4.1 Development Structures

The first contextual cluster of CSFs for RPA contains aspects that are in the majority typical for each development project, i.e., a standardized development approach (B10), a sub-cluster of CSFs to design bots that are built with a focus on scalability and later migration to other solutions, and a sub-cluster related to continuous knowledge management.

In line with other prior literature on other IT projects (Khan and Keung 2016), RPA development should also employ a standardized and structured development approach (B10). This approach ensures that RPA bots are developed as efficiently as possible using previous experience. In the interviews, respondents highlighted that they employ agile approaches such as Scrum with a specific focus on the iterative nature of development: „*Here the phases of development, trial and error and learning are run through until the realization is completely finished*“ (Interview O2.5).

The sub-cluster of CSF to design bots for scalability and later migration to other solutions contains CSFs that focus on scalable and flexible solution design with a maintainable setup (B9) and continuous improvement of the solutions later on (C5). While the first argues from the perspective of development towards maintenance (i.e., create maintainable solutions), the latter stresses that also running solutions need to be continuously monitored for new improvement opportunities (i.e., maintenance can drive new development). In general, both hold true for general IT-driven process improvement projects (Rosemann and vom Brocke 2015; Soldani et al. 2018). However, due to the easy and cheap implementation possibilities of RPA, a focus on a maintainable setup might be more important here - similar to other lightweight process automation technologies. Otherwise, maintenance efforts can increase exponentially (Lacity et al. 2015). Our interviews underline these perceptions: „*Part of ensuring scalability was to develop functionalities using RPA that are maintainable afterward*“ (Interview O2.2).

The sub-cluster on continuous knowledge management comprises CSFs that are generally relevant for IT and process improvement projects and, as such, not RPA-specific (Finney and Corbett 2007; Khan and Keung 2016; Niazi et al. 2006; Ram et al. 2013). In line with prior literature, RPA development projects should be properly documented (B7) internalizing the knowledge from vendors and consultants (B11). Moreover, even during operations and maintenance of the RPA bots, knowledge needs to be continuously codified (C7). Multiple expert interviewees agreed on the importance of knowledge management with „*a knowledge management system for RPAs [being] developed and implemented*“ (Interview O2.3) and the goal to „*…build up the know-how in-house* [to] *make ourselves independent of the external consultant*“ (Interview H5).

Summing up, the first contextual cluster focuses on developing the RPA bots. CSFs in this cluster are highly technology-agnostic and need to be also applied in other IT development projects.

11.4.2 Change Management

The second contextual cluster of CSF for RPA covers change management. Within change management, we could identify 12 CSFs, assigned to the four sub-clusters management support, active stakeholder management, development of adequate skills, and communication.

The first sub-cluster, management support, underlines the importance of top management support for RPA. This support is necessary for RPA both within an organisation by and large (A1) and during the development of single RPA bots (B1). With this, management can also ensure sufficient resources and priorities for RPA operations later on (C1). These success factors are not only mentioned in the existing literature on RPA (Fernandez and Aman 2018; Osmundsen et al. 2020; Tarafdar and Beath 2018) but also in the broader literature on (IT) project management in general (Françoise et al. 2009; Khan and Keung 2016; Müller and Jugdev 2012b; Trkman 2010). Interviewees underlined this perception and argued that one of „*the key factors for success can be the support of the top management*“ (Interview O2.2). Especially the provision of operational and IT resources (i.e., ensuring that projects and operations are adequately staffed) can be understood as separate CSF (A2, B2). While stakeholder involvement is valid for both RPA and other process-optimising technologies, traditional technologies require a stronger focus on the technical side (IT staff) and only take the operational business perspective later. In contrast to this, RPA requires a strong involvement of both sides from the beginning. The main reason for this can be found in RPA being low-code and often business-driven while at the same time having an impact on the IT architecture of the organisation.

The CSFs of stakeholder and expert involvement (A2, B2) form, together with the need for sufficient process knowledge to monitor bot (C2) the overlapping contextual cluster of active stakeholder management. Even within RPA operations and maintenance (i.e., non-project routine tasks), stakeholders must be actively involved. The relevant knowledge and resources to monitor and maintain bots are crucial (Osmundsen et al. 2020). The knowledge can either be transferred to those operating the bots or remain with the business side, which then has to be available to provide their knowledge: „*The technicians, developers or engineers, need to see how the error occurred. As soon as it is a business error, the process expert can then intervene and say, this is an exception [...] or the bot is programmed or built incorrectly, then it has to go to development*“ (Interview H2). In contrast to RPA, traditional systems operations only need little domain knowledge. However, regarding bots executing business logic on top of existing core systems, monitoring bots without sufficient process knowledge becomes difficult or even impossible. As such, this CSF is specific to RPA.

The third sub-cluster is formed by the CSFs required to bring the necessary change about, i.e., the development of adequate skills. Successful change management requires also to actively plan and develop the necessary skills on an organisational level (A3), to then train employees for their changing role (B3), and when operations scale to ensure sufficient training for maintenance tasks (C3). Typically, organisations do not foster the unique combination of IT and business skills necessary to run RPA. As such, this combination of skill and, thus, all three corresponding CSFs are RPA specific. Probably the best way to build these skills is through active involvement of employees in the development processes: „*Generally speaking, the participation of users in the development process and the design along the lines of experience, age, etc. contribute to a sustainable expansion of their competences and their use*“ (Interview O2.3). An additional option is to use vendors to skill up the organisation (B11). In most cases, organisations initially rely on external know-how concerning RPA. This CSF is not RPA-specific as researchers mention know-how transfer from consultants for several new technologies. Exemplarily, it is considered a CSF for ERP implementations, too (Finney and Corbett 2007). Irrespective of the chosen path, the required change calls for careful planning ahead and continuous effort. Otherwise, the full value of RPA cannot be unleashed, as either IT personnel struggles with unfamiliar process flows and is not sufficiently equipped to handle exceptions content-wise, or business personnel does not have sufficient technical knowledge to create and maintain bots.

As in every change context communication is also key for RPA projects. In this cluster communicating the change early on (A6) and carefully managing the communication throughout the project (B6) are combined with the suggestion of a staged approach (A10). The former two factors relate to addressing and communicating the impact of the RPA initiatives on human labor and to the management and communication of corresponding staff redeployment. The latter refers to an approach with a proof of concept (PoC) and creating a minimum viable product (MVP) focusing on technology, skill, governance and regulation. None of these CSFs is fully RPA specific, as the importance of communications for successful (IT) projects is well-known. However, CSF A10 with the suggestion of a staged approach is at least partially specific: While a step-by-step approach and the use of specific process models and project structures are often regarded as success factors in the IT environment (Finney and Corbett 2007; Khan and Keung 2016; Niazi et al. 2006), the factor A10 takes on an RPA-specific peculiarity. It also refers to the first, very quickly created, functional iteration of an RPA solution to ensure action-relevant feedback (or a PoC very early on).

11.4.3 Strategy and Organisational Setup

The last overarching contextual cluster combines CSFs that are mostly specific for RPA. This cluster presents CSFs pertaining to organisational strategy and setup. It combines the sub-clusters strategic approach, coordination across process optimisation efforts and adequate structures (including RPA governance). The two latter ones are hierarchically combined with one additional CSF (B8) to form the sub-cluster of organisational structures.

Starting with the strategic approach, the demand to align any optimisation effort with the overall strategy of the organisation (A8) itself is not new or RPA-specific. It is, however, key to the success of RPA and reflects in several other more specific CSFs. Only if RPA is well aligned with the overall strategy, the right criteria can be defined to select those processes that bring the most value if automated (B5). Having such a clear process prioritisation strategy was seen as a CSF by both literature (Aguirre and Rodriguez 2017; Schmitz et al. 2019) and experts (e.g., Interviews H2, O2.1). A focus in this selection process should also be the high data quality in prior manual processes, that needs to be continuously ensured to maintain quality in the automated processes (C8). Both CSFs B5 and C8 are relevant for any process-optimisation technology but are especially important for RPA. Furthermore, the use of a staged approach (A10) can facilitate iterative strategic alignment (Kokina and Blanchette 2019). Using prototypical techniques such as the creation of a PoC or MVP, with a focus on organisational factors such as governance, internal or external regulations, as well as technological capabilities and existing skills, adaptations can be made in an agile manner (e.g., H5, O3.5). A factor that is very unique to RPA is that in this overall effort, RPA should not only be considered as a means to reduce headcount, but also as a solution to create added value, e.g., a better customer experience (A9). Automating menial tasks can free up employees to deal with more complex, value adding activities. This effect is one of the great strengths of RPA as it can increase employee satisfaction, if they can now fulfil tasks that allow them to realize their full potential. At the same time, this shift in tasks can help the organisation to improve their service delivery and quality. But this is only possible, if an organisation is aware of this potential and actively captures it. Several of our interviewees echoed this, for example, listing the following strategic goals for the RPA introduction: „*Increase in efficiency, reduction of running time, minimization of backlogs, autonomy of personnel resources, increased customer satisfaction, in line with rising quality in recurring processes*“. However, RPA also has distinct limitations (A12). For example, it cannot flexibly react to changes in the underlying systems or processes that a human could incorporate in his actions without being explicitly prompted to. Such a change might require a bot to be reprogrammed. But this is only possible if first someone has noticed that the change will affect the bot. Organisations need to be aware that the bot is not truly intelligent. RPA, for example, reaches its limits when it comes to cognitive tasks: „*[...] the robot is stupid. You really have to say that. It can only carry out activities. It can't recognize logical relationships. [...] from text scanning to certain keyword searches, that always just brings bad luck. [...] you have to integrate other software*“ (Interview H6). Here, organisations have to be careful not to overpromise on the capabilities of RPA; it is critical for the success of RPA that they are aware of the above-mentioned limitations. While this might be true for every technology in a certain phase of the Gartners Hype cycle, we could not find any peer reviewed literature that mentioned this CSF for other technologies.

The strategic approach needs to be complemented with the right organisational structures for process optimisation efforts - potentially supported by a CoE. Integrating a process optimisation effort into the overall process optimisation program (A5) should go without question for any initiative. Apparently, having RPA initiatives without a connection to the overall process optimisation program might severely hamper the success of both. In this context, it must also be clear that like for any other technology, alternative solutions have to be evaluated and the most suitable solution selected (A7). These alternative solutions might be organisational (e.g., process elimination, process improvement) or technological (e.g., core system automation). As mentioned above, process knowledge is crucial for RPA. This applies both to the transparency on process costs to calculate a viable business case (A11) and the availability of sufficient process knowledge as a basis for the automation (A13). RPA is here in so far specific that it is driven by single processes. Thus, an organisation needs to base its efforts on a well-managed process knowledge base.

The third sub-cluster focuses on adequate structures combining governance along the RPA project lifecycle (A4, B4, C4) and security (C6). An organisation needs to ensure that it has an adequate RPA governance which complies with the existing governance. The compliance with existing governance during operations (C4) is again commonplace for any IT solution. However, the definition of the governance for RPA itself (A4) is naturally RPA specific. Our interviewed experts reported that the new solutions should be driven from the process side, implying a loose coupling to the established IT department: „*The process owner should work on the development of the new RPA solution. As the new RPA solution was designed by the own project team, the process owner should take responsibility for integrating the related information and testing the new system*“ (Interview O2.2). The same applies for the need to then integrate this governance with general IT, organisation, and security policies (B4). Establishing an adequate governance can even mean to adapt existing policies like, for example, the security policy (C6). Raza et al. (Raza et al. 2019) extensively discuss the different aspects that need to be adapted to ensure security compliance. Here, RPA appears to be a special as RPA bots interact with underlying systems as human users would (i.e., they use their own credentials) although they are in fact pieces of software. Other process automation solutions do not have this peculiarity and therefore do not challenge the existing governance in the same way as RPA does. To avoid challenges, organisations need to address this discrepancy early on.

The final sub-cluster combines the two sub-clusters mentioned above to form the required organisational structures (both in regards to other process optimisation initiatives and the governance) and introduces the strong recommendation of a Center of Excellence. A CoE that centrally guides knowledge exchange and coordinates efforts can support all the efforts mentioned above optimally (B8). Our qualitative data indicates, however, that a full CoE is not always necessary and that organisations can also achieve such a concentration of knowledge on a more basic level through regular exchange meetings: „*All of us here depend on mutual exchange and good cooperation. Based on this conviction, we […] promote and support the exchange of ideas and experience between IT and the specialist department*“ (Interview O3.2).

In summary we can cluster our 32 CSFs along the three contextual clusters development structures, change management and strategy & organisational setup. This clustering holds the value that it makes different interdependencies between the CSFs more transparent. In the next section we discuss the merits of our findings.

11.5 Discussion

Our research, especially our derived framework, has two main implications for theory: Firstly, with the identified CSFs we provide an overview of antecedents of RPA success. Our framework sheds light on existing interdependencies between individual CSFs and identifies overarching contextual clusters. Secondly, we highlight specifics of RPA, and thereby show in how far CSFs are general or technology-agnostic for process automation and digitalisation. To avoid unnecessary repetition, we first discuss the framework in general and then highlight details about the CSFs both regarding their contextual clusters and their specificity for RPA.

With our complete CSF framework for RPA we close the research gap highlighted by Syed et al. (Syed et al. 2020). Despite the growing number of RPA vendors and products on the market, there is no clear understanding of how an organisation can successfully use and implement this technology. The literature contains many references and considerations about RPA, but it is unclear what critical success or failure factors exist. In general, RPA comes with the advantages of quick organisational introduction and simple bot implementation. Although researchers have documented the benefits of using RPA, there is no guarantee that organisations will realize the benefits in all cases. As such, the present study closes this gap and contributes a CSF framework for RPA.

As of now, our CSF framework mainly presents a theory of analysis and description (Gregor 2006). It describes the phenomenon and identifies constructs (RPA success and corresponding CSF). Descriptive theories are required when limited knowledge about the phenomenon exists. However, our framework is also a step towards an explanatory and possibly even predictive theory of the success of RPAs in organisations.

One interesting theoretical aspect of our findings is that apparently especially the CSFs within the contextual cluster development structures are technology-agnostic. This is especially surprising as several authors have argued that RPA is a new form of IT. As an example, authors have argued that RPA is comparably low-code (Hallikainen et al. 2018; Madakam et al. 2019) with corresponding skills being found outside the responsibility of the IT department on the business side (Osmundsen et al. 2020). Apparently, even low-code software development still can make use of the traditional software development insights. Exemplarily, this includes a structured approach to development, having later lifecycle stages in mind early on, and focusing on continuous knowledge management. More importantly, it might be that for RPA these old findings originating from software engineering practice need to be revisited. While we identified CSF for RPA in this research effort, we did not assess the suitability of existing software engineering CSF for RPA development. As now development happens increasingly outside of the IT department, the general CSFs might still hold true and need to be considered by a new kind of developers. Whether this also applies to the trend of citizen developers requires further studies.

The importance of development skills and capabilities outside of the IT department gives also rise the second interesting theoretical finding. As now business departments are increasingly empowered to build their own solutions (here: RPA bots), the strategic and organisational setup comes under stress. New factors become critical for success that have been not that important in the past. This includes questions of governance structures and coordination processes. Organisations need to find new ways to balance local RPA development in driven by the business units and central IT security and architecture maintained by the IT department. As such, it is critical to define such an RPA governance in terms of technology, standards, and organisation (A4). While it is clear that it needs to be different from the existing structures of heavy-code IT, concrete advice how such governance should look like is missing as of now.

Moreover, the linkage of RPA with the organisations strategy also raises new questions. The integration of more traditional IT with organisational strategy has been comparatively well understood. In contrast, RPA as an example of a new type of technology (Bygstad 2017) has also a new relationship with IT. As an example, prior research identified that RPA needs to fit to the organisational strategy. Apparently, increasing process automation might be seen as negative by customers, especially in high-engaging industries (Plattfaut and Koch 2021). On the other hand, the organisational strategy also has implications on the suitability of RPA. Prior research highlighted that RPA is not used (or able) to optimise existing business processes (Aguirre and Rodriguez 2017; Denagama Vitharanage et al. 2020). Instead, a bot automates the manual tasks exactly as they are, i.e., with all the inherent inefficiencies and imperfections (Osmundsen et al. 2020; Syed et al. 2020). As such, if the strategic imperative of the organisation is radical change of existing processes, RPA might not fit to this strategy. Based on this, several CSFs within the cluster of strategic and organisational setup are rather RPA specific. Again, whether these CSFs also hold true for other lowcode technologies requires further studies.

In addition to these contributions to theory, this article also has direct managerial implications. Automation projects have a high risk of failure. This is equally true for projects that use RPA as an automation technology (Ravn et al. 2016). Organisations and decision-makers are therefore looking for levers to minimize the risk of failure and make project success more likely. With our framework introduced in this paper, we contribute to this effort by identifying factors that are critical to the success of RPA projects. Practitioners are therefore encouraged to address all 32 factors included in the framework.

Not all the factors listed in the framework necessarily have to be implemented, but still need to be addressed. The selection of the CSFs to be implemented depends on a number of internal and external factors. These include the organisation's initial situation in terms of digital and process-related capabilities as well as the objectives of the respective RPA project. While one organisation may already have technology-savvy employees who can be directly integrated into RPA development, other organisations may require specific training. Specific goals of the organisations with regard to the RPA projects can also differ. In the case that RPA is to be used as an interim solution until the implementation of another preferred permanent solution, CSFs from the operations perspective are more likely to be omitted. However, assessing the necessity of the implementation is mandatory.

Within the framework, a distinction can be made between technology-specific and technology-agnostic CSFs. For both categories, there are different implications for practice. While technology-agnostic CSFs are relevant for various diverse technologies and possibly any form of projects, the remaining factors are specifically relevant for RPA projects. In practice, this results in equally specific responsibilities. It is precisely the generalizable factors that affect decision-makers and the management level in the general IT and business area. RPA-specific factors, however, should be addressed primarily by the responsible RPA project managers. On the one hand, this means that specific responsibilities can be assigned. On the other hand, by identifying the technology agnostic factors, we generally contribute to a better management of technology projects by confirming already known CSFs and adding further facets to the known canon.

11.5.1 Conclusion

In our research, we conducted a systematic literature review to identify organisational CSFs and CSFs for the development and operation of robotic process automation. We verified and supplemented the factors previously recorded in the literature (stage 1) with factors based on our qualitative data analysis of 19 expert interviews (stage 2). In the third stage, we cross-validated and filtered CSFs resulting collection by comparing established factors from related and more traditional automation solutions. Based on the qualitative insights from the prior stages, we lastly created contextual clusters of CSF (stage 4). This approach provides a framework of 32 relevant CSFs for RPA projects along three main contextual clusters - taking into account the perspectives on the RPA lifecycle and discussing the specificity of the CSFs for RPA. This framework can serve as a guideline for practitioners planning to implement RPA based process automation projects. Moreover, our framework differentiates specific RPA related CSFs from those existing with regards to traditional approaches, enabling decision-makers to create a better fit between organisational conditions and chosen automation approaches.

Although we took utmost care regarding our research design, however, our research naturally has some limitations. Firstly, and as described earlier, despite their widespread use in the research community, CSF analyses always have weaknesses. To counteract the problems of the qualitative methodological approach, which is characterized by the evaluation of a mostly small data base, we used a much broader data base and source pluralism than usual. While we believe that our multi-method research approach using literature sources, primarily collected qualitative data and secondary data takes a more holistic perspective on the phenomenon (Mendling et al. 2021) and thus ensures a high degree of coverage, it can by far not be considered complete. We have tried to consistently counteract possible biases, which also result from the inherently limited willingness of respondents to provide information, through our research design used (e.g., through the analysis of published research data (Helm et al. 2020)). We could see that some CSFs only occurred in single case expert interviews. As such, it might be that CSFs are context-specific, depending on multiple factors concerning the organisational and project-specific conditions. In addition, specific CSFs from our expert interviews may be subject to the personal bias of the interviewed employees. They have a different understanding of success or do not have complete and comprehensive knowledge of the situation. We have at least partially mitigated this problem through the collection of other case-related data. Moreover, the literature also mentions the risk of unidentified interdependencies between individual CSF. Here, we tried to use these interdependencies as part of our contribution. We provided a conceptual clustering for related and interdependent CSFs. These clusters depict inherent interdependencies between distinct groups of CSFs, as well as overlaps of these groups. Moreover, by applying the three perspectives on RPA projects, we are able to provide another conceptual layer that allows factors to be placed in a phase-based context. Factors within one of these perspectives thus also exhibit a certain interdependence in terms of their influence on the probability of project success. Nevertheless, we cannot exclude that further interdependencies exist within the presented framework. Lastly, while we identified several CSFs, we could not test their degree of influence. Our qualitative data gave some indication; however, there is so far no „*ranking*“ between the importance of CSFs to ensure RPA success in organisations.

Future research can work on these limitations and extend our research to achieve more causal-predictive power and allow a higher degree of prescription for practitioners. Foremost, it would be of great interest to investigate and quantify the individual influence of each identified CSF on RPA success and other CSFs to achieve a form of prioritisation within the framework (Chow and Cao 2008). This approach would allow a more holistic understanding of influencing factors. Also, procedure models, developed on that basis, could guide practitioners through the planning and implementation of RPA projects on the one hand by enabling targeted resource allocation and at the same time highlighting potential synergies. RPA-related research can also contribute further by identifying relevant actors and stakeholders responsible for each CSF within the framework. Identifying the relevant actors would allow practitioners to specifically address these as early as the planning phase of an RPA project, thus ensuring project success as we highlight above with (e.g., A2. Involve operational and IT staff early). This analysis could also help to further identify overlaps and interrelationships between individual factors and categories, e.g., based on CSF ownership by certain actors. For example, top management does not need to concern itself with the implementation details of a CoE or a continuous development approach. All of these elements can help to continue to extend the proposed framework and identify mechanisms that enable or support the implementation of each

CSF. This would allow, in a further step, the development of even more concrete recommendations for action that can support practitioners in the implementation of RPA projects based on their very specific situation. Lastly, RPA can be understood as one example of lightweight, low-code IT artifacts. Whether our CSFs also hold true for these systems is up to future research.

11.5.2 Complete Overview of CSF for RPA

In the following, we give a tabular overview of the CSFs along the three perspectives described in the method. We list a short description of the CSF, literature sources and references to the interviews (where applicable), an exemplary quote (wither from the literature or the expert interviews), and a marker whether the CSF is RPA-specific (+), partially specific (~), or non-specific (-).

Table 11-3: Description, literature sources, and interviews for CSF for RPA in an organisation, for RPA Development, and for RPA Operations.

A. CSF for RPA in an organisation					
CSF Description	Literature Source	Interviews	Exemplary literature quote	Exemplary interview quote	RPA-specific
A1. Make **Top Management support** RPA actively and drive a culture of change	(Asatiani and Penttinen 2016; Tarafdar and Beath 2018)	O1.1, O1.2, O2.1, O2.2, O2.3, O2.4, O2.5, O3.1, O3.2, O3.4, O3.5, H1, H2, H3, H4, H5, H6	„Senior and executive-level management administered the promotion and adoption of the [RPA] platform.“ (Tarafdar and Beath 2018)	„The key factors for success can be the support of the top management, because in the planning phase the support of the manager is very important for the start of the whole project.“ O2.2	-
A2. Involve **operational** and **IT staff early**	(Asatiani and Penttinen 2016; Schmitz et al. 2019)	O2.1, O2.2, O2.3, O2.4, O2.5, O3.1, O3.2, O3.3, O3.4, O3.5, H1, H2, H3, H4, H5, H6	„Early involvement of the people affected by the process automation was shown as a promising approach.“ (Schmitz et al. 2019)	„[…] the introduction should be initiated by the management as an overall strategy and carried out in interaction with IT. [An RPA project] delivers a good result when everyone is present. On the other hand, IT alone is not	~

				very effective...“ O2.5	
A3. Actively plan and **develop** the necessary **skills of employees**	(Asatiani et al. 2019; Fernandez and Aman 2018; Kokina et al. 2019; Schmitz et al. 2019)	O1.1, O1.2, O2.1, O2.3, O2.4, O2.5, O3.2, O3.3, O3.4, O3.5	„The digital workforce has arrived and [employees] must engage in digital upskilling to be part of this new way of work. […] most of these sought after skills are still essential for success, and RPA highlights the importance of some competencies already in line with […] skillsets.“ (Kokina et al. 2019)	„[...] a comprehensive range of training and further education measures to qualify [their] staff. Online training courses and workshops on these topics are offered.“ O3.2	+
A4. Define **RPA governance** in terms of technology, standards, and organisation	(Bygstad 2015; Bygstad 2017; Polak et al. 2020)	O1.2, O2.1, O2.2, O2.3, O2.4, H2, H5	„[RPA] application [should] fully integrated with heavyweight solutions and subjected to heavyweight governance. […] In particular, the issue of IT security and privacy is a real challenge for [RPA] and should of course not be taken lightly. The same applies to IT governance.“ (Bygstad 2017)	„The process owner should work on the development of the new RPA solution. As the new RPA solution was designed by the own project team, the Process Owner should take responsibility for integrating the related information and testing the new system…“ O2.2	+
A5. Integrate RPA into **overall process optimisation program**	(Osmundsen et al. 2020; Schmitz et al. 2019)	O2.2, O2.3, O2.4, O3.1, O3.2, O3.3, O3.4, O3.5, H1, H2, H3, H4, H6	„[…] as pointed out in the case analysis, managing RPA in the business units leads to a lack of focus on end-to-end processes, i.e. processes across an enterprise that create customer value. Truly addressing end-to-end processes is an important principle for BPM.“ (Osmundsen et al. 2020)	„The insights gained so far now lead to a conclusive adjustment of the [previous] strategy and the [RPA solutions] derived from it. With the help of strategic benchmarking, the company's own corporate strategy is now aligned with this and updated, and the interdisciplinary workflows are examined. The	-

				goal is to improve these [RPA solutions] in order to enable competitive advantages and thus achieve or defend long-term benefits.“ O2.2	
A6. Address and **communicate the impact on human labor** and employees job satisfaction early	(Güner et al. 2020; Hallikainen et al. 2018; Penttinen et al. 2018; Ranerup and Henriksen 2019)	O1.1, O1.2, O3.1, O3.2, O3.3, H2, H5	„It was quite natural for employees to have these fears because RPA adoption was justified by expected productivity improvements. However, management actively communicated that there was no intention to lay off people. The message was that, after RPA implementation, people would no longer have to carry out the boring work and could concentrate on more interesting tasks.“ (Hallikainen et al. 2018)	„The process owner should work on the development of the new RPA solution. As the new RPA solution was designed by the own project team, the Process Owner should take responsibility for integrating the related information and testing the new system.“ O2.2	-
A7. Investigate **automation alternatives**	(Lacity et al. 2015)	O1.1, O2.1, O2.4, H1, H2, H4, H5	„[…] back-office automation should be IT projects using existing BPM technology. Specifically, the IT department wanted to test whether BPM could achieve the same results as RPA.“ (Lacity et al. 2015)	„[…] I see that IT as an instance that shows the alternative solutions and that shows that we try to solve everything via robots. But our core system also has some possible solutions. And that is always the question if a robot is the optimal solution or if there is a better solution.“ O1.1	+
A8. Ensure **alignment** of RPA initiatives **with the**	(Asatiani and Penttinen 2016; Schmitz et al. 2019)	O2.1, O2.3, O2,5, O3.3, O3.4, O3.5,	„The cornerstones of the digital strategy combined with RPA as enabling technology can be transferred to other digital	„[…] the [RPA] introduction should therefore be initiated by management as an overall	-

overall strategy		H1, H2, H6	transformations."(Schmitz et al. 2019)	strategy and carried out in interaction with IT [....] and this has shown that even such small changes can only work step by step over a very long period of time and that a clear strategy must be in place." O2.5	
A9. Approach **RPA strategically** and not only as a tool for headcount reduction	(Asatiani and Penttinen 2016; Fernandez and Aman 2018)	O1.1, O1.2, O2.1, O2.4, O2.5, O3.1, H2, H3, H5 Append: and, not as the single and only mean to digitalize your corporate culture.	„[RPA] results in the introduction of new technology acceptance problems and should be addressed well by firms. Based on the professional logic lens, this is an issue that needs to be stressed as it can jeopardize their job opportunity […] Firms that apply PRA to replace human beings will cause competition between humans and robots." (Fernandez and Aman 2018)	„[...] it is important that we understand RPA correctly and can therefore use it perfectly. After all, we almost always focus on [personnel] cost savings. Many processes here are standard processes, so they can actually be automated. This means that existing [personnel] resources can be used more strategically here [...] if this could be fulfilled, we could also get one step closer to digitization…" O1.3	+
A10. Use a **staged approach** with a **PoC** and create an **MVP** focusing on technology, skill, governance, regulation, etc.	(Asatiani and Penttinen 2016; Bygstad 2017; Güner et al. 2020; Kanakov and Prokhorov 2020; Koch et al. 2020; Kokina and Blanchette 2019; Lacity	O1.2, O2.1, O2.2, O2.4, O3.2, O3.4, O3.5, H1, H2, H3, H4, H5, H6	„[…] the key events included setting up the proof of concept with vendor […] and challenges with the information security risk assessment." (Raza et al. 2019)	„[…] I think consciously we started in 2014/2015. There were a couple of pilots. One pilot was in the incoming invoice. [...] everything that can be automated will eventually be	~

	et al. 2016; Raza et al. 2019; Uskenbayeva, R., Kalpeyeva, Z., Satybaldiyeva, R., Moldagulova, A., & Kassymova, A. 2019)			automated.“ O1.2	
A11. Be aware of the **process costs** as a basis for the creation of a **business case**	(Asatiani and Penttinen 2016)	O2.2, O2.5, O3.2, O3.4, H1, H2	„Company understands current cost structure of a task and is able to estimate difference in cost and calculate return on investment (ROI) of RPA.“ (Asatiani and Penttinen 2016)	„[…] the project team has to analyse the whole process of business operation and find out the potential for RPA and improve the original process. Appropriate communication and collaboration, system integration and import of cost and time were also important.“ O2.2	+
A12. Be aware and **communicate the limitations** of RPA	(Syed and Wynn 2020)	O3.1, H1, H6	„The over expectation relates to the users' perception on the bots' ability to perform an assigned task. It was mentioned as one of the main issues that influences user trust in RPA [...] however, as explained by the participant, when bots fail to perform due to several reasons, users get frustrated, they lose trust in the bots' capabilities.“ (Syed and Wynn 2020)	„Really complex technical applications cannot be developed properly by us now [...] a lesson learned if every employee had the opportunity [to communicate this better] [...] the management needs to communicate well how effort and profit pay off faster for us.“ O3.1	~
A13. Ensure **sufficient**	NA	O1.3, H2		„[…] I think that the	+

process knowledge as the basis for automation				understanding of the process that requires a robot is not so pronounced. That you can then program such a robot directly. The interrelationships and what is actually done in the system and what the robot should actually do.“ O1.3	
B. CSF for RPA Development					
CSF Description	Literature Source	Interviews	Exemplary literature quote	Exemplary interview quote	RPA-specific
B1. **Ensure managerial engagement** across the RPA project	(Bygstad 2017; Fernandez and Aman 2018; Kokina et al. 2019)	O1.1, O1.2, O2.1, O2.2, O2.3, O2.4, O3.4, H3 Append: Ensure effective intra-top team collaboration.	„[…] The success of the new technology depends on the organisation’s management support and planning. Support from top management […] are important to enable the system users to gain sufficient knowledge and information. A well-planned and complete management plan should be available to support the adoption of the new system and to tailor the workforce to the newly-reorganised task.“ (Fernandez and Aman 2018)	„The key factors for success can be the support of the top management, because in the planning phase the support of the manager is very important for the start of the whole project.“ O2.2	-
B2. **Involve all** relevant **stakeholders** - especially process and IT specialists	(Bygstad 2015; Denagama Vitharanage et al. 2020; Hallikainen et al. 2018; Kokina et al. 2019; Kokina and Blanchette 2019; Lacity et al. 2015;	O2.1, O2.2, O2.3, O2.4, O2.5, O3.2, O3.3, O3.4, H3, H4, H6 Append: is relevant for strategic level as well as operative team composition	„An RPA team was established in the department for Process Optimisation, consisting of both internal and external personnel. The internal resources consisted of a project manager, process designers, robot configurators and an IT manager with the mandate of establishing	„[…] The most important success factors are the hard work of the project team. Choosing the right project team is very important.“ O2.2	~

	Osmundsen et al. 2020; Penttinen et al. 2018; Ratia et al. 2015; Schmitz et al. 2019)		boundaries between RPA and the IT function.“ (Osmundsen et al. 2020)		
B3. Actively **train employees** for **changing role**	(Fernandez and Aman 2018; Güner et al. 2020; Lacity et al. 2015; Osmundsen et al. 2020; Ranerup and Henriksen 2019)	O1.1, O1.2, O1.3, O2.1, O2.2, O2.3, O2.4, O3.1, O3.2, O3.4, O3.5, H1	„[…] provide enough support and training to employees. Initially, there was a problem in terms of customizing workers with a new task reshuffle. However, that’s our goal of providing solid support and training.“ (Fernandez and Aman 2018)	„[…] Yes, we will have to structure the training system differently. [...] Everything can be learned. But there will be modular learning, the all-rounders will no longer be needed.“ O1.3	+
B4. Ensure **compliance** with **IT, organisation** and **security policies** and establish supporting tools/processes	(Asatiani et al. 2019; Fernandez and Aman 2018; Kanakov and Prokhorov 2020; Koch et al. 2020; Kokina and Blanchette 2019; Lacity et al. 2015; Polak et al. 2020; Raza et al. 2019; Tarafdar and Beath 2018)	O2.1, O2.4, O3.4, H3, H6	„Work with compliance teams to check for modification in the control environment due to automation. [...] aware of the risks associated with employing bots…“ (Kokina et al. 2019)	„[...] the protection of sensitive data is becoming more and more important; we have to deal very intensively with the changing data protection regulations and also prove this…“ O3.4	+
B5. **Select** and **strategically develop processes** according to established criteria	(Aguirre and Rodriguez 2017; Asatiani et al. 2019; Asatiani and Penttinen 2016; Bygstad 2017; Hallikainen	O1.1, O1.2, O1.3, O2.1, O2.2, O2.4, O2.5, O3.1, O3.2, O3.3, O3.4, H1, H2, H3, H5, H6	„The necessity of engaging in an informating process highlights the importance of strategically managing organizations’ collective knowledge capital in the era of increasing implementation of	„ The departments formulate only the most important basic goals for us in advance. From these, individual goals are derived with the respective requirements and assigned a	~

	et al. 2018; Kanakov and Prokhorov 2020; Koch et al. 2020; Kokina et al. 2019; Kokina and Blanchette 2019; Lacity et al. 2015; Penttinen et al. 2018)		automation.“ (Asatiani et al. 2019)	priority in which they are to be realized. The development of the robots takes place in parts, which means that the users start at an early stage and can already show something after regular cycles. In doing so, we [strategically] prioritize the recurring phases of development, test, development, test, etc. It is important that robots can already go live today, while other robots are still in development.“ O3.2	
B6. Carefully manage the **internal communication** and **staff redeployment**	(Asatiani and Penttinen 2016; Fernandez and Aman 2018; Güner et al. 2020; Kokina et al. 2019; Lacity et al. 2015)	O1.1, O1.2, O1.3, O2.1, O2.2, O2.3, O2.4, O2.5, H1, H2, H4, H5, H6 Append: also relevant for analysis phase and different backgrounds	„In order to increase acceptance and adoption of RPA into operational processes, effective change management and communication strategies that ensure workers understand the facts and benefits of RPA are essential“ (Fernandez and Aman 2018)	„[...] proper [internal] communication is very important for [an RPA project] [...] that the members of the project team, always grasping the operational requirements of the end users, the system usage through communication and not through their own considerations…“ O2.2	-
B7. Ensure **adequate documentation** and **knowledge management**	(Kokina et al. 2019)	O2.1, O2.3, O3.3, H2, H3, H4, H5 Append: successfully integrate external knowledge	„In addition to providing process-related documentation to bot designers and developers, as process owners, accountants develop lines of communication with managers, internal auditors, or external	„[...]that knowledge management for RPA is developed and implemented […] the central question is always the importance of knowledge [...] in addition, there is	-

			auditors to explain what the bot is doing.“ (Kokina et al. 2019)	the activity-related documentation of the development of the RPA […] also the preservation of the unique advantages of certain knowledge of the employees in the process.“ O2.3	
B8. Create a **center of excellence** that concentrates resources and knowledge	(Bygstad 2015; Kokina et al. 2019; Osmundsen et al. 2020)	O3.2, O3.3, H1, H2, H3, H4, H5, H6	„[…] an organizing model and a development process, based on a central RPA center of excellence (CoE) and local RPA teams in business units. The local RPA teams suggest candidates for automation, the CoE assess the processes and decides, in collaboration with the business units, which processes that should be automated.“ (Osmundsen et al. 2020)	„[...] this need will be met by developing the first pilot projects, and on the basis of the experience gained, the employees will network centrally with each other and receive further training…“ O3.2	~
B9. Design for **scalable and flexible solutions** with a maintainable setup	(Aguirre and Rodriguez 2017; Asatiani et al. 2019; Bygstad 2017; Fernandez and Aman 2018; Kokina et al. 2019; Lacity et al. 2015)	O2.2, O2.4, H1, H2, H4	„[…] it might even be necessary (due to, for example, scalability issues) to [design], in addition to epistemic tasks, also pragmatic tasks to automation…“ (Fernandez and Aman 2018)	„The current RPA software here in the company allows us developers to do things early [...] to adapt and optimise regulations more flexibly [...] it is true that an [RPA] bot is very flexible [...] and can easily handle changes…“ O2.4	~
B10. Use a **standardized and structured development** approach	NA	O2.3, O2.5, O3.2, H2, H5		„We have therefore set up an internal working group in IT to develop concrete proposals for dealing with this issue, the subject-specific standards to RPA	-

				development, in order to ensure their freedom from errors [...] combine [the RPA design] with standardized processes [...] achieve the fastest results…“ O2.5	
B11. **Use vendors** to skill up the organisation.	NA	O2.5, H1		„[...] in preparation for the project […] training was completed with the basic introduction to the vendor's online courses…“ O2.5	-
C. CSF for RPA Operations					
CSF Description	Literature Source	Interviews	Exemplary literature quote	Exemplary interview quote	RPA-specific
C1. Ensure sufficient **resources** and **priority of tasks**	(Osmundsen et al. 2020)	O2.1, O2.4, O3.2, O3.3, O3.4, O3.5, H1, H4, H6	„Many of the employees involved in the RPA initiatives in the organizations studied, had to [implementing RPA solutions] in addition to their ordinary work tasks […] the employees had to prioritize their time themselves […] the daily operations suffered from these prioritizations.“ (Osmundsen et al. 2020)	„The monitoring of the project and also the selection of the processes in the whole team was done by defining main and intermediate milestones [...] The fine-tuning was basically done via list of measures [...it was necessary to] classify all actors as internal and external stakeholders…“ O2.4	-
C2. Ensure sufficient **process knowledge to monitor bots**	(Asatiani et al. 2019)	O2.1, O2.2, H2, H6	„[…] even though a human supervisor would not do hands-on execution of a work task, he or she must retain good amount of conceptual process knowledge to be able to effectively manage human workers who do the	„[...] and of course you need the orchestrator in the background [...the RPA solution] of course you always have to monitor somewhere…“ O2.1	+

			manual work." (Asatiani et al. 2019)		
C3. Train **operative employees for maintenance** tasks	(Asatiani et al. 2019)	O2.2, H2, H3 H6	„Therefore, while employing centralized knowledge management models may sound appealing because they may seem simpler to manage and maintain, local, re-contextualized viewpoints on the applicability of knowledge „in action" should also be respected." (Asatiani et al. 2019)	„At this point, even the operational users were trained [...] finally, the project team arranged the training all over again [for the operational users]" O2.2	+
C4. Ensure **compliance** with **existing governance** as solutions scale and adapt tools and processes	(Bygstad 2017; Hallikainen et al. 2018; Kokina et al. 2019; Osmundsen et al. 2020; Romao, M., Costa, J., & Costa, C. J. 2019)	NA	„[…] should be subjected to the same governance principles as heavyweight, because of the risks of becoming 'shadow IT' with the associated problems of poor reliability, organisational alignment and security." (Bygstad 2017)		-
C5. Plan for **continuous improvement** for automation solutions	(Penttinen et al. 2018)	O2.1	„According to a [...] employee involved in the project, process improvement work is never ready, a process should be continuously developed in a customer-centric direction. The interviewee envisioned that if RPA seems to work well, there is no showstopper for automating…" (Penttinen et al. 2018)	„In addition to the process owners, we are now implementing the process flow within RPA and, as developers, are thus pursuing a continuous improvement process [...] This enables continuous fine-tuning of the bot" O2.1	-
C6. Adapt the **organisational security framework** to fit RPA	(Raza et al. 2019)	O1.1, O1.2, O3.1, H3	„There are some clear actions. The first one is for security to go back and work on the controls based on the RPA risks we have identified. The second part would be to develop an assessment	„[the RPA deployment] means a complete rethink for the area of auditing and data protection. They have to find their way into every [security-	+

			framework around the controls…“ (Raza et al. 2019)	relevant] process.“ O1.1	
C7. Externalize the knowledge of the employees and ensure **continuous knowledge management** across the organisation	(Asatiani et al. 2019)	O1.2, O2.3	„[...] knowledge transfer as a process where local knowledge needs to be first externalized into generalized form, thereby making it transferable across organizational units. In the second step, the knowledge can be taken into use in a different part of the organization by recontextualizing it for the local needs of the setting.“ (Asatiani et al. 2019)	„[...] build an agile, highly dynamic infrastructure by building, reflecting and continuously developing process knowledge [...] this supports the integration of the principles of the processes into regular operational processes, for example continuous process improvement“ O2.3	-
C8. Continuously **ensure high data quality** in prior manual processes	(Romao, M., Costa, J., & Costa, C. J. 2019)	O1.2, O1.3, H1	„[…] the fact that training based on historical data has its own risks (e.g. lack of accurate and low-quality historical data)…“ (Romao, M., Costa, J., & Costa, C. J. 2019)	„An employee can enrich the data, or increase the quality, through active intervention and interpretation of data. And the robots we have in use depend on high data quality.“ O1.3	~

12 Robotic Process Flexibilization in the Term of Crisis: A Case Study of Robotic Process Automation in a Public Health Department

Table 12-1: Fact sheet publication P7

Titel:	Robotic Process Flexibilization in the Term of Crisis: A Case Study of Robotic Process Automation in a Public Health Department
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 30th European Conference on Information Systems
Ranking[1]	**B**
Authors	**Name** Koch, Julian Vollenberg, Caro Matthies, Benjamin Conders André
Status	Accepted
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[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Robotic Process Flexibilization in the Term of Crisis: A Case Study of Robotic Process Automation in a Public Health Department

Abstract

Due to the pandemic, institutions of the health sector, especially public health departments, are facing major challenges in managing their processes. In a constantly changing environment, new and existing processes have to be adopted or implemented in the shortest possible time, while the process volumes to be managed are constantly increasing. In our article, we use a case study to show how the concept of „*flexibility by design*" can be influenced by RPA in the sensitive environment of healthcare and how exactly flexibility in process execution can be achieved with it. As a result, we show that RPA can positively implement or enable three of the six realisation options from the concept. In the article, we identify and show how exactly RPA can complement existing processes in a healthcare environment in this way and thus, serve to subsequently make rigid process models more flexible.

12.1 Introduction

The stability and resilience of business processes in the healthcare sector depend to a large extent on their ability to respond to dynamic changes (Schonenberg et al., 2008; Costa and Godinho Filho, 2016; Helfert, 2009; Ramon Fernandez et al., 2020). Ensuring that business processes can be flexibly adapted in their execution to varying requirements can be seen as a prerequisite for this (Afflerbach et al., 2014; Thuan et al., 2020). The corresponding concept of „*process flexibility*" can be described as „*the ability to deal with both foreseen and unforeseen changes, by varying or adapting those parts of the business process that are affected by them, whilst retaining the essential format of those parts that are not impacted by the variations*" (Schonenberg et al., 2008).

The COVID-19 pandemic demonstrated in a particular way the importance of the flexibility of healthcare organisations and the flexibility of their processes. The pandemic crisis forced healthcare organisations, especially public health departments, to change existing processes as quickly as possible and to introduce completely new processes on short notice, e.g., establishing processes to track chains of infection (Hoppe et al. 2020; Pressgrove 2020; Zimmermann 2021). This had to be achieved in a very dynamic environment, where fast reactions to new and varying requirements (e.g., regarding infection tracking and countermeasures) were necessary. At the same time, as already mentioned, the process volume, as well as its scaling, increased unpredictably. Inflexible organisational structures and the heterogeneous IT infrastructure of public health departments in Germany made it even more difficult to respond quickly to dynamically changing requirements. Ultimately, it was not possible under these circumstances to quickly and regularly redesign processes and ultimately meet the high demands for flexibility. As a result, public health departments increasingly reached their capacity limits (Dedy 2020).

The technology of Robotic Process Automation (RPA) not only provides the prerequisites for automating business processes but also for enabling flexible processes. RPA stands for the partially or fully automated execution of structured use cases in which a software solution (i.e., robot) carries out repetitive, rule-based tasks across functions and applications (see also Section 12.2.3). Due to its automation potentials, RPA is seen as a useful supplement to classic Business Process Management (BPM) and should increasingly be integrated as such (Agostinelli et al. 2020; Flechsig et al. 2019; König et al. 2020; Syed et al. 2020; Willcocks et al. 2015; Willcocks et al. 2017).

However, RPA can be an enabler role in making existing business processes in healthcare more flexible. An example from the research context of this study: Public health departments are responsible for detecting infection chains and subsequently conducting extensive communications to affected individuals. The way of executing this process is, on the one hand, very context-dependent (e.g., data situation), on the other hand, also dependent on frequently varying requirements of the government. Although standard processes exist in data management and communication channels, they do not meet these new requirements and are often not designed for handling the required process volume and frequency, especially when executed manually. Ad hoc changes to organisational structures and IT infrastructure are also not possible as a countermeasure. In this context, RPA offers the possibility to quickly intervene in existing structures and implement cross-system and cross-application routines (e.g., as a bridge between heterogeneous, separate systems such as a classic citizen database and the system for tracking infection chains). The design of alternative and easily adaptable routines is also possible (e.g., for proactive modeling of response paths to foreseen and unforeseen requirements in tracking and communicating infections chains). Therefore, RPA can mimic the flexibility that humans have in using information systems and proactively provide that flexibility for alternative process executions, depending on the required context.

Although combinations of RPA within a BPM environment have already been studied many times (Agostinelli et al. 2020; Flechsig et al. 2019; König et al. 2020; Syed et al. 2020; Willcocks et al. 2015; Willcocks et al. 2017), the possible effects of RPA on the concept of process flexibility and how RPA can realize the flexibility of processes have not yet been researched in depth. For this purpose, the given case of an unpredictable situation with unforeseen needed actions (here: pandemic) in an inflexible environment (here: public health department), enables us to study the flexibilization of existing processes by RPA in a realistic environment. In particular, we want to investigate if and how RPA can support the concept of „*flexibility by design*“ (see Section 12.2.2). Specifically, the question is how existing processes can be made „*flexible*“ in retrospect by „designing“ alternative execution paths in existing process models, from which the most suitable can be selected depending on varying requirements. A concept that we call „*Robotic Process Flexibilization*“. Therefore, we aim at answering the following research question:

RQ: How can RPA support „flexibility by design“ in process environments?

To this end, we conducted a case study in which three types of data were collected: field observations, interviews, and documentation (e.g., project status reports, RPA-development documents, test protocols). Within this case study, we investigated how far a RPA-solution was able to fulfill the six realisation options of process „*flexibility by design*“ according to Schonenberg et al. (2008).

The remainder of this paper proceeds as follows. In Section 12.2, we explain the background and the theoretical aspects regarding this study - process flexibility and RPA. In Section 12.3, we explain the research method we used. In Section 12.4, we present the data analysis and a set of results. In Section 12.5, we discuss and conclude our results with the possible implications for theory and practice that emerge.

12.2 Background

12.2.1 Research Setting

The healthcare sector is generally characterized by the particularly critical and sensitive business processes that must be carried out there. In the operational handling of these business processes related to healthcare services, problems continue to increase due to growing work pressure, work compression, and an increasing investment backlog in digitisation and technology. Moreover, as a result of the pandemic, several new processes arise and have rapidly been introduced, e.g., tracking infection chains by public health departments (Pressgrove 2020; Zimmermann 2021). Given the growing complexity and increasing demands in the healthcare sector, the lack of flexibility of business processes in service provision and the associated administrative processes is of great importance but has not been adequately addressed by academia to date (Legido-Quigley et al., 2020; Ceukelaire and Bodini, 2020; Ayatollahi and Zeraatkar, 2020).

However, in public health institutions, organisational structures and processes are additionally outdated, processes are often done manually by employees, and digitisation has not yet progressed very far (Vollenberg et al. 2021). As a consequence, health departments are reaching their capacity limits in handling the new and their existing operational processes (Ceukelaire and Bodini 2020; Mazzucato and Kattel 2020). As a result, health departments react with an increasing expansion of personnel capacities by hiring new employees (Koch et al. 2021; Mazzucato and Kattel 2020; OECD 2020). With the growing number of employees, the problems of a heterogeneous and separated IT infrastructure as well as inflexible organisational structures in public institutions even increase (Hale et al. 2020; Marabelli et al. 2021; O'Leary 2020). This makes it ultimately more difficult for public health departments to act quickly and flexibly. These circumstances, therefore, offer us the opportunity to explore a case on how to gain process flexibilization by RPA.

12.2.2 Process Flexibility

The need to manage the ever-increasing demands of change is growing (Mejri et al. 2016), not only since the pandemic. Process flexibility enables organisations to deal with change, uncertainty, variation, and evolution in their business operations (Hinkelmann 2016; Reichert and Weber 2012). In line with this, process flexibility can be defined as the ability to variably adapt the execution of business processes to such changing requirements in the external environment (Schonenberg et al. 2008).

The concept of Schonenberg et al. (2008) defines four types of process flexibility:

1. *Flexibility by design*: the ability to incorporate alternative execution paths into a process model at design time.
2. *Flexibility by Deviation*: the ability for a process instance to deviate from the execution path without changing its original process model.
3. *Flexibility by Underspecification*: the ability to execute an incomplete process model at run-time.
4. *Flexibility by Change*: the ability to change a process model at runtime so that the currently executing process instances are migrated to a new process model.

According to our research question, we concentrate on the type of „*flexibility by design*“, as flexibility in processes is to be actively created (i.e., „designed“) through the targeted integration of RPA. „*Flexibility by design*“ describes the modelling of alternative executions in a process model at the [re-]design time of a process. In this way, the most appropriate execution path can be selected from the predefined alternatives by each actor at the runtime of a process. Overall Schonenberg et al. (2008) define six realisation options of process „*flexibility by design*". These six realisation options, in particular, are *Parallelism, Choice, Iteration, Interleaving, Multiple Instances, Cancellation*.

Parallelism describes the opportunity to handle two or more activities in parallel (Russell et al. 2006; Weber et al. 2008). The realisation option *Choice* defines different courses of action regarding a starting point on which the decision to the following action is made (Russell et al. 2006). *Iteration* realizes an execution of a „*task repeatedly*" (Schonenberg et al. 2008). *Interleaving* describes „*the ability to execute each of a set of tasks in any order such that no tasks execute concurrently*" (Schonenberg et al. 2008) and *Multiple Instances* empower an employee to execute several instances of one task at the same time. The realisation option *Cancellation* is the „*ability to withdraw a task from execution now or at any time in the future*" (Schonenberg et al. 2008).

Process flexibility concepts are an important topic for researchers in BPM but have not been studied in conjunction with RPA (Mejri et al. 2016; Thuan et al. 2020). However, such a combination seems to be reasonable, since the prevailing interpretations of process flexibility concepts aim at improving the performance of business processes without requiring a comprehensive redesign of the underlying process model (Hidri et al. 2019; Mejri et al. 2016; Reichert and Weber 2012; Schonenberg et al. 2008). This is exactly what integrating RPA can support as a solution for automating cross-system and cross-organisational routines.

12.2.3 Robotic Process Automation in the Healthcare Sector

RPA can be described as „*a preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution of a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with human exception management*" (IEEE Standards Association 2017).

Put more simply, such software robots mimic human interactions at the user interfaces of information systems, allowing, e.g., data entry and data processing to be automated, as well as cross-system data exchange (van der Aalst et al. 2018a; Vollenberg et al. 2021; Willcocks et al. 2015). Processes with a high number of routine tasks and comparatively high employee involvement offer therefore great potential for automation by RPA (e.g., administrative back-office processes, such as tracking and communicating infection chains) (Asatiani and Penttinen 2016b; Lacity et al. 2015; Plattfaut et al. 2020b; Willcocks et al. 2015).

RPA can also implement comparatively simple, quick-to-implement, and cost-effective solutions for process support without modifying the existing IT infrastructure (Plattfaut and Koch 2021; Scheppler and Weber 2020; Vollenberg et al. 2021). Especially the latter argument can contribute to the flexibilization of processes „*by design*“, i.e., to implementing new alternatives for process execution, even retrospectively. This is because RPA can act as a „*bridge*“ to mimic the flexibility of humans working between information systems (e.g., flexible jumping between applications) or implementing workarounds, but without or making complicated technical adjustments to those same information systems or comprehensively redesigning underlying process models.

The use and benefits of RPA in the healthcare sector have already been researched in different cases and the relevance of using digital automation technologies has risen (Liu et al. 2020b; Ratia et al. 2018; Vollenberg et al. 2021). Especially the current situation of the pandemic has shown in many ways that the support and the discharge of the employees in healthcare by digital technologies have to be faced. In the next years, the use of RPA in healthcare will rise, especially because of the „*heightened need to optimise costs and scarce healthcare resources during the coronavirus pandemic*„ (Gartner 2021). Particularly in the healthcare sector, RPA can bring many advantages to optimise back-office processes due to the still existing manual and paper-based processes, the variable systems, the various stakeholders involved, and the different specifications, regulations, and requirements.

The mentioned advantages of RPA are also relevant in the healthcare sector - e.g. the reduction of repetitive tasks and the increase of efficiency (Ratia et al. 2018). For example, the effort for repetitive tasks of documentation processes in hospitals can be reduced by the use of RPA and free nurses or healthcare staff from tedious work and can therefore increase the time for the work on and with the patient (Vollenberg et al. 2021). Further exemplarily applications of RPA in healthcare are the use for appointment scheduling, where RPA can assist by booking an appointment based on criteria and availabilities of the healthcare staff (Ratia et al. 2018). Another example is the case of compliance warranty - here „*RPA enables healthcare providers to track, document each process step in structured logs files so that the company can comply with external audits*“ (Dilmegani 2020). The healthcare sector and the public healthcare institutions are signed with unstandardized and high amounts of different and non-homogeneous systems (Ågerfalk et al. 2020; Ceukelaire and Bodini 2020; Legido-Quigley et al. 2020). Even though modern technologies such as process mining and artificial intelligence are sufficiently scientifically researched in the context of healthcare, robotic process automation, especially the automation of business and administrative processes, has not yet been sufficiently scientifically considered (Ayatollahi and Zeraatkar 2020; Plattfaut

2019; Ramon Fernandez et al. 2020; Rojas et al. 2016b). In particular, the insights that modern enterprise process management brings, such as flexibility efforts of process design, have not yet been addressed, even against the background of ensuring business process speed - resilience and stability in healthcare, and thus offer room for further research (Ågerfalk et al. 2020; Doyle and Conboy 2020; Legido-Quigley et al. 2020; Marabelli et al. 2021; Mazzucato and Kattel 2020; O'Leary 2020).

12.3 Method

According to our formulated RQ, our research aims to gain an understanding of the potential of RPA technology on the „*flexibility by design*" of business processes. To this end, we used a case study approach. According to Yin (Yin 2013), this approach is most suitable because it allows us to study a novel phenomenon in an appropriate real-life environment, at best using triangulation of different data sources to create profound knowledge. In doing so, a case study is a suitable method for gaining a thorough and detailed understanding of the various influencing, inhibiting, and shaping factors (Yin 2013). In this way, the study of cases studies helps to expand existing theories based on real-life observations (Eisenhardt 1989).

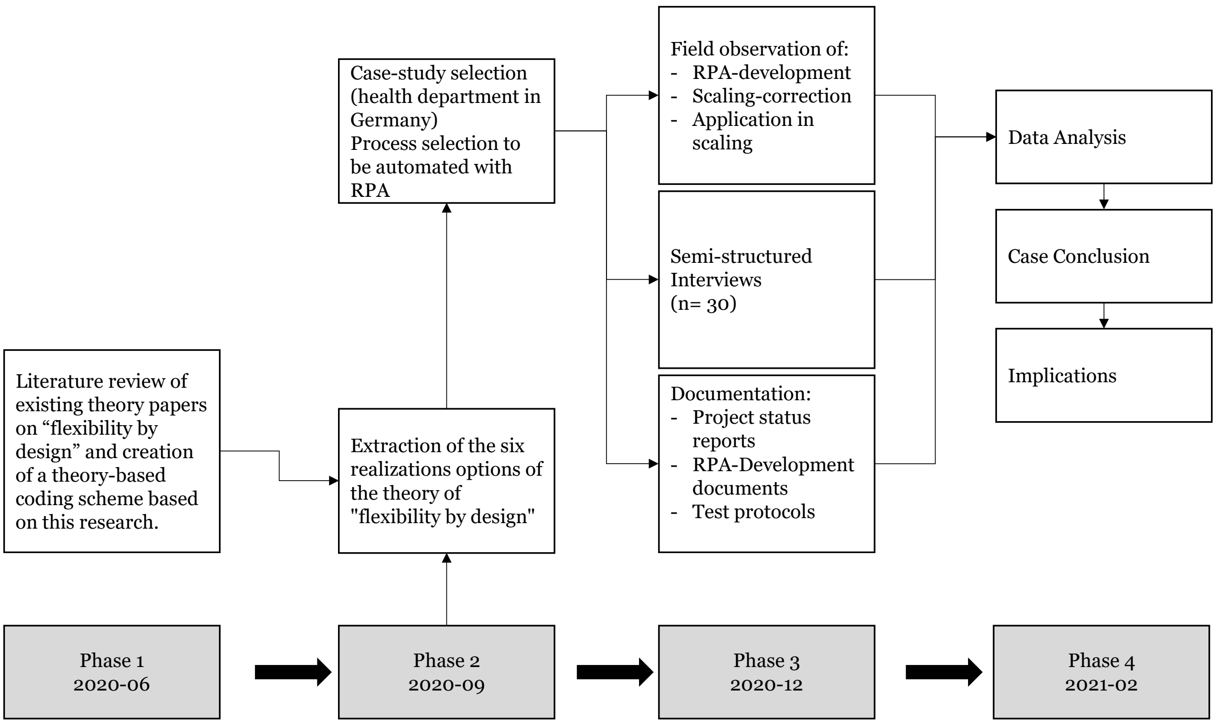

Figure 12-1: Modified Case Study Research Model.

The study presented here was carried out in four phases, as shown in Figure 12-1. Phase 1 was conducted from June to September 2020. In this phase, a literature review of the concept of „*flexibility by design*" was performed. This literature review included the use of the search operators: *flexibility*, flexible*, flexibilization* AND *process* AND concept*, design*, *theory*. As a result, a total of 11 utilizable papers were identified. These address the concept of „*flexibility by design*“ in the context of business processes. From this literature review, following Kelle and Kluge (Kelle and Kluge 1999), an initial theory-driven coding scheme was created for the subsequent qualitative data analysis. The coding scheme included the six realisation options of the „*flexibility by design*“ process, which are: *Parallelism*, *Choice*, *Iteration*, *Interleaving*, *Multiple Instances*, and *Cancellation* (see also Section 12.2.2).

In Phase 2, which ran from September to December 2020, we selected the specific case study in a public health department (see Section 12.4 for details). We then identified, through field observations, suitable existing processes automated by RPA, considering the six flexibility criteria defined in the coding scheme. Phase 3 (December 2020 to February 2021) represents the phase of additional data collection using semi-structured interviews with process participants (i.e., process executors and RPA developers). From February to April 2021 (Phase 4), data analysis took place using the above-mentioned coding scheme. We then summarized the results and implications for theory (see Section 12.4 and 12.5). In this regard, the research we conducted is interpretive and based on extensive empirical data.

This specific case study was chosen because the selected health department had difficulty responding to the substantial increase in the scope and scale of existing processes, as well as very dynamic process changes and the quick introduction of new processes during the pandemic. Typically, qualitative case study approaches, such as the one we use, have small sample sizes, are singular, highly focused, and attempt to explain why an event occurs; here we further enrich our research approach with more flexible data collection (field observations, interviews, and documentation) (Marshall and Rossmann 2016; Runeson and Höst 2009). We conducted the case study in a health department in western Germany that consistently had very high incidence rates and infections since the beginning of the pandemic. Accordingly, the community was continuously classified as a high-risk area. As a public health service, it is the mission and goal of the health department to promote and protect the health of the population. Therefore, it was necessary to increase staff capacity to handle existing and new processes. The given conditions of predefined processes in a heterogeneous environment with constantly changing requirements and conditions gave us the unique opportunity to investigate the potential of RPA on the flexibilization of existing processes. We investigated the potential of RPA as a functional way to automate existing processes and at the same time make them more flexible, so that not only employees are relieved, but also process changes can be carried out faster and more scalable.

Data collection, known as data triangulation, was conducted using four types of data, described below: First, field observations of process execution. Second, field observations of the RPA solution development process, evaluation, and scaling process. Third, conducting semi-structured interviews (n= 30; 23.10h) with participating staff. Fourth, documentation in the form of project status reports, development documentation, acceptance, and test protocols of the RPA solutions. The participants in this study were all clerks (n= 6) of the health department in the municipality where this study was conducted; these clerks could be both process executors or RPA developers in their roles. In addition, part of the research team collected process data from processes optimised by RPA projects with the intention of understanding to what extent the flexibility of existing processes could be supported by RPA. Table 12-2 below shows the data collection, separated by individual collaborators.

Table 12-2: Data sources and associated expert roles.

Designation	Data Sources	Expert's Role
Employee A	Pilot interview (1 x 60 min); Interview (6 x 90 min); Status reports (10); Development documentation (11)	Department manager front office
Employee B	Interview (18 x 30 min); Development documentations (18); Status reports (2); error logs (30)	Back office clerk
Employee C	Pilot interview (1 x 70 min); Status reports (2); error logs (33)	Back office clerk
Employee D	Interview (1 x 90 min); Status reports (1)	Back office clerk
Employee E	Interview (2 x 30 min); Status reports (11); error logs (44)	Back office clerk
Employee F	Interview (1 x 30 min)	Back office clerk

As mentioned above, we conducted 30 in-depth interviews with health department employees. We chose semi-structured in-depth interviews as our primary data collection method because they allowed us to systematically generate new and detailed experiences of RPA development processes as well as their contexts of use. To this end, we developed a common interview protocol that focused on capturing the details of the creation, correction, and use of processes, their goals, the actors involved, the RPA technology used, the associated inputs and outputs, key decision points, etc. Non-leading questions were used to ensure that the responses covered a broad range of respondents' experiences. All interviews were conducted on-site. During the interviews, we asked the interviewees to show relevant documentation, artifacts, or excerpts from actually implemented RPA-solutions as additional input. The interviews were transcribed verbatim, including line-by-line coding and constant comparison. Subsequent coding was conducted using the aforementioned scheme, with statements assigned to the six implementation options of „*flexibility by design*“ (see also Section 12.4).

12.4 Results

We used a coding scheme to analyse the transcribed interviews (employees A-F) using the six realisation options of the „*flexibility by design*“ concept. In addition, the respective process automation solutions were examined, all of which were created and operated using the UiPath software platform.

The automated processes observed originated from the administrative processes of the health department. In particular, quality management processes were examined, such as the creation of deviation reports, as well as the processes of escalation management and central document archiving. In doing so, we could observe under which specific facets RPA can subsequently make existing process designs more flexible.

At the beginning of our study, we found that the redesign of existing processes required adjustments in different system environments, due to the fractured IT infrastructure. This is why the redesign of the processes in this infrastructure was not an option, due to these differences in the prerequisites of the systems as well as the non-transparent process specifications (caused by the pandemic). Furthermore, the originally proposed redesign of existing processes with RPA also did not work for the following three main reasons. On the one hand, the „*setup costs to learn the tool*“ (B), in this „*stressful environment*“ (A), were too high and caused the resistance of employees. Second, the „[test] *duration of new* [RPA] *solutions was too short*“ (B). Thus, the pressure on the employees „*due to the short test duration*“ (A) was also too high. This caused „*many errors*“ (C) so employees ended up being „*more resistant*“ (A). The last reason for the failure of redesigning the processes with RPA was the „*enormous high collection of requirements*“ (C). These requirements „*changed abruptly*“ (A) and „*randomly*“ (C) so that „*only insufficiently good* [RPA] *solutions*“ (E) could be developed. Finally, the failure of completely „*redesigning*“ processes with RPA caused a different approach. Nevertheless, we have observed that this works particularly well, however, for so-called „*ETL* [Extract-Transform-Load]“ processes (A), which operate automatically in the background. ETL processes describe data extraction, data transfer, and data loading from one or more different systems.

To implement flexible processes, however, a solution was needed that proactively considers possible changes in environmental conditions to allow the process to adjust flexibly to all environments that actually occur. Our research identified an approach to generate subsequent flexibilization of the design of processes by an RPA-solution that aligns all environment parameters - a *flexibility layer*. The RPA-based flexibility layer can be understood as a bundle of additional, alternative process sequences that are „*attached*“ to the existing process model (cf. Figure 12-2), but without changing it or making technical modifications to the underlying (fractured) systems. Thus, alternative process variants are offered, from which the appropriate one can be selected depending on the current context (i.e., conditions). RPA enables this by not only mimicking the flexibility of humans in working with information systems (i.e., working flexibly between systems or implementing workarounds) but moreover by automating it.

An example: at a specific process sequence, an existing process requires approval by a specific group of people. How and by whom this approval is to be given is highly context-dependent and varies accordingly (e.g., varying group of people, varying communication channels, varying approval forms). An RPA solution can efficiently implement this variation by implementing this alternative, rule-based approval options (e.g., through cross-system workarounds using, e.g., emails or alternative approval forms) without having to modify the original process model or make changes to the rigid approval system. Another example is the possibility of resolving a conflict of objectives through the RPA-based flexibility layer, namely the preservation of transparency and *explainability* with simultaneous automation of process and process part executions. Healthcare professionals need to maintain full traceability and control over process execution, as they are responsible for the correct transfer, input, and retrieval of the correct data into the various information systems.

With the help of a flexibility layer based on RPA, process execution can be variably adapted to fluctuating exogenous requirements, both retrospectively and on the fly, while being tracked, monitored, managed, and controlled by the individual user. Thus, the RPA solution is only used proactively by employees when certain orders of magnitude are reached, i.e., when the process volume in the documentation and approval process increases by leaps and bounds. Only then do the employees actively use a corresponding RPA solution to support sub-processes such as, for example, within the documentation processes, the additional plausibility check of master data entries, and the associated data extraction, transformation, and transfer between the various information systems used. In this way, the flexibility layer based on RPA technology ensures the scalability of high-volume processes and at the same time the necessary control of the processes for the various stakeholders, especially in a critical area such as healthcare.

As an example, the process „*Change in Covid 19 test plan*“ can be mentioned here. Here, changes that are entered in the information system in the test plan by the corresponding clerk in a semi-structured way as free text are read out by the RPA solution and transferred directly to the billing process and the billing system of the municipality by linking the billing objects contained in the test plan with benefit catalogs and charge tables. The process execution by the RPA solution runs sequentially and can, if desired, be actively triggered depending on the administrator and always confirmed in the final result.

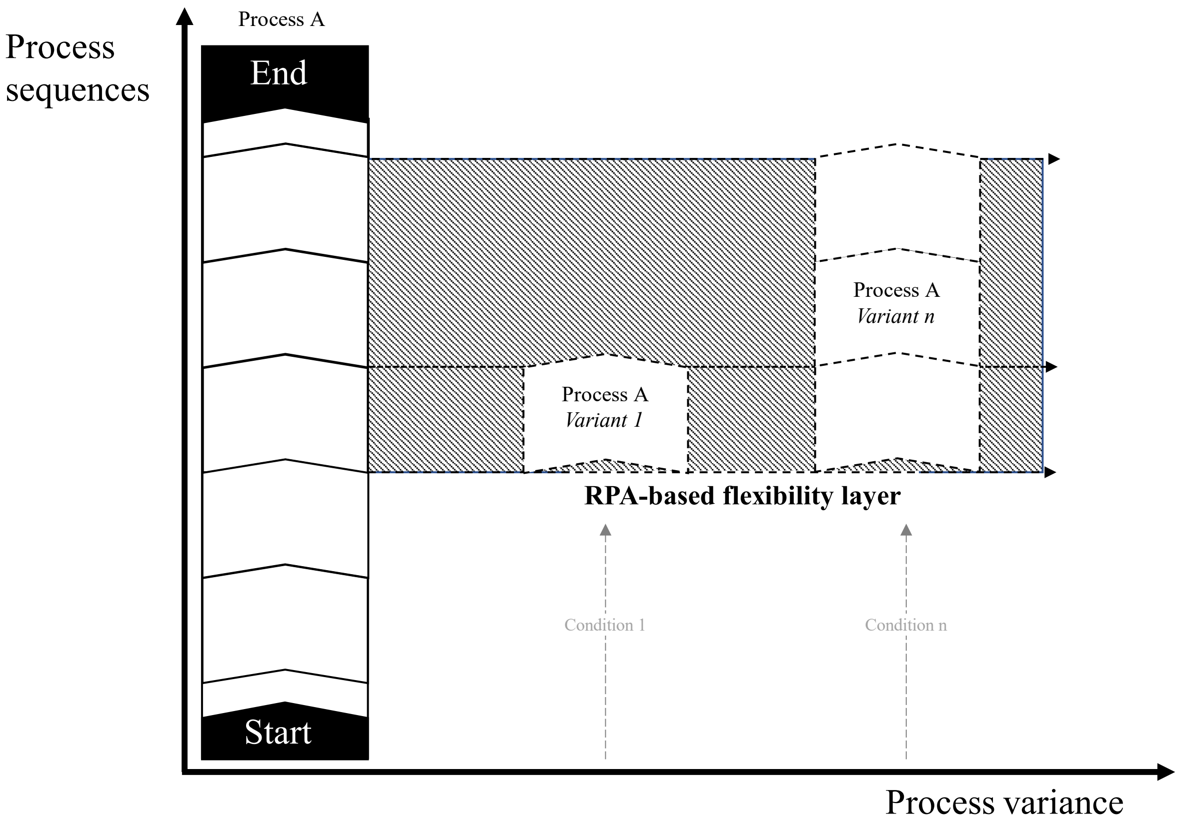

Figure 12-2: RPA-based Flexibility Layer.

We analysed the interviews to determine the extent to which the RPA-based flexibility layer fulfills the six realisation options of process „*flexibility by design*“ (cf. Figure 12-3). Finally, we were able to aggregate the six realisation options to two aggregated theoretical dimensions (see Figure 12-3): *Range* and *Response*. *Range* describes the extent to which a solution can adapt and therefore involves the realisation options *Parallelism* and *Iteration*, while *Response* is the speed at which the solution can adapt and therefore involves the options *Multiple Instances* and *Cancellations*. No relevant influences were found for the *Choice* and *Interleaving* realisation options of process „*flexibility by design*“ in our observations.

In more detail, as shown in Figure 12-3, the approach of the flexibility layer through RPA can realize three 2nd level realisation options of the „*flexibility by design*“ theory, namely *Parallelism*, *Iteration*, and *Multiple instances*. The option *Cancellation* could not be supported.

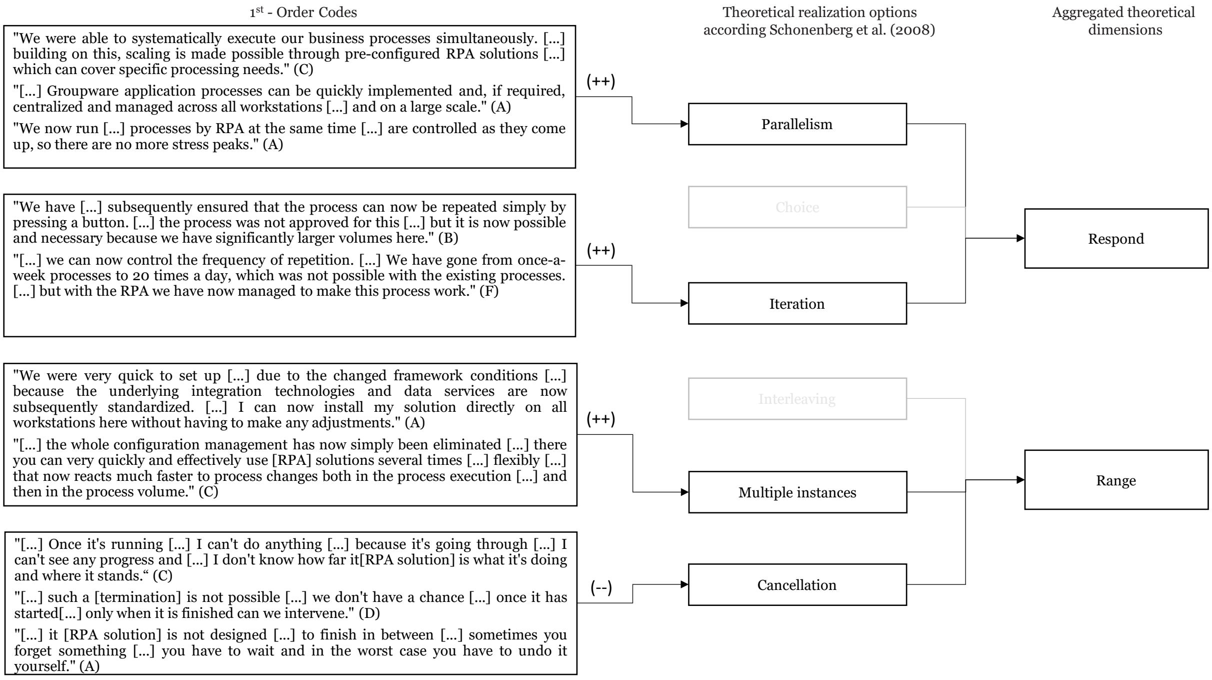

Figure 12-3: RPA-supported flexibility options.

Our results show that the described flexibility layer was „*the main influencing factor*“ (A). We observed that this approach „unifies the IT-based environmental variables“ (D) and thus enables „*flexible introduction, implementation and simultaneous automation*“ (D) of the individual process steps. We were able to show that the existing „*processes can be flexibly modified,* [...] *extended*“ (F) or „*automated*“ (F) by using a flexibility layer based on RPA. This suggests that existing processes can be partially modified retrospectively using RPA to adapt the environment to the existing fixed process model. This largely enables a visible „*fast*“ (A), „*flexible response*“ (F), to sudden changes in the organisation studied. It was also shown that the RPA flexibility layer „*unified dependencies, links*“ (F) and „*configurations for operating system environment variables*“ (F). The flexibility layer homogenizes the „*existing heterogeneous structures*“ (A) and processes can be flexibly „*re-implemented*“ (A), „*extended*“ (E), or even „*replaced*“ (F) without further adjustments.

With specific reference to the six implementation options examined, it became apparent that the flexibility layer by RPA realized *Parallelism* by enabling to run „*processes by RPA at the same time*“ (A). Further, the flexibility layer „ensured that the process can now be repeated simply by pressing a button“ (B) with the „control [of] the frequency of repetition“ (F). This fact realizes the option of *Iteration* of „*flexibility by design*“. With the solution of a flexibility layer, *Multiple instances* of one task can be executed at the same time due to „*the underlying integration technologies and data services* [that] *are now subsequently standardized*“ (A). The realisation option of *Cancellation* was refuted and could not be realized with the flexibility layer by RPA, because the ability to withdraw a task while RPA is running was not realizable. „*Once it's running*" (C) the chance to cancel a task is only given „*when it is finished*" (D). The flexibility layer by RPA „*is not designed* [...] *to finish in-between*" (A).

Overall, our results show that the flexibility layer by RPA can indeed retroactively implement the studied realisation options of process „*flexibility by design*" from the literature, at least in the three realisation options described for an original, fixed process model.

12.5 Conclusion and Discussion

Effective process execution is essential in the sensitive context of the healthcare sector. The motivation of this study was to investigate how this can be supported even in a dynamically changing environment, such as caused by the pandemic. As a solution approach for this, the potentials of RPA for the pragmatic, subsequent flexibilization of processes were evaluated. The study's contributions in this regard are twofold.

First, the case study confirmed that „*flexibility*" can be added to operational processes in health departments retrospectively and at short notice without changing their IT infrastructures. This has proven to be a solution to critical problems arising from the pandemic's dynamically changing challenges. The explication of the concept of the RPA-based flexibility layer is a key contribution in this regard. This concept certainly offers further potential for application and research in the health care sector in the future.

Second, in the course of examining the processes of health departments, specific theoretical contributions are provided for the implementation of RPA as a promoter of the concept of „*flexibility by design*". Our results have shown that the approach of a flexibility layer realized by RPA can fulfill a total of three of the six realization options of process flexibility from theory - namely *Iteration*, *Parallelism*, and *Multiple Instances*. Through the case study, we found out and showed that RPA can be applied as a „*flexibility layer*" to existing outbound processes. RPA applies this flexibility layer to the original processes to unify the requirements and systems, and then to make the existing processes more flexible. So, in the context of the case study we examined, the RPA solutions provided subsequent flexibility to the process design, primarily by automating the ETL portions of the processes that were static in execution but volatile in volume, through RPA, and in the manifestation of this solution can scale to dynamic changes much more efficiently. It could also be found that the often criticized increase in complexity through „*flexibility by design*" (Antunes et al. 2019) can be minimized through its systematic implementation by RPA. According to our research, and in response to the initial research question, RPA thus makes this visible contribution to the theoretical approach of „*flexibility by design*“ of business processes. We, therefore, call this approach, which has been proven to work, „*Robotic Process Flexibilization*“.

Furthermore, the theoretical concept of process flexibility was extended by aggregating two relevant dimensions for successful process flexibilization with RPA solutions: the scope (*Range*) and the speed (*Response*) of adaptation of a process flexibilization. These aggregate dimensions show interesting results for the existing model of design flexibility, as we empirically extended the model by two higher-level stages. The aggregated dimensions *Respond,* and *Range* represent the elementary drivers of business process flexibility from the RPA perspective. Both dimensions are directly dependent on and influenceable by the use of RPA technology. They thus show the possible influence of RPA on existing, established business processes and the possible shaping of „*flexibility*“ within these processes by RPA.

Finally, the downstream flexibilization of existing, mostly static processes with RPA is thereby enabled in a heterogeneous environment with non-standardized and non-uniform environmental conditions as well as with high, constantly, and rapidly changing demands on a process. In summary, our case study research shows that in an environment with constantly changing process requirements, a kind of ad hoc possibility can be created to make existing processes more flexible and at the same time to automate them. In doing so, the research presented here has provided insights into which specific manifestations of process flexibility are influenced by RPA, thereby answering our research question of what impact RPA has on process flexibility.

In this context, existing theories around the „*flexibility by design*“ approach can be usefully supplemented and extended from the RPA perspective. This can then help to mitigate the existing disadvantages of the „*flexibility by design*“ concept, which states that all alternative execution paths must be built into a process model at design time. In this context, we were able to show that these disadvantages can be functionally circumvented with RPA, allowing for subsequent design flexibility.

We were able to show that RPA exploits the fact that not all alternative execution paths have to be created at design time but can be adapted via a flexibility layer. The practical contribution of our research is thus to provide implications for managing very fast-growing process volumes while increasing IT infrastructure complexity. In this sense, the research presented here also makes a valuable contribution to understanding and dealing with very rapidly growing process volumes as IT infrastructure complexity increases. Furthermore, we have made a first value-added contribution to the existing research gap in the field of business process automation (here e.g., by means of RPA) in the healthcare sector by showing to what extent certain specific aspects and framework conditions of the working context in the healthcare sector can be considered. Thus, the flexibilization of business processes in the healthcare sector can lead to added value in terms of flexibility and thus subsequently to the resilience, robustness, and speed of business processes - even under the specific conditions that exist there, such as sensitive process handling with simultaneously very high change resistance of the process designs, high transparency requirements in process handling, volatile process volumes with high susceptibility to external shocks, or insufficient prior IT knowledge on the part of the process executors.

This type of empirical research, however, has inherent limitations in the form of bias in the participant survey and due to the comparatively small number of respondents, processes covered, and organisations studied. Nevertheless, we believe that we have validly investigated the conditions under which implementing the flexibility layer through RPA can be a basis for enabling flexible processes in the short term. To achieve even better generalizability for this, it needs to be explored in more case study organisations. To this end, we plan to work with a health department in a much smaller community (~ 20,000 population) in the future to replicate our findings in this organisational context.

13 The Dark Side of Process Mining. How Identifiable Are Users Despite Technologically Anonymized Data? A Case Study from the Health Sector

Table 13-1: Fact sheet publication P8

Titel:	The Dark Side of Process Mining. How Identifiable Are Users Despite Technologically Anonymized Data? A Case Study from the Health Sector
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 20th International Conference on Business Process Management
Ranking[1]	**C**
Authors	**Name** Koch, Jannis Koch, Julian Vollenberg, Carolin Bade, Friederike Maria Coners, André
Status	Accepted
Full Citation	Koch, Ja.; Koch, Ju.; Vollenberg, C.; Bade F. M.; Coners, A. (2022): The Dark Side of Process Mining. How Identifiable Are Users Despite Technologically Anonymized Data? A Case Study from the Health Sector. In: *Proceedings of the 20th International Conference on Business Process Management*

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

The Dark Side of Process Mining. How Identifiable Are Users Despite Technologically Anonymized Data? A Case Study From the Health Sector

Abstract

Over the past decade, process mining has emerged as a new area of research focused on the analysis of end-to-end processes through the use of event data and novel techniques for process discovery and conformance testing. While the benefits of process mining are widely recognized scientifically, research has increasingly addressed ethical concerns regarding the use of personal data and highly sensitive information that requires privacy protection and compliance with data protection regulations. However, the ethical debate is currently answered exclusively by technical safeguards that lead to the anonymisation of process data. In this ongoing research, we analyse the real-world utility of these process data anonymisation techniques and evaluate their suitability for privacy protection; to this end, we use process mining in a case study to investigate how responsible users and specific user groups can be identified despite technical anonymisation.

13.1 Introduction

Healthcare providers, especially hospitals, are under increasing pressure from policymakers and patient advocates to manage rising healthcare costs while improving the quality of care. The lack of efficiency due to poorly coordinated processes is considered a fundamental problem in achieving cost and quality goals (Mans et al. 2009; van der Aalst et al. 2012d). Since most of the information flow is mapped through the Hospital Information System or occurs „*through informal communication, unsystematic processes, and uncontrolled access to information*“ (van der Aalst 2018b), information deficits can often occur at interfaces. A patient's data must therefore always be recorded and updated in concrete terms so that effort can be reduced, quality increased, and risk reduced.

Process mining has already been successfully applied in healthcare and has helped to provide various insights to improve healthcare processes (Erdogan and Tarhan 2018; Mans et al. 2009). However, the purely administrative processes of healthcare that require exclusively IT-based processing, such as care documentation or billing processes, have so far only been addressed peripherally (Mans et al. 2013; Martin et al. 2020; Rebuge and Ferreira 2012; Rojas et al. 2016). While the benefits of process mining are widely recognized, the scientific community also expresses concerns about the irresponsible use of personal data. Thus, the ethical and legal issues are also of great interest to researchers acutely. It is therefore becoming increasingly important for scientific efforts in this area to address privacy and confidentiality issues in process mining; according to Pika et al. (2020), Grishold et al.(2020a), Mannhardt et al. (2019) or vom Brocke et al (2021), research should also specifically address these issues in the future.

However, the resulting ethical debate has so far been answered and addressed by the use of technical data transformation techniques to anonymize process analysis data (Loxton 2016; Martin et al. 2020; Pika et al. 2020; Rafiei and van der Aalst 2021; Rovani et al. 2015). Therefore, many research and practical efforts have been made in recent years to develop, implement, and integrate appropriate privacy and confidentiality protection techniques in process mining.

However, this consideration of ethical aspects has been treated here still too inadequately and one-sidedly, because on the one hand it only considers the personal data of e.g., patients, but not those of the process executors, and on the other hand it only refers to the measures of data protection and privacy of obvious personal data via usernames.

Our ongoing research starts here and shows that privacy debates beyond the usual personal data are important and need to be part of an ethical discourse. By showing that process mining can provide a way to provide role-based and personal information, e.g., when data has been changed and despite technically anonymized data. Here, we want to clarify to what extent PM can attribute the execution of process steps (deviation from the target process) or the change of data to a specific originator, especially if the identification of the user in the existing system (here: hospital information system) is explicitly technically prevented by the system.

Our research question is the following:

> *RQ: Can PM provide identification of users in explicitly technically anonymized systems and assign errors directly to them?*

The case of a hospital in Germany with a hospital information system presented in this study gave us the unique opportunity to investigate how technically anonymized PM data can be used, despite anonymisation, to identify sources of error among assigned users and thus avoid errors. The data basis used for this purpose was worked out with the responsible persons and users as well as the hospital's ethics committee in an experimental setup, so that no ethical or legal concerns could arise for our research itself.

13.2 Background

The last decade has seen a significant increase in interest in process mining, both in research and in practice (Ghasemi and Amyot 2016). Due to the increasing amount of available event data in the easily accessible information systems of organisations, multiple opportunities arose to analyses and optimise processes using information from these event data (van der Aalst et al. 2012). The goal of process mining is generally to gain a traceable overview of a process, provide insights into a process and the actual process flow, and support improvements (van der Aalst et al. 201; van der Aalst 2018). However, the awareness of privacy issues, and thus the ethical issue of using PM, has increased significantly (Pika et al. 2020; Rafiei and van der Aalst 2021).

Process mining encompasses techniques that are used to analyses and optimise processes. These techniques provide data-driven methods of process analysis that focus on the evaluation and extraction of information from event logs - information stored in IT systems about individual and actual process steps. Event logs store information such as the entity, e.g., a person or device, that performs or triggers an activity. In addition, event logs store timestamps of an event or data items recorded with an event. These event logs may contain direct and indirect identifiers of personal data and may disclose personal data of the user or groups of users. The discussion on disclosing this data is also increasing due to the new General Data Protection Regulation. Through various privacy preserving techniques, original data is anonymized in the event log (Rafiei and van der Aalst 2021).

Already Pika et al. (2020) has analysed and evaluated existing privacy approaches to anonymise process data for process mining. They tested the suitability of three different approaches, confidentiality framework, PRESTA and differential privacy model for event logs. The analysis showed a trade-off between privacy and utility. The methods that maintain higher data utility for process mining purposes (e.g., encryption) do not provide strong privacy protection.

Especially in healthcare, process mining has gained a lot of interest in recent years (Loxton 2016; Mans et al. 2008; Mans et al. 2015; Rojas et al. 2016; Rovani et al. 2015). Hospitals in particular face the challenge of streamlining their processes and the documentation of patient data. The processes in hospitals are characterized by the fact that several departments may be involved in the process of patient care. As a result, problems often arise in obtaining data related to healthcare and hospital processes in particular. This setting therefore offers great potential for the use of PM due to the involvement of different actors, the various systems in place, including the hospital information system, and the huge amount of data and event logs available (Mans et al. 2009; Rovani et al. 2015). However, data security and anonymisation of these data, especially in healthcare, is a high priority and therefore regulated by high standards, laws, and guidelines. In particular, personal data must be anonymized to ensure data security and to protect personal rights. PM can be used to identify and quantify patterns that reflect how users act in processes (Pika et al. 2020). Despite the use of privacy transformation techniques to anonymize data, the use of PM offers the possibility to provide both anonymized and non-anonymized data about user information and thus personal data. However, this also depends on the given conditions of the existing system. It is only possible if the user data is available in the existing information system, only then can PM provide transparency about which process steps are carried out by whom and at what time. Patient and staff identity can be revealed with the help of background knowledge and the event log (Martin et al. 2020; Rafiei and van der Aalst 2021).

Thus, despite technical security measures to anonymize the data, the question should be asked whether the use of PM is ethically correct, as conclusions can still be drawn about patients and staff through the background information on the process. Especially when the process flows in practice often do not correspond to the predefined process models, the weak points can be identified, poor quality, loss of time and higher process costs can be avoided.

13.3 Methodology

To achieve sustainable results in the rather explorative nature of our study, we use a case study approach. Since we want to gain an understanding of the anonymisation and identifiability of users or groups of users in anonymized event logs in case of ethical aspects, as per our formulated RQ, a case study approach according to Yin is most appropriate (Yin 2017). As it allows us to study a phenomenon in a firmly grounded context by using triangulation of different data sources - PM data, field observations, interviews, and documentation - to gain insights, this approach is well suited for our RQ (Yin 2017). The case study method is suitable for gaining a thorough and detailed understanding of factors (such as anonymisation and identifiability in our case) (Yin 2015), and it involves the use of case organisations to proof existing theories of PM anonymisation systems based on empirical evidence. In addition to the primary PM data collected, we use a coding paradigm according to Flick, which we created by analysing the PM data (Flick 2020).

13.3.1 Case Selection

To arrive at a representative selection of objects of study, we deliberately chose a hospital maternity ward in Germany to cover a broad spectrum of particularly sensitive and especially anonymous process data or event logs. In this context, it was key that the users and data originators were informed in advance about the data use and analysis and gave their consent to our research. In our case study presented here, we focus on the data collection process at birth, where the first data of a new life is collected and entered to the Hospital Information System as core data for each newborn. During a hospital stay, however, there are always changes in the master data recognized, which lead to unintentional errors and consequential effects. These irregularly executed processes of master data manipulation ultimately have an extremely negative impact on the performance, conformance, and compliance of process fulfillment within the treatment of the newborn. Further, this also affects the work of the medical staff in the different departments as well as the mother and the newborn. For example, if not all information of the newborn is available after the release from the hospital, examinations must be repeated in the hospital; this means additional work for medical staff, higher financial expenses for the hospital, and an unnecessary burden and stressful process for the young mother and the newborn as well.

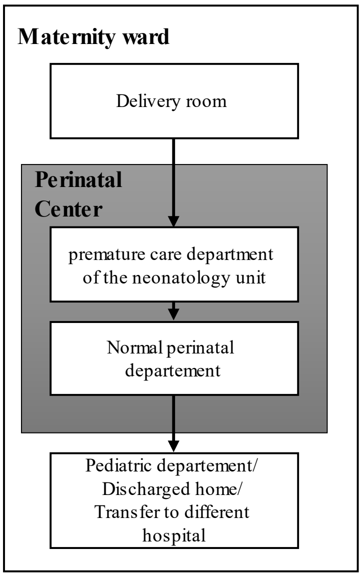

Figure 13-1: The delivery process of a premature child

The treatment of a newborn in the studied maternity ward and the regarded master data process takes into account, among other things, the course of a premature baby from birth in the delivery room to the time of transfer to the normal pediatric ward or discharge from the hospital as demonstrated in Figure 13-1. After the birth of a premature child, the child is initially physically located in the delivery room. After that, the child gets to the premature care department of the neonatology unit. Later it is transferred to the normal perinatal department of the center before the child leaves the center and gets to the pediatric department of the hospital, is being discharged home, or transferred to another hospital.

Because the child and the patient master data are entered, used, and passed through several different departments, the medical staff in the various departments of the hospital, considered in the case study, frequently recognized changes, missing master data or wrong adjustments of the master data and had problems assuming the relevant data, e.g., assigning the premature child, or often had to do extra administrative work by asking other staff to obtain information. Often the staff had to search for patient data because the system does not list the data or incorrect data are listed, e.g., the name of the premature child or the accurate date of birth. In concrete terms, data loss and changes between the individual departments occurred over time again and again. Accordingly, these documentation processes of premature child's master data (e.g., the name of the newborn) and the additional according to data (e.g., the treatments, the parameters of treatment, and continuously raised parameters of the newborn) were selected for our research, by using PM to proof the anonymisation of the user or user groups that are responsible for changes in master data.

Our application of this methodology is summarized in three steps according to van Dongen et al. (2005). In step 1, we defined the scope of the extraction by screening out the granularity of the data and the largest possible observation period as well as associated attributes from the Hospital Information System. This dataset went back a total of 20 months. In step 2, the event logs were analysed by applying process discovery and conformance checking methods with the PM solution *ProM* (van Dongen et al. 2005). In step 3, the discovered process model was evaluated using the measures of fitness, precision, and generalizability proposed by van Dongen et al. (2005). In step 4, these data were anonymised using a common and established technical protection measure within the *ProM* programme package, specifically including all resource names (proper names, usernames, user abbreviations, logins), case IDs and roughly detailed timestamps (months and years).

13.3.2 Data Collection

In our case study, we followed the established approach of Yin and enrich our research approach with more flexible data collection (field observations, 18 interviews, 5 programmer documentations, and 2 data documentations of the Hospital Information System) in addition to the primary PM data (Yin 2017). We collected data of the PM usage to get insights of the documentation process of master data and proof this process by PM in healthcare to avoid errors and extra work and deliver master data right. As semi-structured interviews allow us to gain an understanding of the whole documentation process and the role of PM in this context, we chose this method as our primary data collection. For this purpose, we developed an interview protocol that was largely based on the collected PM data and included, for example, the single-cell process steps and possible deviations or inconsistencies. The collected and analysed PM data thus semantically specified the interview structure used. We collected a total of 340 minutes of interview material, which was transcribed verbatim, and computer coded by two authors according to the methodology of Flick's depth analysis (Flick 2020). The used Interview pool consisted out of 8 Respondents: 3 Nurses, 2 Assistant Doctors, the head of patient management, a staff member of the clinical IT, and an external Application Manager of the Hospital Information System as demonstrated in Table 13-2.

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Table 13-2: Overview of data collection

Participant	Data Scope	Participant’s Role
Respondent 1	(2 x semi-structured interview in total 70 min)	Nurse
Respondent 2	(4 x semi-structured interview in total 60 min)	Nurse
Respondent 3	(1 x semi-structured interview in total 20 min)	Nurse
Respondent 4	(1 x semi-structured interview in total 20 min)	Assistant doctor
Respondent 5	(2 x semi-structured interview in total 30 min)	Assistant doctor
Respondent 6	(6 x semi-structured interview in total 110 min)	Staff member clinical IT systems/interface manager
Respondent 7	(1 x semi-structured interview in total 15 min)	Application Manager Hospital Information System (extern)
Respondent 8	(1 x semi-structured interview in total 15 min)	Head of Patient Management

13.4 Tentative Results

The processes of the Hospital Information System extracted by PM contained 3913 historized complete executions of the examined master data process so far. After reviewing the correctness of our process, we found that in about 17% (n = 661), the master data did not comply with the compliant-process flow and were always changed later than the initial entry. In 71% (n=469) of these error cases, the cause of the error could be assigned to a specific identifiable user or user role by the other users running the process, even though the system had anonymised the data through technical protection measures.

Based on the recorded traces, we have so far been able to determine that the occurrence of these irregular process executions or irregular changes to the master data has certain patterns. In doing so, we assume that we can establish a discernible link between certain execution routines and the erroneous master data manipulations and changes. Based on the recorded traces, we were able to determine that the occurrence of these irregular process executions or irregular changes to the master data exhibited certain patterns. This made it possible to establish a recognizable connection between certain execution routines and the erroneous master data manipulations and changes. This made it possible to identify a user group or in many cases (n=188) even the specific process owner via the corresponding process knowledge of the process owners. This became possible on the basis of the detailed sequence of process steps with the help of PM, in that there the errors in the process were made possible by certain individual process sequences or execution sequences to the individually unique user assignments, and this although only anonymized data were available.

As an example, we present here the process variants identified so far, each of which led to the most frequent manipulations and changes of master data in case study data. This exemplary identified process flow is shown in Figure 13-2 and consists of the following collected process steps.

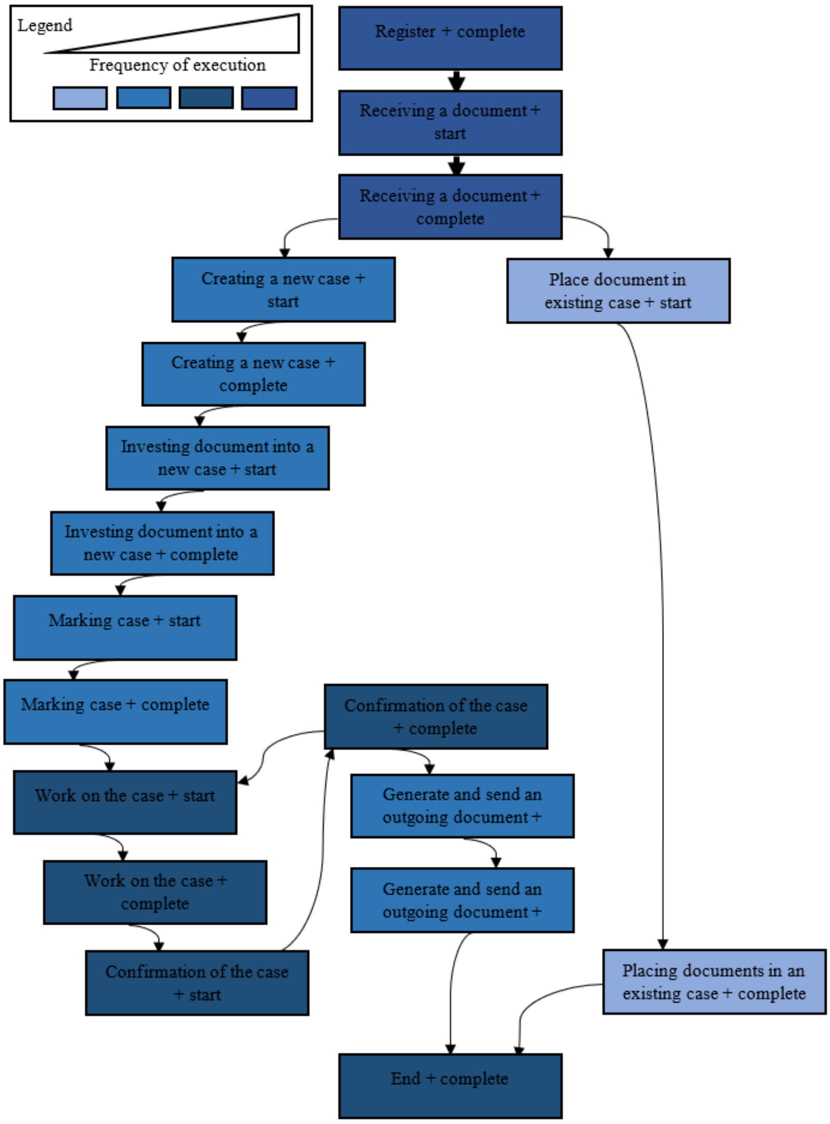

Figure 13-2: Master data process in process mining.

As can be seen in Figure 13-2, certain process steps are executed with different frequencies. This allowed us to directly assign certain sequence combinations and variations to specific users or user roles via certain combinations in the process variance, taking into account process knowledge and by contextualizing the execution variations. For example, internal staff perform the steps in a different sequence than external temporary staff, and Intensive and Aesthesia nurses work through the processes in a different sequence depending on the duty roster and assigned nurse manager.

However, despite ongoing research and only preliminary results, we can already see how avoidable security measures can be circumvented without much effort. For example, despite anonymizing advanced identifiers such as usernames and timestamps to ensure user anonymity, we were able to identify individual users, which raises further scientific questions about how PM should be used in the future and what security measures need to be taken to enable process analysis with PM without violating privacy, data protection, and ethical principles. Considering the fact that PM is becoming more and more important, and thus more widespread, especially in healthcare, our preliminary research results are of great importance for this ethical perspective, which has so far focused on purely technical approaches.

Our findings are of course always limited, since in this work presented here, they are initially restricted to a single case study and the data collected and available there, together with those responsible and the ethics committee. However, we estimate the transferability of the results outside the case study context used here to be very high, since medical procedures, but also information systems, are largely used internationally and must comply with international standards throughout. We also have to assume that other PM technologies and used procedures may provide different results in anonymisation quality, nevertheless, the identifiability of process performers via mere variations and combinations of process flows and steps is of course technically not solvable.

Since this work is only a research-in-process of an overarching research project, we will continue to be able to collect data from other process environments and compare the results and approaches. In this way, we will be able to describe the safeguards and protection concepts that are inherent and widespread in PM in terms of their legal and ethical appropriateness. Based on this, we intend to conduct a Delphi study with legal and ethical experts in the future to empirically investigate and further develop ethical issues in this type of process research.

14 'From nurse to nerd!' How to accelerate eHealth using no-code approaches

Table 14-1: Fact sheet publication P9

Titel:	From nurse to nerd! How to accelerate eHealth using no-code approaches
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 28th Annual European Operations Management Association Conference
Ranking[1]	**n. R.**
Authors	**Name** Koch, Julian Koch, Linette Vollenberg, Carolin Plattfaut, Ralf Coners, André
Status	Published
Full Citation	Koch, J.; Koch, L.; Vollenberg, C.; Plattfaut, R; Coners, A., (2021): 'From Nurse to Nerd!' How to Accelerate eHealth Using No-Code Approaches, In: *Proceedings of the 28th Annual European Operations Management Association Conference*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

From Nurse to Nerd - Robotic Process Automation in the Healthcare Sector

Abstract

This article used case study research to explore the possibility of autonomous development of process automation, by the end user in healthcare. To this end, a qualitative case study was conducted to understand what factors influence the ease of use, intention to use and usefulness of such solutions. The results suggest that in the execution of automation solutions visible transparency and "*explainability*" play a critical role, and that there are clear trends towards smaller automation solutions, rather than the achievement of more complex overall business process integrations.

14.1 Introduction

Not only since the permanent burden of the Covid 19 pandemic has professional nursing been characterized by increasing work pressure, work compression, and growing physical and psychological stress (Burton-Jones et al. 2020; Hege et al. 2020; Konttila et al. 2019). This is accompanied by an increasing investment backlog in digitisation and technologization in the context of care processes (Burton-Jones et al. 2020; Cajander et al. 2020; Klinker et al. 2020).

At the same time, administrative processes are one of the important basic processes for needs-based, quality-oriented, and safe care (Baumann et al. 2018). In the light of increasing complexity and gaining requirements in healthcare, digitisation is very important in the provision of healthcare services and administrative processes. This is particularly true for hospitals. In hospitals, the efforts involved in administrative work and the complexity of documentation increase enormously. Hospital staff spend a lot of time on data entry and transmission (Blum and Müller 2003; Levinson et al. 1997; Ong et al. 1995). Currently, hospital nurses in Germany spend 36 percent of their working time on bureaucratic activities, especially data input and output (Deutscher Ärzteverlag GmbH 2015). Particularly in connection with administrative documentation obligations for patient-related data, high expenses arise and workload is getting higher (Becker et al. 2010). Hospitals are therefore actively seeking digital solutions to provide technical support as far as possible and to automate upstream and downstream processes.

However, there are numerous barriers, such as the lack of empowered staff, the lack of flexibility in volatile processes, or the lack of an infrastructural framework for implementing automation (Cajander et al. 2020; Hege et al. 2020). The scientific discourse describes that the possibility of self-service development of automation, preferably by the end-user, can allow to control the development costs and to deal more dynamically with changes in the overall structure and environment (Cooper et al. 2019). Based on this, our research objects address the following questions to be investigated:

RO1: *Can nurses independently develop RPA-solutions for nursing documentation in the field of critical care?*

RO2: *How is the usability and ease of use of RPA development environments for independent RPA-solution development by nurses evaluated?*

The remainder of this article is organised as follows. First, we present the theoretical background of RPA and the participation of employees in the development of self-service automation. Then, we explain the case study research methodology we used. The sections afterward are organised according to the three phases of the case study methodology. We conclude the paper in the last two sections with the implications for practice and limitations of our research as well as giving an overall conclusion of our main findings.

14.1.1 Robotic Process Automation

Robotic Process Automation (RPA) is a term used to describe software tools that fully or partially automate human activities that are manual, rule-based, and repetitive. RPA works by replicating the actions of an actual human interacting with one or more software applications. The tasks performed may consist of data entry, processing standard transactions, or responding to simple customer service requests (van der Aalst et al. 2018a).These tools look at the screens that employees are looking at today and fill in and update the same fields in the user interface, adding relevant data in the appropriate place (Houy et al. 2019; Kirchmer 2017; Syed et al. 2020; Willcocks et al. 2015).With RPA, an organisation can automate routine tasks quickly and cost-effectively (Plattfaut 2019). RPA frees people from monotonous, low-value-added tasks like data entry tasks, helps increase the quality of output, and it improves speed by finding and retrieving all the necessary data in the background (Asatiani and Penttinen 2016; Koch et al. 2020; Lacity and Willcocks 2016). This makes employees available for higher-value tasks that require human ingenuity, decision-making, and trust (Boulton 2018). The RPA solutions do not change the existing information systems or software infrastructure. RPA bots can easily be integrated with other broader automation initiatives - such as process and decision automation or data collection initiatives - to add value to the automation program (Hofmann et al. 2020; Ivančić et al. 2019; Madakam et al. 2019).

14.1.2 Employee participation

As in many other industries, the transformation of employees from passive to active agents who proactively shape change in their own work environment has become significantly more important in the healthcare industry over the last decade (Garmann-Johnsen et al. 2020; Hege et al. 2020). This has led employees to enter into a dialogue with the organisation and taking on various tasks that were previously the responsibility of the organisation's IT (Hege et al. 2020; Konttila et al. 2019).

Fittingly, RPA technologies are defined as technological interfaces that allow employees to create a solution on their own, without the direct involvement of service staff or IT (D'Onofrio and Meinhardt 2020; Plattfaut 2019). To express the notion of self-service in the context of RPA, there are several terms or concepts in the literature such as „*partial employee*“, „*virtual employee integration*“, „*co-production*“ and „*co-creator*“ (Aguirre and Rodriguez 2017; Hofmann et al. 2020; Syed et al. 2020). RPA technologies can thus be described as new operating models that imply new types of employee interactions and employee touchpoints, and they will play an even more important role in service delivery in the future (Asatiani and Penttinen 2016; Ivančić et al. 2019).

Autonomous employee input is a key success factor in realizing the potential of RPA technologies in the future (Junxiong Gao et al. 2019; van der Aalst et al. 2018a). In response to the increasing role of RPA technologies, researchers have begun to examine the various effects of RPA technologies from either the organisation's perspective or the employee's perspective (Ivančić et al. 2019). Effects from the organisation's perspective include factors such as speed of delivery, accuracy, and alignment with employee preferences, cost reduction, as well as productivity and efficiency gains, and improved competitiveness and market share (Cohen and Rozario 2019; Ivančić et al. 2019; Syed et al. 2020).

From an employee perspective, RPA can provide opportunities to decrease their tedious works and realizes more time for value-added work. However, this is only possible if there is trust in RPA, as well as the good functionality of an RPA solution (Koch and Fedtke 2020). The active involvement of the employee in the development of the RPA solution as well as the understanding of quality aspects and RPA has to be promoted (Aguirre and Rodriguez 2017; Madakam et al. 2019). In these cases, the usability of RPA and the RPA development environment is very important.

This paper takes the perspective of an organisation that offers RPA technologies and self-service development to its employees. In the organisational context, the researchers point to the role of usability. Although issues related to the quality of RPA-solutions, in general, have been discussed in several conceptual and empirical publications, the area of usability has not been explored in detail - especially in the context of healthcare and in hospitals and the development environment of RPA (Garmann-Johnsen et al. 2020; Harris et al. 2019; Hege et al. 2020; Ratia et al. 2015). Usability can be defined as the extent to which a system, product, or service can be used by specific users in a specific context of use to achieve specific goals effectively, efficiently, and satisfactorily (Juristo et al. 2007). It includes several dimensions such as functionality, ease of use, predictability, accessibility, or intuition (Caniato et al. 2018). Research has shown that by using the competencies on the process of the involved employees' usability is rising in each dimension.

Apart from these initial statements confirming the research relevance of the topic, there are research gaps in the area of usability during development and usability during execution of end-user based RPA applications. As RPA technologies become more widespread, usability becomes increasingly important. Previous research emphasizes that inadequate usability can lead to less value in case of the RPA use. The following work, therefore, attempts to fill this research gap by investigating how RPA works as well as the independent development by employees and the usability of RPA development environments can be improved in existing RPA software solutions.

14.2 Research Design

To achieve our research goal, we conducted a multi-case study within 5 intensive care units (ICU) of hospitals in Germany. The case study research method consists of three phases that structure the research process. The first phase, case settings and unit of analysis, refer to the characteristics associated with the design of the case study and the selection and eligibility of the case study participants. The second phase, data collection, refers to the quality of the data collection process, including the choice of methods (qualitative and quantitative). Finally, the third phase, data analysis, deals with the findings from the interviews and the derivation of interpretations as a basis for the evaluation of use and usability.

We believe that case study research is particularly well suited to our problem for two reasons: First, case study research provides the opportunity to analyse the usability and ease of use of RPA development and the use of these RPA solutions in a natural setting, i.e., without control over the process or participants. This allows us to study this contemporary phenomenon in depth. Second, our analysis draws on multiple sources of evidence, as we use both qualitative and quantitative data. Additionally, case study research allows us less prior knowledge than other research methods call for.

14.2.1 Case Setting and unit of analysis (Phase 1)

We conducted a case study in cooperation with a training center for neonatology and intensive care medicine, which is one of the largest specialized facilities for the comprehensive care of life-threateningly ill children, adolescents, and young adults. Through the training centre, we were able to recruit 5 nurses as participants, each of whom worked in different internal medicine facilities in Germany. In addition to basic patient care, the tasks of intensive care nurses include monitoring vital functions as well as performing treatment care, administering medication, assisting with various minor procedures such as inserting a central venous catheter. Intensive care units can therefore be seen as a field of critical care. Inevitably, intensive care also includes IT-supported nursing documentation. The nursing documentation examined is the sum of all nursing-relevant data recorded for a patient, consisting of the nursing process, nursing planning, and service recording. It is regulated in Germany and serves as a memory aid, for communication, and as evidence of nursing interventions performed or not performed. All nursing and therapeutic measures and their effects on the patient are recorded and written down.

The specialized training in anaesthesia and intensive care, which is conducted by the training center, includes theoretical instruction and nursing internships in various ICUs as well as the preparation of a technical paper and allows to take a closer look at a special, nursing-relevant topic. In the context of this training, part of the author team conducted a case study investigation with 5 participating nurses (in different ICUs) in order to record and investigate the usability of the development and use of RPA solutions for nursing documentation processes in different intensive care units in Germany. We conducted a case study from July to November 2020, demonstrating high usability as a key factor in the successful use of IT technology (in this case, RPA) for the nursing documentation processes. Data were collected on an ongoing basis during this period.

With our research objectives we focus on the phenomenon to be investigated: Are there any criteria for usability in the independent development and application of RPA-solutions for nursing documentation? The nursing documentation we studied, especially the IT-based part which had to be automated by RPA, is composed of different building blocks. The nursing staff enters the personal data of the person in need of care into a documentation system. In addition to name, address, and health insurance affiliation, the contact data of relatives is also recorded or taken from other software solutions, such as information on the patient's medical history. Based on the documentation of the family doctor or therapist on previous illnesses, the current diagnosis and the intake of medication are transferred from other electronic documents into the nursing documentation system. Besides detailed nursing reports as an electronic document that must be transferred, the known risk factors or isolated information on planned nursing activities, a detailed daily and weekly structure, and any rehabilitation measures that necessarily must be noted. At regular intervals, the data are transferred to the nursing report systems by the responsible nursing staff and compiled. These were structured differently in our case study, either in the form of a nursing diary system or only as a continuous text or Excel document.

Accordingly, these documentation processes were selected as the focus for our research on independent development and usage of RPA. Three procedures for the development and usage of RPA-solutions for each of the processes were focused on:

The first procedure was the development of an automated data entry to create a Nursing Minimum Data Set (NMDS) in a system for standardized collection of basic nursing data. This contains all the data required by law to be collected from a patient. The RPA development was done independently by the nurse without the presence and support of an RPA professional (referred to as procedure 1, unassisted RPA development).

The second process was the RPA development by the nurse, as in procedure 1, but with the assistance of an RPA specialist (referred to as procedure 2, assisted RPA development). The third procedure involved the full automation by an RPA specialist and subsequent usage by a nurse (referred to as procedure 3, nurse use only).

To ensure valid results and to create the organisational conditions in the pilot, procedure 1 was conducted in hospitals 1, 2, and 3, and procedure 2 was conducted in hospitals 4 and 5. Procedure 3 was conducted in all five clinics to provide a basis for comparison.

14.2.2 Data Collection (Phase 2)

To obtain a more comprehensive picture of the phenomenon of interest, the relevant literature recommends the use of multiple sources to study the unit of analysis (Buse et al. 2011; Kitchenham et al. 2002).

We conducted an unstructured, in-depth interview with n = 5 intensive care nurses. Each of the ICU nurses worked in a different hospital, so we ended up studying 5 different ICUs. The goal was to gain insights into the nurses' view of the usability and ease of use of the developed RPA-solution for the three different documentation processes (cf. procedure 1-3). Since the nurses must work with the data entered by the RPA-solution and are responsible for the correct determination of the nursing data, it seemed crucial to let them assess the usability of the different RPA-generated data sets. The interviews had an average length of 30 minutes and were conducted from August 2020 to November 2020.

14.3 Data Analysis and Results (Phase 3)

During the study period, 17 RPA-solutions were developed independently by nurses using RPA, with an average of only 3 process steps within the RPA solutions (cf. procedure 1 and procedure 2). Also, 8 RPA-solutions were developed by the RPA specialist (cf. procedure 3). During the project, it was found that the RPA application performed the IT-based nursing documentation process in a more time-efficient manner: Time savings (measured as effort per nurse) compared to the traditional process of data entry by a nurse was up to 70%. Regarding RO1, we can affirm that nurses can independently develop RPA-solutions for nursing documentation, but we could recognize that they are, however, associated with limitations and fulfilment of certain frameworks. Our results first show that the participating nurses selected the same nursing process types for automation. These were the processes of extracting and compiling raw data, possible textual data transformations such as exchanging first and last names and transferring to a target system such as another documentation system. Archiving processes such as document creation and storage were also selected by all nurses. The selection was characterized by the fact that all nurses chose processes where they „[...] *often make mistakes*“ (interviewee 2), „[...] *forget to do it*“ (interviewee 3) or felt *„[...] that the others have already done it*“ (interviewee 5).Concerning our RO2 and the usability and ease of use of RPA development environments, we examined the following results. None of the participants use the scripting language provided by the RPA development environment, which is „[...] *too complicated*“ (interviewee 1) and „[...] *rather discourages*“ (interviewee 2), to use the RPA technology at all „[...] *if you see something like that (program code) already*“ (interviewee 3). Without exception, all participants work with the so-called desktop recorder function of the RPA environment. The recorder makes it possible to automatically record mouse movements of the user interface and keyboard activities to generate automation scripts from them without having to do any programming themselves. Only small parts of processes were automated, involving only 2-5 process steps; larger processes were „[...] *too difficult to do because something always goes wrong*“ and „[...] *incomprehensible errors occur*“ (interviewee 4).

Our data analysis resulted in the criteria of „*process suitability*“ and „*added value of automation*“ taken from the literature (Asatiani and Penttinen 2016; Syed et al. 2020; van der Aalst et al. 2018a; Willcocks et al. 2017) were only very marginal, almost negligible, rather the main criterion was only the „implementation effort“ of the RPA-solutions. A new sub-criterion emerged that we were not aware of, which we called „*understandability*“. Here, „*explainability*“ of the RPA-solution was increasingly addressed, such as „*[...] the robot runs too fast, but I always have to look at what it is doing [...] that goes too fast for me, it should do it slower“* (interviewee 2). It became clear that they „*[...] don't want to use it if [they] don't understand it*“ (interviewee 1) and „*[....] you don't understand it because it goes so fast*“ (interviewee 4). Therefore, the RPA solution was artificially slowed down by the RPA specialist, which then resulted in the RPA solution „*[...] running more understandably for all of us*“ (interviewee 1). It was also mentioned that collaborative RPA solutions often had the problem that they *„[...] were not properly documented during a project*“ (interviewee 2) and that this often led to „*[...] confusion and uncertainty about further use when this (RPA-solution) suddenly looks different again*“ (interviewee 3). However, the simplicity with which the development of RPA-solutions could have been done in the RPA development environment provided in this case study also caused a rise of RPA-solutions. The number of developed RPA-solutions increased unnecessarily significantly, which in no way formally relieved the documentation processes investigated, but rather placed an additional burden on them.

Implications and Limitations

The focus of this work was on the employee-centric development of RPA-solutions. From a practical perspective, the results presented have implications for the providers of RPA development environments. To target group suitability, our work provides valuable insights that can be summarized under the term „*Explainable RPA*“. Here, not only the self-explanatory visual development of RPA solutions is important, i.e., that users do not write program code but use standardized visual modules, but also that the execution of these solutions is still explainable and comprehensible. Also, problems frequently arose in the RPA projects studied due to the lack of transparency of changes to the RPA-solution. RPA-solutions invite users to quickly make changes to the solution themselves. However, when end users make changes themselves, they often do not know how these changes affect other users of the solution and in the process. For this very reason, standard processes for making changes to RPA solutions must be created to document them in detail and create transparency between the different users of the RPA-solution.

Among the limitations of this study, of course, is that the results may not be generalizable because only a small number of participants (n = 5) were studied for each of the five organisations. Also, we used only a single representative software development environment to derive our criteria; further pluralistic research will be conducted here in the future to obtain more valid conclusions. The use of perceptions through participant interviews always carries with it the limitation of strong subjectivity by them.

14.4 Conclusion

Within our research objectives, we were interested in learning where the participants experience usability issues with the development and usage of RPA-solution. In this case, we conducted a sub-survey. We involved the nursing staff in the phase of formulation of necessary usability by independent development of RPA-solution to find possible criteria. For this purpose, we went through different procedures of the development of RPA-solutions (cf. procedure 1-3) in the case study to see how which criteria of usability of the development environment affect the nurses' intention and ability to develop an RPA-solution. In our case, we found that the investigated usability of the RPA development capabilities affects in two different ways. On the one hand, usability is strongly influenced by the „*explainability*" of the developed RPA-solutions. Caregivers move from a passive role to an active role in the processes. As the nurse is responsible e.g., how data is transmitted and entered, by developing and implementing RPA-solutions themselves to improve their system environment, they ask for traceability and control possibilities of the RPA-solutions. All participants indicated that the obstacles they encountered were related to explaining and understanding the program flow of the RPA-solution. On the other hand, even the presentation of the simplest script code was very daunting to the nurses, even if it is only presented sporadically, in an additional explanatory context, and without intersections or actual touchpoints. Further research should also address the detected increasing number of RPA-solutions, which were not necessary and complicated the whole documentation process itself but led to simplicity in the use of the software for the nurses.

15 'Mirror, Mirror, on the Wall': Robotic Process Automation Using a Digital Twin

Table 15-1: Fact sheet publication P10

Titel:	'Mirror, Mirror, on the Wall': Robotic Process Automation Using a Digital Twin
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 28th European Conference on Information Systems (ECIS), Marrakesh, Morocco
Ranking[1]	**B**
Authors	**Name** Koch, Julian Trampler, Michael Kregel, Ingo Coners, André
Status	Published
Full Citation	Koch, J.; Trampler, M.; Kregel, I.; Coners, A. (2020): 'Mirror, Mirror, on the Wall': Robotic Process Automation Using a Digital Twin. In: *Proceedings of the 28th European Conference on Information Systems*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

'Mirror, Mirror, on the Wall': Robotic Process Automation in the Public Sector Using a Digital Twin

Abstract

We transfer the core philosophy and methodological approach that the digital factory has brought us to automate business processes based on robotic process automation (RPA) technology. We investigate the transformation and adaptation of specific planning tools from the ideas of a digital twin, which is a virtual representation of a physical product or system and has its origins in the engineering sciences. This should enable us to realize an integrated business process based on a digital twin. The digital twin therefore forms the basis for the conception and development of RPA. This article describes findings from the application of digital twins for RPA development. This is based on a case study of public administration. As a result, the case's processes are examined and thus the real procedures are discovered and analysed with its interactions and logical links. This can provide an orientation for developers, employees and researchers and allows further research.

15.1 Introduction

Organisations use information technology (IT) to improve efficiency and effectiveness of their business processes and, thus, of their value creation for customers. Automating businesses processes is one of this means (van der Aalst et al. 2018). In the past, process automation often came with complex and difficult to change legacy systems. This reflected in high costs, the lack of flexibility to add new innovations, and mostly vertical information silos. These characteristics can be understood as heavy-weight IT (Bygstad 2017; Ovrelid and Halverson 2018). In contrast, Robotic Process Automation (RPA) is a technology that allows a comparably easy development of computer programs (i.e., bots) that automate digitalized business processes through the usage of graphical user interfaces (GUI, Lacity and Willcocks 2016). These solutions can be understood as light-weight IT (Bygstad 2017; Ovrelid and Halverson 2018). While the development of these bots is reported to be less complex, it still requires substantial resources. Lacity and Willcocks (2016) report on 5 ways to source RPA capacity with outsourcing being an integral part of 3 of these ways. However, as RPA builds upon existing core systems, outsourced development still requires access to these core systems.

The IT architecture of the target system needs extensive requirements for safety instructions, server capacity and dependencies to the RPA software. With our case study research, it is possible to outsource an RPA bot without using these dependencies. Artificial intelligence (AI) in combination with the RPA technology makes the outsourcing process faster and more efficient (Madakam et al. 2019). Furthermore, authorisation concepts to comply with data protection reporting lines are no longer necessary and provide a solution that enables outsourcing providers to create RPA bots without having direct system access. This can be generalized to other light-weight IT solutions (Osmundsen et al. 2019).

With our case study in public administration we followed the most common research approach for such issues according to Yin (2017). Digitalisation is one of the major topics in the public sector for many years now. Citizens expect easy communication via convenient electronic channels, a high response speed including status updates and fast processing times. The status quo is far away from digital administration and the implementation cannot be achieved by the human resources alone. Employees are struggling with inefficient work and an increasing flood of data. Therefore, a new approach is required that can contribute to an optimisation of processes and reduction of citizen workload. For this purpose, processes must be automated and development processes accelerated.

In engineering, the term „*digital twin*“ refers to the transformation of a physical construction into a digital image, for example into a CAD model. In our case, the image is not generated from a physical construction, but rather from a digital user process in an application. The bot represents the correlation between the user input and the automation into a digital process. So, it is possible to mirror the system input into a digital twin which use RPA. This image is recognized by an AI algorithm and applied to the original system. This process is shown in Fig 1. With the help of digital twins, RPA bots are developed by an outsourcing provider. When the bot is transferred to the customer, the RPA software uses an RPA-supported machine vision solution to automatically recognize the GUI masks and make the corresponding mapping. Thus, even process steps with minor differences in the GUI replication or GUI remodeling are correctly identified, classified and then processed.

The concept is based on the digital twin idea. The digital twin is a virtual representation of a product, simulation or service. The special procedure of digital twin creation for automation outsourcing is realized as a prototype. Digital twins are used in product development in various industries, primarily during early phases of the development process. They can be defined as a scale or full-sized format model and used to demonstrate and evaluate the functionality of a design (Limbuddha-Augsorn and Sahachaisaree 2010). They facilitate interaction between all participants of the product development process. Therefore, they enable a visual and tactile feel for the product concept which reduces uncertainties and misunderstandings about the product to be developed (Schlecht and Yand 2014).

There are already numerous studies on first-time RPA implementation. These usually deal with different aspects of RPA project success. These studies can be divided into success factors (Asatiani and Penttinen, 2016; Cooper et al., 2019; Lucija Ivančić et al., 2019) and success criteria (Andres Jimenez-Ramirez et al., 2019; Kedziora and Kiviranta, 2018; Santiago Aguirre and Alejandro Rodriguez, 2017). In contrast, there are currently no studies that focus on the application and use of a Digital Twin concept and present case studies. There is therefore a strong interest in understanding what contributes to the success of such a project and which steps are applied. Taking this into account, we formulated the following research questions:

RQ1: *What does a development process for RPA solution based on digital twins look like and how are development phases defined there?*

RQ2: *How can these development processes be recorded in a structured way?*

RQ3: *Is the presented approach of a Digital Twins for RPA development possible and sensible to use?*

This study is part of an ongoing research project and aims to provide initial answers to these questions. In this paper, the case study of a large German city is presented regarding its procedure for the development of automation solutions based on RPA. This explorative case study is intended to be a first step towards a better understanding of this topic and to provide information for further confirmation studies.

We developed a digital automation of an administrative process in cooperation with the IT department, without having access to the IT systems over a longer period. The digital process was transformed into a digital twin in accordance with our RQ1. The captured process flow enabled the creation of an RPA bot offsite and without accessing the user's IT systems. This iterative process flow is illustrated schematically in Figure 15-1. This was intended to protect internal IT resources and keep IT risks, e.g. in data protection or IT security, as low as possible. Through our observation, we were able to divide the digital twin approach into four stages. As shown in Figure 15-1, the requirements of an automation solution are met more precisely with each stage and the real process is better supported. The concept not only transfers methods from the engineering sciences to the

IT sector, but also combines the development of business process automation with an outsourcing philosophy, which opens a new research approach.

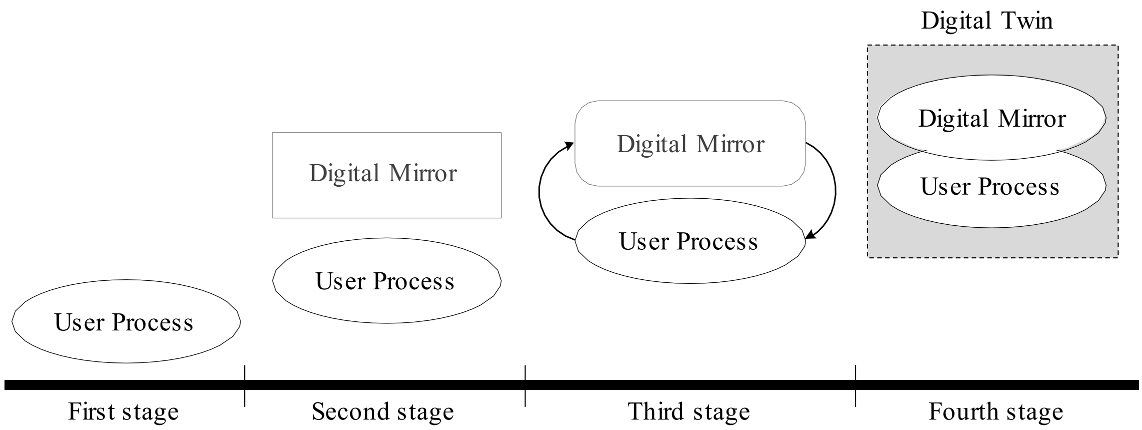

Figure 15-1: Proposed digital twin stage model

In our research, the digital twin can be used to mirror business processes consisting of objects and systems as software representations on a digital layer - including ongoing updates, continuous optimisations and adjustments. So, the representation provides all process steps in form of GUI, which are used by the developer for automation with RPA. After this GUI have been delivered, an external IT team can carry out most of the automation work independently, before all that remains is to replace the placeholders and connect the automation solution to the real system, i.e. for implementation in an RPA-based workflow.

15.2 Related Work

Shorter product development times and concurrently minimal developments costs are major challenges in the industry (Uhlemann et al. 2017). It has proven useful to work with digital models instead of real prototypes. Such digital models are called digital twins. digital twins are computer-generated (digital) models or simulations, the appearance of which can be and/or functionalities of products to be developed (Schiavullo 2019). So, it is possible to virtualize almost everything without limits: from the machine to the factory, from the car and its driving characteristics to entire cities - everything can be captured by computer and reproduced virtually (Kritzinger et al. 2018). Developers can modify functions, test new settings and calculate complex simulations at a fraction of the cost of conventional methods. digital twins can also be used only as graphical replicas (Tao et al. 2018). The use of a simulation tool such as digital twins enables in addition to the reduction of the time and money expenditure, higher product quality and improved security (Sato et al. 2018).

Product information is regularly stored in a database as an information exchange medium so that all other employees involved in product development can access the latest information. This procedure - in the sense of Simultaneous Engineering - enables processes to be more closely parallelized, so that product optimisation can be carried out earlier than before or errors in the model can be detected ahead of time. The testing of a prototype or sample construction of a later product, if possible, in original size, starts later than before in the development process (Uhlemann et al. 2017). Since the components in the digital twins have been tested very precisely using calculation and simulation methods, the physical components already have a very high degree of maturity at the beginning of their testing (Zhang and Li 2013). This significantly shortens the development time of a product and thus the time it takes for the product to reach the market. The use of digital twins in the product development phase requires the consistent use of computers in order to significantly reduce the costs for physical prototypes. The focus, however, is on the qualitative aspect through the early and interdisciplinary use of digital twins for geometric, functional and production-related validation (Schleicht et al. 2017) This allows meaningful results, e.g. assembly and crash simulations, to be achieved at an early stage without hardware safeguards (Yun et al. 2017). The use of digital twins is associated with corresponding costs for hardware and software and in addition often requires an adjustment of processes and organisational forms - the ability of employees to work together in teams or permanently is required (Schneider et al. 2009).

15.3 Research Design

To achieve sustainable results in the more explorative character of our study, we use a case study approach (Gibbert et al. 2008; Walsham 1995; de Sousa et al. 2019; Berryhill et al. 2019; Sun and Medaglia 2019). To illustrate the difference in the capabilities required for the use of digital twin-based RPA applications, we go into more detail. The observations described below are also from interviews. This research examines how the capabilities to develop an RPA-based application within a digital twin approach evolve over time. To answer our research questions, the research method was structured into the following three components:

First, the dynamic RPA development capabilities that existed within the case study organisation are identified.

Second, the capabilities are outlined and categorized into their respective levels and their development capabilities within digital twin approaches.

Third, how and how quickly the capabilities were implemented in an RPA application in which the digital twin principle was applied. In the present case study, however, the focus is on the digital twin approach and how it synchronizes with the technology governance requirements of the entire IT organisation. We examine the scalable architectures, the possibility, the capabilities for reusability, and the flexibility of digital twin based on-site deployment. We examine the extent to which case handlers can exert control over application testing, quality, and performance metrics while integrating a solution with RPA techniques.

The research team monitored the RPA development throughout the whole period. This is shown in more detail in Table 15-2, broken down by method and associated expert role. They collected weekly status reports and version management data on RPA development progress and many other documents covering the time period of August 2018 - September 2019. The weekly development reports included information about the state of the RPA application, milestones and capabilities fulfilled for that week, performance tracking, project utilisation rate, project on-time delivery, project scheduling, project resources. The Employee satisfaction survey was also part of the data collection.

The team also conducted 41 in-depth semi-structured interviews, as illustrated in Table 15-2, consisting of: a pilot; (length approx. 130 minutes; 2 respondents); 12 individual interviews (90 minutes; 2 respondents per interview); 27 interim findings interviews to consolidate and validate preliminary results (30 minutes; 1 respondent); and a final follow-up interview with documentation review. The interviews were semi-structured to allow free flow discovery of information and interactive analysis at the same time.

Table 15-2: Data sources and associated expert roles

#	Data Sources	Expert's Role
Employee A	Pilot interview (1x 60min); Interview (6 x 90min); Status reports; Records of the changes	Department manager front office
Employee B	Default logs; Interview (18x 30min); Records of the changes; Archive of the individual states of a project	Back-office clerk
Employee C	Pilot interview (1x 70min); Default logs; Version management data	Administrator Front Office
Employee D	Interview (3 x 90min); Status reports	Administrator Front Office
Employee E	Default logs; Interview (9x 30min)	Back-office clerk

In response to our RQ2, the research team has studied each level of RPA development in detail. The monthly determination of measurable success / benefit criteria showed the process of the development stage of the individual subjects. Using the project portfolio management and social collaboration software used in conjunction with the version management system, we examined the individual RPA development process within the digital twin environments. We used the Default Log, the RPA software solution's integrated execution and diagnostic log, which is generated each time a robot is executed. It contains time stamps, activity names, types, variable names, arguments, etc. The interviews were carried out with the respective employees who supported the first analysis. Finally, the document analysis of the version control system revealed the development of the capabilities beyond the actual deployment of the first applications.

15.4 Findings and Analysis

In our case study it emerged that from an organisational point of view, a digital twin approach promises advantages over previous development models or a process-owner solution. First experiences, in the case study, with the implementation of a complex business process automation solution based on the digital twin concept showed that such an implemented solution could significantly reduce specific development times. It also showed that the missing harmonisation of business processes across different organisational units, value creation levels and the local separation through the digital twin approach resulted in several disadvantages.

In our introductory interviews, we first asked the RPA developers about their understandings of the process and the perceived transparency. In our interviews, it became clear that the RPA developers had no knowledge of the employees or process managers. The question of who would carry out the processes based on their individual abilities could in no case be answered by the developers.

The RPA developers were not informed about the further process and system intersections. In the interviews, they did not have any knowledge of the real IT infrastructure in the public administration; questions such as how the processes could be technologically supported could therefore not be answered by the RPA developers. According to the case study, the digital twin approach prevents the actual process optimisation and process reengineering, as the interview shows that there is no knowing how the actual process performance is measured and controlled. Also, the RPA developers obviously knew nothing about the actual process responsibility of the process to be automated, which meant that in the case study they had no knowledge about who was responsible for the process and outcomes.

A status quo survey of the current process design was also carried out, followed by a detailed evaluation. This was used to determine target/actual deviations and to identify deficiencies and weaknesses in the implementation and search for their causes. It also became clear that the digital twin approach resulted in no knowledge of the value chain in the process. It is evident that RPA solutions created in this way are generally less powerful than conventionally developed solutions. In the case study, the RPA solutions were created process oriented. The software developer defines rules for the behavior of the bot in the virtual environment. The rules become active when the RPA solutions run through virtual trigger points in the process simulation. The Process flows could thus be efficiently implemented in the case study and the programming effort for the individual RPA solutions was considerably reduced.

The result presents a concept for the development of RPA applications using a digital twin. In our case study, the digital twin provides a lever to quickly align administrative functions, administrative units and operations. The digital twin approach does not initially require a based process knowledge or the correct selection and adjustment of the supporting systems.

After each interview, a process diagram of the development process was compiled. The process diagram shows the essential processes of the RPA developers and their connections & interactions visually. The focus lies on the illustration of the real activities in the executed order and everything that is done to fulfil them. This resulted in a diagram that helped to organise the responsibilities and cooperation in a process-oriented way by structuring the processes appropriately.

In the next step, the information in the chart was further broken down and presented in two workshops in September. For each process, the individual sub-processes were defined and examined. The results were supplemented visually in the diagram. As a result, it was possible to see at a glance how the digital twin approach really works.

In the workshops, development processes were compared with practices used in the respective literature. These showed not only organisational adjustment possibilities, but also illustrated in simple process illustrations which tools, feedback and coordination activities make sense at which stages.

For our diagram, we have outlined some processes roughly, we speak of an approximate scale, while others are very detailed. Our diagram shows the processes and thus the real proceeding of the case study of the digital twin approach in a public administration graphically arranged. It can be used as a guide by developers, employees and researchers. The approach is illustrated with the interactions and logistic links.

After collecting the data, we created a user-centric creation flow (Figure 15-2) to the captured development process to formally map the individual phases within the RPA development process that the user goes through when developing RPA solutions. With this development process we were able to map the captured Digital Twin development process.

The design we created is based on the interviews and data collected using execution and diagnostic protocols. The design starts with the recognition and identification of the development steps of the users from the interviews. It is then important to first understand and specify the development-specific requirements and then the context of use (Yin 2017; Creswell and Creswell 2017. This conceptual representation was then presented to the creators and users so that they could give a detailed comment. With the additional data we can collect new steps in the development process and integrate them into the originally created concepts, so that a loop in the process is created until the concept is valid enough. Thus, we have created all the prerequisites to outline a creation process. After evaluating this solution, we worked with users and developers to create the visual image of the development process shown in Figure 15-2.

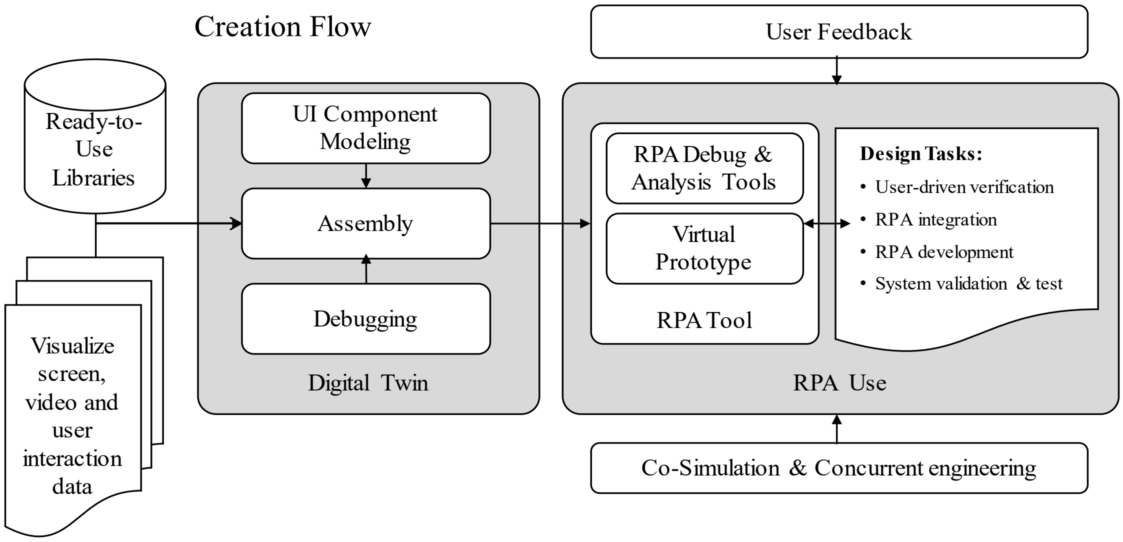

Figure 15-2: Case study's process diagram

The approaches described in the previous sections, consisting of development logs, versioning data, project status reports and interviews based on them, are mainly used to combine high-level information into a process creation log. This is intended to be a tool for us to get an additional overview of the process execution and to better validate the different process variables.

Within workshops, we then analysed to what extent the process flow recorded to date corresponds to the process flow of the development process that we surveyed. For this purpose, we have identified in the interview's parts of the process where the protocol does not match and the process instances that are different. To answer our RQ2, a process verification is also performed, i.e., whether the actual execution corresponds to the previously defined and presented sequence in the development process.

The projects with a digital twin approach are considered by the respondents in our case study to be most suitable for the development of systems with low back-end content (Employee D) and low complexity and high front-end interactivity (Employee B). The applicability of projects with a digital twin approach should therefore be excluded for large infrastructure projects such as company-wide database systems (Employee C). In fact, our interviews indicated that digital twin development projects are often carried out in parallel (Employee B). Therefore, there is a certain consensus among the respondents and the data collected that the development of Digital Twin is not suitable for real-time or safety-critical systems (Employee C) and for very large and complex automation (Employee E) where the functional requirements are not sufficiently known in advance (Employee A).

Our research shows that the problems with RPA development using digitally mirrored GUIs, thus excluding the end user, often led to problems in the deeply rooted organisational habits of recruitment, retention and motivation (Employee A). The problems were a manifestation of deeper problems within (Employee D) of the authority.

This externally guided development of automation quickly led to a reflection on the sense of the current process practice (Employee A) of the affected employees. The presented technique demonstrates here very well the problems of motivation as well as quality assurance and personnel evaluation (Employee B) in the investigated public service. However, it also showed that by transferring process responsibility from the end user to the RPA developers, a much faster and more thorough reaction to deficiencies was achieved (Employee A). The implementation of the digital twin approach was supported by the timely provision of process data by us in the case study. From this study, inherent reasons for using an adapted digital-twin approach in the RPA development process were found, with the limitations mentioned above.

15.5 Preliminary conclusion and outlook

Our case study on RPA using the digital twin approach introduces process automation outsourcing and highlights the importance of user-centric process knowledge for strategic decision making in this field. The case study also aids in analysing the requirements of the approach in public administration. We can answer and observe our RQ3 and thus describe an approach that can help to measurably accelerate the development of RPA solutions. This study offers a new approach that offers three things: First, it focuses on a new development methodology (RQ1) for business process automation outsourcing. Second, it observes and measures the development steps of the rapid prototyping process used for this purpose in the development of RPA solutions (RQ2). Thirdly, the functionality as well as the adaptability of the approach was tested in a practical environment (RQ3).

Research into the use of the virtualisation technology approach of a digital twin in the development of RPA solutions is still at an early stage. In this paper we reported on the application of the practices of the digital twin. However, only isolated administrative processes were automated using RPA solutions. Further knowledge about the development of such solutions considering networked middleware and open questions about user rights, access security, integrity-protected applications in a remote system as well as confidential message exchange between client and server could not be answered.

The research outlined in this paper will also contribute to the development of simultaneous development approaches for critical resources. Further research could examine the development lifecycle for RPA solutions, the stability after a scheduled automation lifecycle with digital twin practices and focus on generating „*Minimum Viable Products*“ using the presented approach. This means using the digital twin to investigate those development processes that, despite minimal configuration, offer users a concrete and tangible performance promise and keep this promise in daily use. An even closer look in future research can show where, when and how comprehensive the triggering takes place and where corrective action is required.

A long-term case study would probably be the most reasonable approach, as all data never will be available and there is certainly too little and often insufficient information available. The approach has been validated to provide results that fit into the overall picture and different sources of evidence and personal experience of employees. These usually provide input for further and deeper analysis and action plans. For example, it would be useful to include the degree of complexity and process background of possible solution developments as a variable aspect of an analysis in order to deduce the best process types for automation.

Understanding and investigating this problem and going beyond the scope of this paper would be a good opportunity for further methodology refinement. The identified critical areas can then be analysed in more detail. The support of more sophisticated software solutions would allow a better granularity of exploration of the developed solutions.

16 Click here, click there! Analysis of the differences in process remodelling using robotic process automation: A comparative case study between the public sector and industry

Table 16-1: Fact sheet publication P11

Titel:	Click here, click there! Analysis of the differences in process remodeling using robotic process automation: A comparative case study between the public sector and industry
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 27th Annual European Operations Management Association Conference
Ranking[1]	**n. R.**
Authors	**Name** Koch, Julian
Status	Published
Full Citation	Koch, J. (2020): Click Here, Click There! Analysis of the Differences in Process Remodeling Using Robotic Process Automation: A Comparative Case Study Between the Public Sector and Industry", In: *Proceedings of the 27th Annual European Operations Management Association Conference*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Click Here, Click There! Analysis of the Differences in Process Remodelling Using Robotic Process Automation: A Comparative Case Study Between the Public Sector and Industry

Abstract

This research article shows the reconstruction of the differences in the design and application of business process automation by software robots (Robotic Process Automation - RPA) in an industrial environment and in the public sector. To this end, we conduct several case studies in the form of the implementation of four automation approaches of the same business processes and supplement them with quantitative data from software creation protocols. In this way, the phases and activities of planning, development and implementation of the processes could be recorded and compared to gain insights into different factors of process design.

16.1 Introduction

Public sector operations are significantly challenged by the digitalisation. New products and services must be evolved and new expectations from citizens and organisations arise the management of change and transformation are significant, including process management and technological innovation. Business processes represent a significant part of the costs of the public sector. Managing business processes provides significant opportunities for improving market share, decision making and performance (Bruijn 2002, 2003). Robotic Process Automation (RPA) refers to a software technology that automates front and back office processes (Lacity and Willcocks 2016). RPA imitates how humans operate their computers, use applications, and execute processes. By imitating user input via the user interface of an application, the time-consuming programming of an application interface can be eliminated (Madakam et al. 2019). RPA also does not interfere with a company's existing systems or IT infrastructure or make changes to applications. This means that there is normally no need for a costly investment to adapt the software (Schmitz et al. 2019). The increase in the use of RPA by public administrations is becoming a long-term trend, as a growing number of processes and digital connections no longer appear up to date with conventional methods of process optimisation (Aguirre and Rodriguez 2017). RPA has the potential to improve the provision of public services and promote process optimisation in the core areas of public administration in a particularly time-efficient manner.

Many public authorities have increasingly networked processes for the provision of services and information, which makes direct process execution, for example with service recipients, more complicated (Adcroft and Willis 2005). RPA appears here as one of the effective techniques that can be used to understand automation and improve business performance. Our research approach enables a common understanding and analysis of the creation of such RPA solutions based on business processes. RPA is considered here as a technology approach with the goal to improve the efficiency and effectiveness of business processes inside and outside the administration. The strength of our research is, besides expert interviews, the thorough consolidation of available clickstream and logging files on error handling, system exception and debugging of RPA bots (Ko et al. 2015). The research presented here provides a contribution for practitioners and researchers by describing a comprehensive view on the functional applications of RPA and the creation and remodelling process. This research focuses on the different segments of RPA modelling to identify the differences in the cause-effect relationships between public sector and industry practice.

16.2 Research Background

Recently, more and more papers have emerged in science about RPA based on practical observations. By default, these are presented in the form of a case study in an industrial company, such as or in the research of (Fung 2014; Harris et al. 2019; Plattfaut 2019) individual case studies are presented in industry. They usually examine real world examples of the practical use of RPA. From a methodological point of view, researchers should be aware of the general methodological choices and prepare case studies. The research design and methodological approach is regularly followed in the literature by semi-structured interviews with different respondents, mostly process participants. Interviews are conducted and the results of these interviews are presented, including the impact on individuals and the business context. In the most recent work from March 2020, the RPA technology is beginning to address different industries, especially public administration, as shown by the research of (Houy et al. 2019) shows an example of the introduction of cognitive RPAs in public administration, (Cohen and Rozario 2019) outlined how auditing could benefit from the use of RPAs.

The next important technologies in this case are two RPA-specific development tools as well as a self-developed software solution for evaluating RPA logs. The logs allow us to be in control of „*who is doing what*“, including how exactly the work and development of robots is performed. In other words, by using log collection and analysis, the workflow is built and made visible where human workers, RPA robots or other digital agents perform which activities within these workflows. Additionally, the research method is used for monitoring and measurement. We were able to track where the process owners manually intervened when they considered it appropriate, where standard business rules were overridden, and how the prioritisation and distribution of robot creation work steps was done. Another major benefit related to this case is that it allowed us to determine which robots are assigned to each work queue. This allowed us to capture and analyse across multiple RPA solutions to reveal possible coherent benefits. This integration will be achieved within the assumption of the available RPA logs, here we could capture and analyse a workload distribution, functionality building blocks, the behaviour in sleep mode, which are developed, defined, and managed decentral.

16.3 Research Process and Methodology

The research was based on a qualitative case study design, with the main units of analysis being the organisational departments within the case organisation. (Yin 2018) notes that the need for case studies arises from the desire to understand complex developmental processes and that the case study method enables the investigators to retain the holistic and meaningful characteristics of real developmental events (Siegmund et al. 2014). Furthermore, the reason for a single case study is the opportunity to examine the organisation in question over a period that would otherwise not have been possible. (Wohlin et al. 2012; Yin 2018) notes that an enlightening case is a possible reason for selecting a single case. In this case, the researcher had the opportunity to investigate in detail a case that was not possible before. The company under investigation is a medium-sized steel processing company with worldwide operations and approximately 1000 employees. The problem context of the company was subject to considerable expansion in the past 3 years. The company realized that it had to improve and automate its processes if the company wanted to expand and improve its competitive position. The public administration under investigation is a major German city with a population of approx. 200,000. Both investigated entities employ about 10 people for the development, organisation, and maintenance of RPA-based solutions and both companies started RPA development in the company around the beginning of 2019.

Table 16-2: Survey methods, data sources and respondents

	Type of company	Survey method	Expert's Role
Employee A	City administration	Pilot interview (1x 60min); interview (6 x 90min); status reports; Version management data	Department manager front office
Employee B	City administration	Default logs; interview (17x 30min); Version management data	Administrator Back Office

Employee C	City administration	Pilot interview (1x 70min); Default logs; Version management data	Administrator Front Office
Employee D	Industry	Interview (3 x 90min); status reports	Administrator Back Office
Employee E	Industry	Default logs; interview (7x 30min); Version management data	Administrator Back Office
Employee F	Industry	Pilot interview (1x 30min); default logs: Version management data	Head of Process Management Lean Management Group

The research approach of the case study was chosen to also investigate the research phenomena, i.e. the selection of suitable automation modules, the implementation, integration and use of RPA technology, and the evaluation of the development mechanics over a longer period of time. The case is considered from two perspectives:

(1) a medium-sized company,
(2) a public administrative body of a major German city,

Both institutions are constantly striving to automate their administrative activities but have no experience with process automation or RPA technology. Data collection was carried out by regular semi-structured interviews with 6 respondents from two participating institutions and by analysis of internal data including clickstream data and RPA event logs.

In this study, three main implementation steps were applied, which model the actual process from the logs, analyse the actual process and model the expected process. The preparation of the first step - modelling the actual process - was done by collecting the logs for categorized RPA bots. Here, the information flow in each RPA bot was first made visible. The process analysis from the logs was observed by looking at the processing time in each of the activities in the actual process model and benchmarking with the developers to identify the problem. The creation practices for RPA development were collected by literature research and then discussed with 6 development experts in different units to discuss the identified development practices. The selected practices were incorporated into scenarios for the future development process and simulated to identify changes in processing practices in the public sector and industry comparison. The scenarios were also compared to see the different development steps. Using the log data in conjunction with the interviews allows us to better understand the complex relationships of the subject under investigation (Freire et al. 2013). The organisational process, management and environment are part of a complex reality that is otherwise difficult to understand when development processes are viewed in isolation (Freire et al. 2013; Wohlin et al. 2003).

16.4 Results

The development steps of the two case study participants partly differ fundamentally from each other. Within the public sector, they result „*not exclusively from the requirements of day-to-day business*“ (Employee B), but are based on „*customer-oriented interaction*“ (Employee B), an integrated „*day-to-day business IT approach*“(Employee A). Day-to-day business and IT merge and take „*joint responsibility*“ (Employee A) for the development of RPA solutions.

However, this merging process is usually not reflected anywhere (Employee C). Responsibility for the RPA strategy is also „*inexplicable and diffuse*“ (Employee B). Within the industrial company, it has been assigned to a different management level, such as the group manager for Lean. However, both companies considered RPA, in close cooperation with „*the specialist departments*“ (Employee F), to be responsible for the realignment of the company's „*digital capabilities*“ (Employee E). Within the public administration, this role is not filled by a single employee in personal union; there, close cooperation with clearly „*demarcated responsibilities*“ is essential (Employee A). For the public administration, the perspectives of „*security and sustainability*“ (Employee A) are decisive for the definition of the development steps. Here, the resources of the RPA technology are intended to open „*new opportunities*“ (Employee C), to increase customer benefits and, for example, to enable new services for customers (Employee B). In addition, the approach should be „*not geared to the market*“ (Employee A). With the help of RPAs, findings can also be incorporated that provide relevant „*information about citizens' expectations*“ (Employee B).

In operationalizing the digital strategy, we identified two speeds through the case study. In public administration, the implementation of the goals is carried out equally by several departments, whereby these are interdependent in numerous ways. The public administration is focused on „*application stability and cost efficiency*“ (Employee A). The higher-level department for ITC controls the business-critical processes and ensures a „*slowed down development process*“ (Employee C).

For industrial companies, which focus on high „*employee satisfaction*“ in the RPA project (Employee D), often proceed on a departmental basis, and require agile working methods, the focus is on rapid development with significantly faster life cycles. Our investigations showed that it is characteristic to initiate fast development steps via trial-and-error procedures, which the development in public administration was not able to do.

The most important difference in the industrial company is the „*dissolution of departmental thinking*“ (Employee F). Together with the day-to-day business, IT RPA implements projects without neglecting the future security of IT operations (Employee E). In this way the industrial company tries to strike a balance between efficiency- and innovation-driven approaches and roles.

The investigation also revealed that there was no universal organisational approach to RPA development in the industrial company. As our study showed, each individual RPA project was given its own IT approach, which was decided on a case-by-case basis. As our research showed, where particularly fast implementation cycles were carried out, the development teams acted largely detached from other departments. As our investigation showed, public administration, on the other hand, must orient itself more strongly towards IT structures - even if the departments can exert influence on this in individual cases, a project is still officially at the interface of IT.

As our study showed, the necessary requirement for functioning in public administration is cooperation between IT and Operations. In public administration, the main tasks of enterprise resource planning development are to understand the effects of changes in process flows, to detect errors in tests at an early stage (Employee B), to monitor activities in process execution (Employee B), to check performance processes with regard to the „*interaction of IT and day-to-day business*“ (Employee A), and to support „*day-to-day business operations through automation*“ (Employee A).

The results of the expert interviews were compared in Table 16-3 and Table 16-4, summarizing them in the categories drivers, advantages, and disadvantages. In contrast, our study shows that in industrial companies the RPA are adapted to rapid changes in the business processes and that version control and fast rollbacks are integrated so that occurring errors in the business processes do not disturb the running operation. In industrial companies this is part of the development process to understand the implemented RPA solutions and to facilitate error analysis. As our investigation showed, it is characteristic for public administration to adapt speeds to the situation.

Table 16-3: Drivers, advantages, and disadvantages of the public sector

Public administration: Here the public administration is setting up an independent subdivision with a focus on RPA development. Some of the employees have the task of driving forward the development processes of RPA solutions.		
Driver	Advantages	Disadvantages
Sustainable strategic development of innovation and knowledge	Sustainable knowledge acquisition; integration of the historical authority architecture	Internal availability of staff and expertise; employees are closely linked to day-to-day business
Close networking of initiatives with numerous areas within the organisation	Development of knowledge within the organisation; comprehensive involvement of several government departments	Little involvement of the individual divisions; difficult balancing of traditional day-to-day business
Strong innovation-driven initiatives strengthen employee involvement	Availability of internal staff and expertise	Risk of being bypassed by the IT department; potential for conflict through silo formation
		Management commitment and support for the initiatives is often difficult
		Problems with the integration of the external unit into the traditional IT organisation

Table 16-4: Drivers, advantages, and disadvantages of the industrial sector Company

Industry Enterprise The industrial company approaches RPA development in a cross-departmental and decentralised manner within a defined time and resource budget.		
Driver	Advantages	Disadvantages
Quick establishment of a temporary and clearly defined environment	Suitable external contractual partners and availability of employees; initiatives with clearly defined start and end dates	Integration of external knowledge
	Suitable cooperation partners with the willingness to integrate	Potential loss of knowledge and possible inhibition of internal talent development after completion of the project because the procedure does not become part of the fixed corporate or IT culture

16.5 Discussion and Conclusion

The evidence gained showed that efforts should initially focus our research on a small number of high priority areas that bring the greatest added value. In this paper we presented an empirical approach to survey the design process between industry and public administration. The approach was applied to the data of a city administration and an industrial company. The research design helped us to model the investigated design process and allowed us to illustrate iterative development processes. The detailed process examined in this research work consists of 53 task steps that are related to each other in a complex way. We identified 33 iterations in the original development process. The two processes were visualized in Figure 16-1 and Figure 16-2 in a comparative manner, using the findings from the expert interviews and enriched with the data from the corresponding log files.

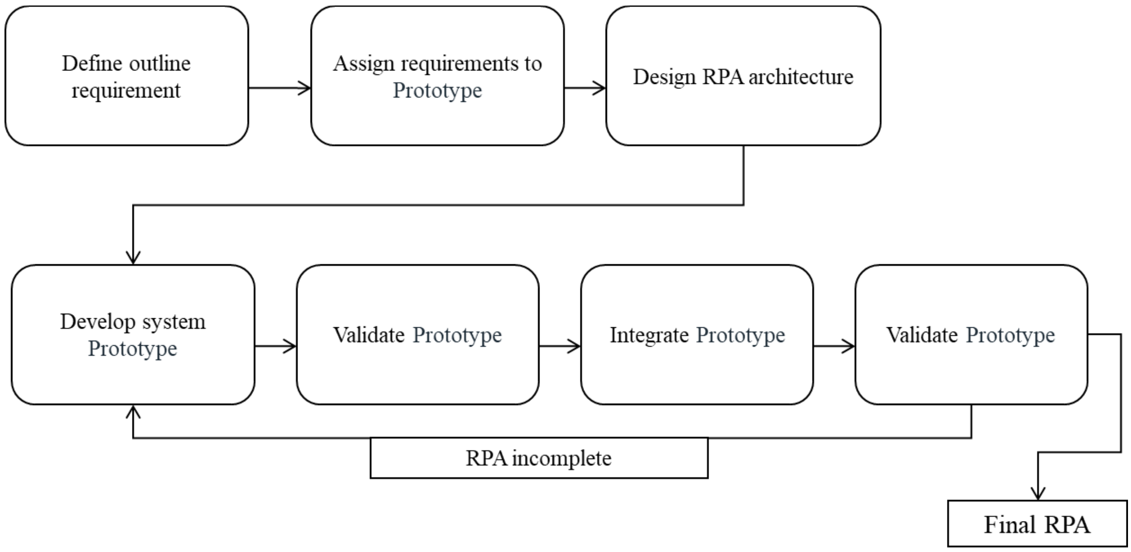

Figure 16-1: The development process in the examined industrial company

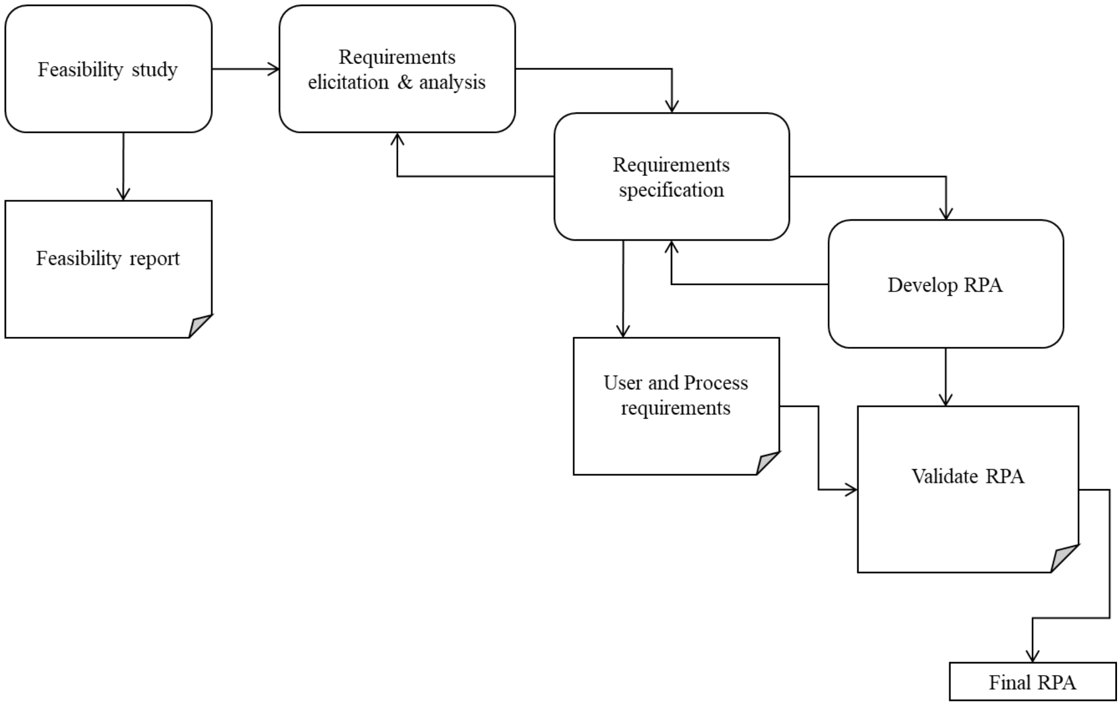

Figure 16-2: The development process in the examined public administration

After partitioning using the expert interviews, the number of iterations was reduced to 9. The collection effort via the log files is important and challenging, but the benefits are so attractive that the approach is worth the effort. This study will be continued to obtain quantitative evaluation of the development elements.

Business process automation is one of the fastest growing tools, which is most effective for industries that are in urgent need of change and improvement, especially when the potential of the required automation is large (Pollanen 2005; Propper 2003). In this study we have compared the development process of RPA solutions.

The benefits of our research designs were to identify and measure significant redesign opportunities, establish a dedicated comparative illustration (Figure 16-1 and Figure 16-2) of performance, and determine which steps in the development process are most common.

In the future, it is important that we can identify further development patterns and thus introduce our process model for RPA development in the company. Thus, the biggest advantage of our survey approach is also its simplicity of software development representation, without using the formal programming code, thus bringing the development closer to the users. This makes it more important to extend our process model to include quantitative factors in the creation of RPA solutions in the company to prevent failures due to a poor development process.

In this paper, a mixed method of interviews and data analysis of log files is presented, which can be used to merge real event logs from distributed development projects in one study. This allows us to analyse the operation of software systems under real conditions and use construction techniques to obtain accurate and formal models (Kitchenham et al. 2002; Seaman 1999). In addition, the development techniques will be used to monitor and improve development processes, e.g., through performance analysis and conformance testing. We have tried to present a formal definition, implementation and instrumentation strategy based on the two models we have created. Our case study showed how, after specifying some simple point sections, we quickly gained insight into the development process and the main performance bottlenecks associated with these development processes (Fernández and Passoth 2019). In this paper we started from a development process analysis, but the development of process degradation techniques to support this could provide valuable additional insights besides the interviews. Finally, with the emergence of software event logs and software versioning data rich in data and semantics, new development processes could subsequently focus on information and sub-processes not yet contained in the models discovered.

17 Process Mining for Six Sigma: Utilising Digital Traces

Table 17-1: Fact sheet publication P12

Titel:	Process Mining for Six Sigma: Utilising Digital Traces
Publication Type	Journal
Publication Outlet	Computers & Industrial Engineering
Ranking[1]	**B**
Authors	**Name** Kregel, Ingo Stemann, Dietmar Koch, Julian Coners, André
Status	Published
Full Citation	Kregel, I.; Stemann, D.; Koch, J.; Coners, A. (2021): Process Mining for Six Sigma: Utilising Digital Traces. In: *Computers & Industrial Engineering* 153, S. 107083. DOI: 10.1016/j.cie.2020.107083.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Process Mining for Six Sigma: Utilising Digital Traces

Abstract

Six Sigma is one of the most successful quality management philosophies of the past 20 years. However, the current challenges facing companies, such as rising process and supply chain complexity, as well as high volumes of unstructured data, cannot easily be answered by relying on traditional Six Sigma tools. Instead, the Process Mining (PM) technology using big data analytics promises valuable support for 6S and its data analysis capabilities. The article presents a design science research project in which a method for the integration of PM in Six Sigma's DMAIC project structure was developed. This method could be extended, refined, and tested during three evaluation cycles: an expert evaluation with Six Sigma professionals, a technical experiment and finally a multi case study in a company. The method therefore was eventually endorsed by 6S experts and successfully applied in a first pilot setting. This article presents the first developed method for the integration of PM and Six Sigma. It follows the recommendations of many researchers to test Six Sigma as an application field of PM as well as using the potential of big data analytics. The method can be used by researchers and practitioners alike to implement, test and verify its design in organisations.

17.1 Introduction

New challenges for companies in recent years include an increasing complexity of products accompanied by complex processes and supply chains (Bode and Wagner 2015; Bozarth et al. 2009). With the help of big data as an innovation accelerator, digitalisation promises faster and more efficient processes and innovative products (Tiwari et al. 2018). This article focuses on using companies' microlevel process data, often called digital traces, for business process improvement via Six Sigma (6S). 6S is one of the most popular and successful process improvement methodologies and management concepts (Jacobs et al. 2015; Shafer and Moeller 2012). It originated in manufacturing and was later applied to other industries, such as the service sector (Heckl et al. 2010). Three practices are critical for 6S: the role structure (belt system), the structured improvement procedure (define, measure, analyse, improve and control, also known as DMAIC) and the focus on metrics (Zu et al. 2008).

In this article, we concentrate on the data analysis capabilities of 6S and its technological connection to big data analytics. Typical elements of 6S include data-based decision making, data collection tools and techniques as well as process control planning (Kwak and Anbari 2006). 6S relies on a systematic, fact-based approach, including 'classical' inductive statistics such as hypothesis testing or the design of experiments. Based on new digitalisation challenges though, the traditional data analysis toolset of 6S is confronted by limitations. For example, many traditional 6S projects rely on only 30-1000 observations (Zwetsloot et al. 2018). Big data analytics (BDA) though, uses datamining techniques to target very large amounts of unstructured data and much more complex questions and problems (Hoerl et al. 2014). How big data can be utilised for 6S is one of the major current trends in the field of 6S research (Antony et al. 2019; Sony et al. 2020). On the software side, Minitab as the most prominent 6S product, offers a large variety of statistical tools for process analytics, but with clear limitations for data mining (Jang and Jeon 2009). Competitors like JMP already work on gaining advantage by providing advanced BDA functionalities. The young field of Process Mining (PM) could be one of the upcoming technologies profiting from traditional 6S limitations, offering access to the 'digital traces' and using BDA (Pentland et al. 2020).

For this purpose, we present an approach for integrating Process Mining (PM) technologies into the 6S toolset to enhance its data analysis capabilities. Most processes in large corporations are supported by or executed in IT systems that store large amounts of data. Systems for enterprise resource planning, customer relationship management, workflow management and manufacturing execution contain valuable process-relevant data that is often not accessible under the usual improvement project circumstances. These massive trails of microlevel data have already been identified in the literature as a new opportunity for research (Addo-Tenkorang and Helo 2016; Shang et al. 2020). Terwiesch (2019) calls this 'digital exhaust', an operations' archive at a very fine level of granularity. Our research aims to access and use this data by integrating PM procedures into the 6S toolset.

The centre of our article forms a method for using PM in 6S projects and showing how it can be integrated into the DMAIC project phases. For this purpose, we expand the application scenarios of 6S by connecting PM as a new source of data and evaluating its usefulness. We are using interventions as a source of theory (Oliva 2019) by facilitating a 6S expert workshop, a technical experiment and a case study. The article therefore focuses on exploratory research to answer the following overall research question:

'How can Process Mining be used to support the Six Sigma methodology?'

The article is structured as follows. Section 17.2 starts with the research background as well as a general introduction to PM, its characteristics and potential. Section 17.3 summarises our research process, its methods and evaluation strategy. The method on how to integrate PM into the 6S toolset forms section 17.4, describing a variety of scenarios in which 6S projects can benefit from PM. Afterwards, in section 17.5 the method will be extended and evaluated during three design cycles before the articles culminates with a conclusion and outlook in section 17.6. The main elements of the research process and the article structure are visualised in Figure 17-1.

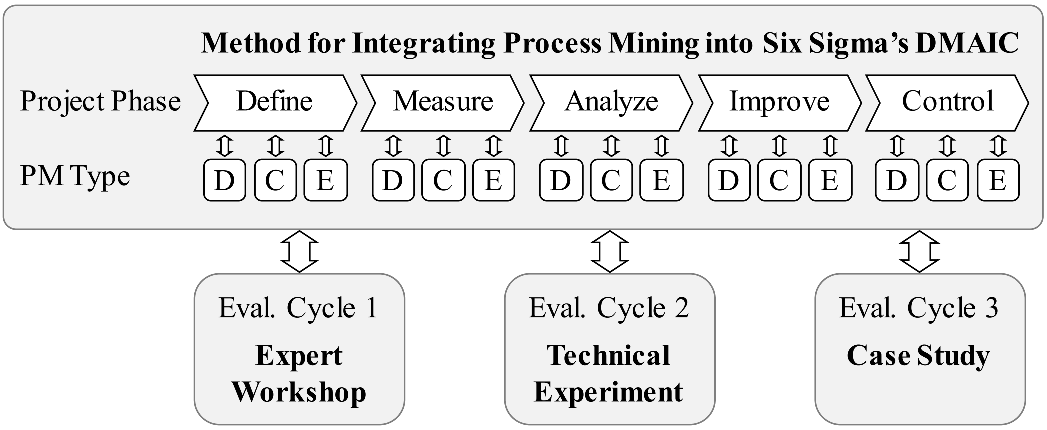

Figure 17-1: Article structure and research process

17.2 Related Work

17.2.1 Research about Six Sigma

The reputation of 6S and its development are often connected to first-mover companies like Motorola and General Electric and high figures of project benefits and net income benefits (Shah et al. 2008). A wave of 6S research literature started in the late 1990s and became much more comprehensive and diverse after 2004 (Aboelmaged 2010; Muraliraj et al. 2018). Research initially focused on manufacturing and the 6S toolset, but more and more articles appeared beginning in the late 2000s addressing cultural and soft factors, such as leadership. Another focus was on domain-specific challenges and the customisation of 6S, for example, in the service and public sectors (Antony et al. 2017; Kregel and Coners 2018). However, methodological issues still represent one of the most prominent 6S research areas of the last decades (Niñerola et al. 2021). The majority of 6S research remains rather practice oriented. Its lack of theory, however, has already been identified and addressed in the literature (Linderman et al. 2003). Schroeder et al. (2008) summarise the common elements from the literature and define 6S as follows:

'Six Sigma is an organised, parallel-meso structure to reduce variation in organisational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives.'

The meso structure integrates both micro and macro levels of analysis and is created in parallel to the existing organisational hierarchy. 6S generally is not considered a project management method only. In fact, it targets the whole organisation as a system and establishes a coloured belt system comparable to martial arts standards. The most important role for this article's focus is the black belt, who is intensively trained in statistical methods and typically already gained large project experience (Coronado and Antony 2002). The DMAIC's project phase structure will be a reoccurring theme, as we demonstrate the use of PM in each phase and later specifically address them during the evaluation cycles. Performance metrics, as mentioned in the definition, have always been a key element of 6S. In times of continuing digitalisation and industry 4.0, the utilisation of data increases even more. Aspired aims include real-time monitoring and predictive analytics (Dev et al. 2019; Subramaniyan et al. 2018). Already nearly twenty years ago, Han and Lee (2002) demanded 'future plant operation systems' to 'provide the users with all the supporting functions to collect and analyse data, develop models, design experiments, and control the process at the optimum condition'. Big data analytics, including data mining and PM, provides many opportunities to enhance classical measurement capabilities and to address these challenges.

A popular and very related topic in practice as well as in literature is Lean Six Sigma (LSS). This philosophy includes the experience from 6S and Lean management and combines them into a deployment approach mainly consisting of the following three features: 'integration of the human and process elements of improvement; clear focus on getting bottom-line results ($); and a method that sequences and links improvement tools into an overall approach' (Snee 2010). As LSS includes the elements of 6S, our research about integrating PM into the DMAIC specifically addresses 6S, and therefore indirectly influences LSS.

Project leaders remain free in their choice of methods and tools supporting either the 'process lens' (such as flow diagrams) or the 'data lens' (such as hypotheses tests). However, there are a large number of standard methods and tools being trained in practice and published in books and journals. Until now, the topic of PM has not been included in popular 6S books (Pyzdek and Keller 2014) or the International Organisation for Standardisation (ISO) standard for 6S (International Standards Office 2011). Most of the elements of 6S were included in its toolbox decades ago. In a comprehensive literature review regarding the most frequently used tools and methods in 6S literature, neither data mining (nor its most important methods) nor PM were found (Uluskan 2016).

There are examples, however, for using other data mining techniques in 6S projects. Ghosh and Maiti (2014) use decision tree algorithms in an Indian grey iron foundry context. Zwetsloot et al. (2018) present three case studies involving data analytics experts as consultants for black belt projects. Finally, George (2019) summarises a large number of case studies where 6S could benefit from data mining, such as applications of neural networks, artificial intelligence and deep learning. The overall field of big data is recognised as having a very large potential for 6S while still not being extensively researched (Antony et al. 2017). A literature review about big data in Lean Six Sigma (Gupta et al. 2020) identified only a single article about using PM in an operations management context: Rovani et al. (2015) present a case study of a Dutch hospital where process mining was applied to discuss current process executions, check conformance and analyse deviations. Despite the inclusion in the literature review, neither Lean nor Six Sigma were explicitly used in this case study. The general potential and influence of big data analytics on operations management is recognised, but also still part of an ongoing debate in this field (Mišić and Perakis 2020). Gunasekaran et al. (2019) even speculate that a new philosophy beyond 6S and total quality management (TQM) could emerge in the next few years.

17.2.2 Research about Process Mining

Process Mining applies data mining techniques to the field of business process modelling and analysis. Its main idea is 'to discover, monitor and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs readily available in today's (information) systems' (van der Aalst et al. 2012a). These event logs usually have an initiator, refer to other tasks or activities, refer to a process instance (case) and are marked by a timestamp. The timestamp is of decisive importance, as it brings the activities into their chronological order and visualises the process sequences. PM can therefore analyse and display the execution sequence of process steps, decision rules, communication paths and processing rules. It allows for the analysis of historical data from a selected time frame and the real (instead of the ideal) process flow to be measured, which typically includes several process loops and flaws. Software vendors promise to help reducing the complexity of data integration, one of the major barriers for big data analytics (Moktadir et al. 2019).

PM is still a young scientific discipline (van der Aalst 2018a). The beginnings go back to works by Cook and Wolf (1998) who derived process models in the context of software processes from event-based data. They summarised this work under the term process discovery. First articles in this field developed ideas how to utilise workflow management system logs (Agrawal et al. 1998; van der Aalst and Weijters 2004). Most publications on PM deal with the derivation of the control flow of processes (Ghasemi and Amyot 2020), which is also known as control flow mining. Typical techniques to perform PM include heuristic algorithms, genetic algorithms, Markovian approaches, neural networks, and cluster analysis (Tiwari et al. 2008).

There are numerous areas in which PM techniques can be used meaningfully. According to a current literature review, the most popular application domains are healthcare, information and communications technology (ICT), manufacturing, education, finance, and logistics (Garcia et al. 2019). Implementations up to today are mostly seen in the finance and accounting departments across all industries. Typical pilot candidates to start an initiative are order-to-cash and purchase-to-pay processes. PM in manufacturing processes is possible and can be found in the literature, but its rather complex use cases are still in an early stage (Fahmideh and Beydoun 2019). Generally, PM is applicable to any sector and case where its data requirements are met. Major support factors for its introduction are high-volume process executions, high complexity in the process sequences and high cost or competitive pressure.

van der Aalst (2016) distinguishes three major types of PM:

Discovery: Creates a process model out of the event log data. A pre-existent model is not required; the model can be generated purely based on the data in order to 'discover' the real process with all its connections, potential loops and sequence variety.

Conformance: Compares an existing process model with the discovered model created from the event log data to verify or contradict the conformance of a current process model. Conformance can be used for various purposes, including checking for violations of process rules, process monitoring and quality auditing. Further purposes can be compliance-checking for risk management (Caron et al. 2013) and financial auditing (Jans et al. 2014).

Enhancement: Uses the information from event logs to find ways to improve the current process. Possible solutions are to automatically correct the current process model or to extend the model with additional data, such as throughput and processing times, frequencies, decision rules and quality measures. This PM type may inhibit the largest potential for future developments. For example, PM can be used for real-time recommendations and predictions of process instances. This can be used for process control decisions like prioritisation as well as answering customer inquiries (van der Aalst et al. 2011).

Despite more than twenty years of research and huge progress, PM still offers much space for new research directions. In their 2012 'Process Mining Manifesto', a large number of researchers from 53 different institutions summarised and concretised their view on PM (van der Aalst et al. 2012a). In their document, they declared PM as an enabling technology for management approaches such as continuous process improvement, total quality management (TQM) and 6S. Four years later, van der Aalst et al. (2016) renewed their recommendation for future research directions to 'bridge the current gap between Process Mining and Six Sigma'. Therefore, to answer these researchers' calls and connect both elements with each other is part of our research motivation.

17.2.3 Research Method and Evaluation Strategy

Our research method is design science, which is increasingly being adopted in operations management (Holmström et al. 2009; van Aken et al. 2016). This method is particularly popular in information systems research and is often used there to create, implement and evaluate innovative frameworks and IT artefacts (Hevner et al. 2004). In operations management, design science is explicitly recommended for research with high practical orientation, which matches this article's intentions (Browning and Treville 2018).

Design science shares many elements with action research, a method much more common in operations management (Coughlan and Coghlan 2002; Westbrook 1995). Although both methods have many characteristics in common, they also differ in significant elements. They share a strong connection to practice and intervene in real-world scenarios rather than describe observations or confine in the creation of theoretical constructs (Cole et al. 2005; Järvinen 2007). Their distinction, though, can be summarised best by referring to their origins. Design science comes from the fields of engineering and computer science and usually concentrates on describing a design object and validating its usefulness and applicability. Action research, on the other hand, focusses on the organisational context of a phenomenon which is accompanied and influenced by the researchers (Peffers et al. 2007). In some cases, a combination of both methods, called 'action design research', can be the best option to explore the organisational context of an implemented design solution (Sein et al. 2011).

The foundations of design science research (DSR), including the first descriptions of its outputs or products, go back to March and Smith (1995). Their definition of IT artefacts is repeated and concretised by Hevner et al. (2004) as follows:

„*IT artifacts are broadly defined as constructs (vocabulary and symbols), models (abstractions and representations), <u>methods</u> (algorithms and practices), and instantiations (implemented and prototype systems).*"

Methods as a design science artefacts can also be defined as 'actionable instructions that are conceptual' (Peffers et al. 2012b). As we are enhancing the existing 6S method by

PM, we are therefore designing our own method artefact. To summarise our research process, Figure 17-2 describes the main elements of the research project by using the 'DSR Grid' framework developed by vom Brocke and Maedche (2019). It consists of six blocks, describing the problem's starting position, the research process, and the solution. Additionally, input and output knowledge, as well as the most important concepts of this article, are summarised.

Design Science Research Project Grid: ***Process Mining for Six Sigma***

Problem	**Research Process**	**Solution**
Data analysis limitations of classical Six Sigma approach. Big data sources and digital process traces are typically not targeted and utilised during Six Sigma projects.	After developing a method how to combine Six Sigma and Process Mining (PM), three design evaluation cycles are executed to refine and further develop its validity and usability.	A method including a set of proposed situations and scenarios how Process Mining can be used in all five DMAIC phases of Six Sigma projects.
Input Knowledge	**Concepts**	**Output Knowledge**
Current body of knowledge how classical Six Sigma projects use data analysis methods and the DMAIC approach. PM theory and current PM software capabilities.	Process Mining, Six Sigma, DMAIC, Big Data Analytics, Data Mining	Designed and evaluated method how to use PM in Six Sigma projects, including recommendations for the potential applicability of three types of PM in each DMAIC phase.

Figure 17-2: Research method summary

Our research approach follows the work of Hevner (2007) by describing cycles between creating and evaluating a design object. This concept shows similarities to the plan-do-check-act (PDCA) method of Deming (1986). Following the method engineering categorisation of Goldkuhl and Karlsson (2020), our method is co-generated by practitioners and scholars. For its evaluation, we combine three different evaluation techniques by implementing a technical experiment, an expert evaluation and finally a case study (Peffers et al. 2012b). Design evaluations can be categorised by their point in time as well as their evaluation environment (Pries-Heje et al. 2008). Ex ante evaluation strategies analyse an object before it has been acquired or implemented and focus on the potential of the design object. On the contrary, ex post strategies perform the evaluation after its implementation and focus on the outcome (Klecun and Cornford 2005). The environment of evaluation can either be naturalistic (if a design object can be evaluated in a real scenario) or artificial (if it can only be observed in a theoretical or contrived way). Regarding the presented categorisations, we are executing two ex post strategies.

The design object is first analysed artificially during the technical experiment and the expert workshop. Afterwards, we evaluate it naturalistically during a case study.

17.2.4 Integrating Process Mining into Six Sigma's DMAIC

Many classical 6S projects analyse existing process models or can only rely on the input of a few workshop participants to understand the process flow. Usual data analysis is based on data reports or individual data selections or is done by manually performing new measurements. Analysing trustworthy existing data saves resources for the interpretation of the data and for more time- and cost-efficient projects compared to manual data collection. In addition, the refinement of existing process models generated out of data is much less time consuming than building the models from scratch.

A major component of 6S is the belt system mentioned previously, which includes the green belts and black belts for typical project leaders and yellow belts for project members (Antony and Karaminas 2016; Hoerl 2001). When integrating PM into the 6S method, organisations will need to determine who will analyse the PM data. There are two main alternatives: The PM knowledge can either be included in the black belt training as an additional data analytics topic, or it can be offered to 6S project managers by a separate organisational unit specialising in data analytics, as in the case studies analysed by Zwetsloot et al. (2018). We make no specific recommendation about this detail as our research to this point does not reveal clear superiority of one of the alternatives over the other.

In the following subsections, we will describe how PM can be integrated into the DMAIC's five structured project phases.

Define

As the first of five project phases, the *define* phase provides the basis for a successful project. The main aims are to determine the project scope and its goals, which will be important throughout the project and for the eventual calculation of the project's benefits. Defining the right project measures is highly important for the potential effect of the project. Further instruments in this phase include, amongst others, the voice of the customer to develop the indicators critical to quality, a stakeholder analysis and the suppliers, inputs, process, outputs and customers (SIPOC) diagram for a first rough process step overview.

Although its strengths lie in the later project phases, PM can support the define phase by contributing preliminary data insights via screening the available processes. With the help of a first look into the process data, the project scoping can be supported to avoid an endless project (scope too wide) or an overly limited project, which could end without significant improvements and low project benefits. Furthermore, the choice for major project goals could be verified and their target values roughly substantiated.

Measure

The emphasis of the *measure* phase in most projects lies on the data as it covers the collection of data and its planning. The project leader is responsible for contacting and considering every potentially useful data source to create a process analysis that is as complete and accurate as possible. Collecting new data is usually more cumbersome and time-consuming than using existing data. Unfortunately, existing data are often not available for all needed process aspects, or their validity cannot be trusted. Another perspective in the measure phase is the detailed comprehension of the as-is process. A typical element is to model the most relevant processes by creating flow charts or Business Process Model and Notation (BPMN) models.

PM offers another source of data for 6S projects, which, in most cases, has not been used before. For example, manually connecting to a SAP system and extracting timestamps at multiple points in the process is considered extremely time consuming and could even make it necessary to contact IT consultants to create specific data queries or interfaces. PM software vendors specialise in the interfaces of common software products and can therefore deliver the needed data much faster and at a lower cost than the manual method. Due to the analysis of the event logs, PM typically focuses on measures such as throughput time, idle time and waiting time. Additionally, the presented discovery type of PM can support or even replace the manual process of model creation. The model automatically created on the data could be used for an expert workshop to verify the process and build upon it to reach a complete picture of the as-is process. Combined with the throughput and waiting time data, the creation of value stream maps is also possible. Finally, the conformance of process models can support the measurement of standardisation. PM can easily count the number of process variants, and the process experts can determine which of those are conformant to the business rules or to what extent the process standardisation already is or is not successful.

Analyse

Data are more important in the *analyse* phase where the main goal is to create causal relationships to identify which factors influence the process most significantly and, therefore, how we can positively influence its most important indicators. This work can be supported by brainstorming techniques to find potential influence factors (hypotheses) and to use the expert knowledge of the process-related employees. The most significant outcome of this phase is the transformation from many potential influence factors to the identification of a few of the most important factors that will be addressed later in the next phase. For this transformation, the input and experience of employees and process experts, as well as the detailed analysis of all available data, can be of use.

PM can offer many useful aspects based on the analysed event log data. Most PM software products can identify potential bottlenecks in the processes and visualise them in the generated process models. These automated findings can then be the basis for an expert workshop to verify and discuss the hypotheses and combine them with further findings from other sources. Validating existing hypotheses by PM data is also a valuable contribution in this project phase. The comparison of different layers of data—for example, several factories of the same company—can also be transferred to PM. The algorithms can determine whether the processes are being executed the same way or whether different factories deviate from the standard and receive better or worse performance results. Furthermore, with the help of the process indicators and timestamps, the most efficient process, the shortest process and so on can be selected from amongst multiple variants to be discussed by the project team as a candidate for the future process.

Improve

The *improve* phase directly follows up on previous work. The main causes identified in the analyses now represent the requirements for improvement. Potential improvement ideas must be developed and evaluated, followed by finally selecting the best-fitting ones for implementation. In some projects, the design of experiments allows different process configurations to be tested to arrive at the best result.

The PM enhancement especially can support the redesign of the processes. However, the data can also be used to verify potential benefits from process changes or to quantify the scope of change. If conformance is a major topic in a project, process variants can be harmonised and standardised amongst different locations, shifts, persons and so on. In the PM software market, advanced functionalities for simulation and forecasting are expected (Gartner 2018). They could be used by project managers to calculate the prospective effects of planned solutions and to assist in the selection of the best solutions regarding costs or benefits. For now, PM enables the prioritising of detected issues and making fact-based decisions on which improvement measures should be started first.

Control

In the fifth and final project phase, *control*, the sustainability of project benefits is the major topic. Main project indicators are measured again now to determine the exact achievement of the improvements and to calculate the project benefits. Few key measures are summarised in a process control plan for long-term process monitoring. The goal is to keep the new (higher) process performance and quickly detect significant performance changes.

PM can also assist in this phase in many ways. For the benefit calculation, the process standardisation can easily be measured again. The same applies to all the analyses in the measure phase as well as the implemented solutions in the improve phase, which must now be controlled for changes and success. Furthermore, PM facilitates business activity monitoring, which can be used for continuously monitoring performance indicators (Janiesch et al. 2012). Another useful aspect is compliance monitoring. Quality managers can control the emergence of new process variants or the proportion of non-regular process executions. PM can also automate or at least support recurring process audits and process certification initiatives.

17.2.5 DMAIC Summary

We summarise main relationships between 6S and PM in Table 17-2. Our concept has been the basis for the following evaluation cycles. We could refine it during each cycle and gain experience about the fit and potential of PM during each DMAIC phase.

Table 17-2: Six Sigma's DMAIC structure, partially based on de Koning and de Mast (2006)

Phase	Summary	Input from Six Sigma	Support for Six Sigma
Define	Problem selection and benefit analysis	Scoping, selected process steps, appropriate analysis intensity	Identification of potential process problems by process screening
Measure	Translation of the problem into a measurable form, and measurement of the current situation	Required measurements, measure intervals, appropriate logging	Capturing 100% of the processes' activities
Analyse	Identification of influence factors and causes that determine the critical factor's (CTQ's) behaviour	Target-oriented hypotheses and measurement points, collection frequencies	Real, 'lived' process, variants, weaknesses, decision rules, and communication flow
Improve	Design and implementation of adjustments to the process to improve the performance of the CTQs	Assessment of potential solutions	Improvements especially by PM's enhancement type

Control	Adjustment of the process management and control system in order to ensure that improvements are sustainable	Process control concepts and required reporting	Digital screening

17.3 Design Evaluation

17.3.1 Evaluation Steps

Feedback and improvement advice for the design object are essential in design science projects. The contact and discussion with practitioners is an important element to assure the relevance of research and especially to recommended practice-oriented research in operations management (Toffel 2016). As company cases about the combination of PM and 6S were rare, we began to evaluate our approach by using an expert workshop during a non-academic 6S conference. The workshop team consisted of nine persons with different types of expertise, including five master black belts, one black belt, one statistics doctorate and two PM software representatives. The workshop had two main elements, which we worked on:

- *Expert evaluation*: To receive feedback on our approach regarding how to integrate PM into 6S's DMAIC cycle, we presented the current method draft, discussed it with the workshop participants and proposed changes and extensions to the approach.
- *Technical experiment*: We introduced a comprehensive dataset to the participants that came from a large automotive supplier company with about 10,000 employees and annual sales of about 2 billion euros. The dataset contained event logs of receiving, processing, and answering claims. Together in the group, we explored the claims process using the *Lana PM* software to experiment with its applicability for 6S. We simulated a fictional DMAIC project and discussed the usability of PM in each phase, including corresponding examples on how to benefit from its capabilities in different project situations.

After these two evaluation cycles, we added a practical evaluation by executing a multi case study in a company. The refined method how to combine PM and 6S was introduced and subsequently applied during a 6S project. To have a direct comparison, we examined a second project in parallel, which worked towards the same goals, but used 6S without PM methods. Our PM introduction followed the cross-industry standard model CRISP-DM (Shearer 2000) which we adapted and calibrated to the specific case of process data (see appendix).

17.3.2 Expert Evaluation and Technical Experiment

The analysed data already provided important input for the fictional 6S project's define phase as it delivered a good overview of the process and its measures. The PM software created the process model shown in Figure 17-3 and had already annotated existing indicators. An important factor for the main goals of the project is the automatic acceptance of claims if they are not processed within a specific time frame. Therefore, main indicators for the process are throughput time, claim acceptance rate and first pass yield. In the measure phase, the workshop participants went into the details of the PM model. All process activities were logged with timestamps and connected to potential influence factors, such as product group, location, country, division, customer and order volume. The main process indicators could be visually analysed both via Figure 17-3 and inside the software when browsing through each step or following the flow. The execution counts of each step could be broken down into process variants, leading, for example, to different endings of either accepted or rejected claims. Checking for conformance was possible, as well as comparing the discovered model with others from employee workshops or work instructions to identify deviations.

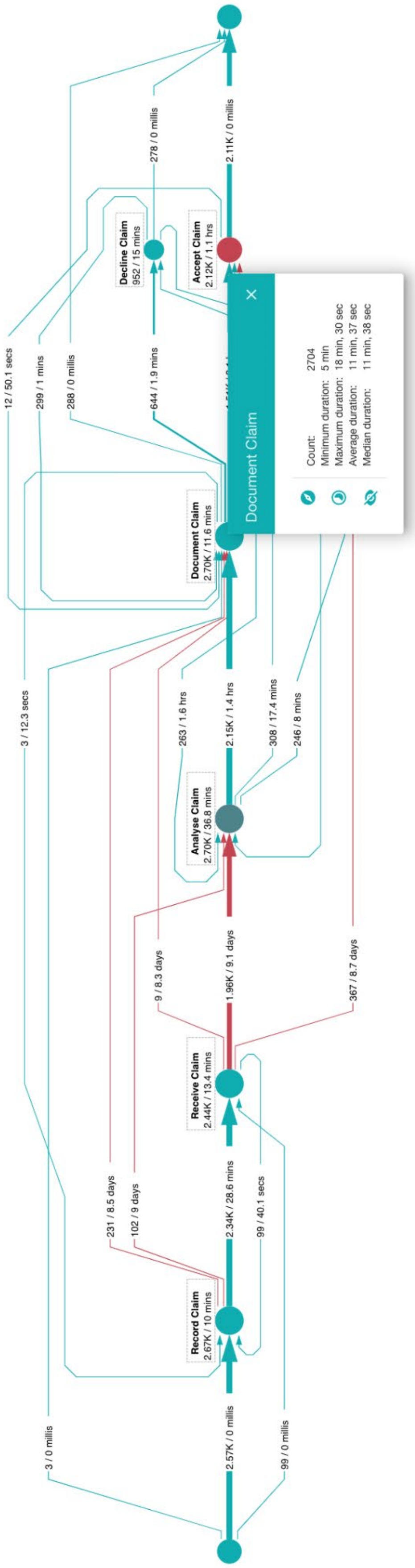

Figure 17-3: Process visualisation from the LANA Process Mining software

In the analyse phase of the experimental project, different attributes and their influence on the key indicators were compared to find the most important influence factors. This analysis was triggered by specific expectations of the workshop participants; that is, which factors to analyse. Alternatively, an automatic mode could already highlight the most significant influence factors. In our experiment, a clear bottleneck was identified, as more than 60% of claims were processed after more than 10 days. This delay was even worse for a single product group. At this point, the work should be continued in the classical 6S way by including more data sources, process analyses and expert opinions to find the most significant influence factors, which will be addressed in the improve phase. A typical aspect for improvement is the optimal allocation of human resources. The PM analysis can support this allocation as it provides the processing times and quantities. In the control phase, the PM system can be used to take over some of the process control activities to create continuous process monitoring to sustain the project's improvements.

After discussing both the approach to integrating PM in the DMAIC and the technical experiment, the workshop focused on discourse about which processes would benefit most from PM. The results are as follows:

First, most activities of the process should be implemented digitally or be continuously supported by IT systems that store process data about the executions, such as timestamps, sequence of activities and so on. Workflow management systems are a good example. If only a small section of the process is handled digitally, the benefits are very limited. This is one of the major limitations of using PM in 6S projects in general.

Second, historical data are relevant for process analysis and improvement. PM can only deliver its full potential benefit if high volumes of historical data are available for the process analysis. Another option is the real-time PM, which is more complicated, has higher requirements for the process and can only process new cases and not potentially large amounts of already stored data from past executions.

Third, the more complicated, time-consuming and/or costly the manual data collection in a project or problem setting, the greater the potential benefits of PM for the 6S project.

Another major point of discussion centred on concerns about data quality. A traditional element of the measure phase is the measurement system analysis (MSA) in which the project manager must validate the repeatability and reproducibility of the measurements. The accuracy, trueness, biases, stability, and linearity of the measurements are of interest as well. The MSA can be very time consuming and, if the results are not good enough, the measurement system must be significantly changed, leading to further project extensions. Regarding data quality, we agree with Hoerl et al. (2014) on the importance of the following ‘building blocks of statistical thinking’: clear problem statement, process understanding, analysis strategy, variation sources, quality data, domain knowledge, sequential approach and modelling process. High-quality analysis is not achieved by just ‘pushing a button’ to let the PM software solve every problem. The mentioned domain knowledge and process understanding let the project manager decide how to set the analysis scope and how to interpret its results.

Workshop participants who were experienced 6S coaches typically ask questions like, ‘Do you completely trust your data?’ or ‘Would you bet money on the accuracy of your data?’ during project coaching meetings. Big data is characterised to handle four qualities: volume (size of data), velocity (rate of data production), variety (format of data) and veracity (uncertainty/reliability of data) which are called the four V’s (Belhadi et al. 2019; Tiwari et al. 2018). Some authors also mention up to three more V’s, such as value (analytical usefulness, Addo-Tenkorang and Helo 2016; Shukla and Mattar 2019). Without high data quality (‘Veracity’), the best algorithms and technologies cannot be successful (Saha and Kumar 2018). On the contrary, they can deliver inaccurate results, misleading projects into wrong directions (Hazen et al. 2014). The more data you can use, the more challenges that can arise regarding how to receive a deep understanding of the data generation process and how to carefully derive correct theories out of the data (Terwiesch 2019). PM can also bring a positive impulse for working on data quality. Especially during the setup process of PM, data quality insufficiencies can be identified, and the data generation can be improved. The introduction of PM can therefore serve as a trigger comparable to the classical MSA to raise the data quality to a required higher level. Not only 6S projects can profit from this development.

At the end of our evaluation workshop, we asked the participants to assess PM’s use for 6S and the DMAIC. We will use this information to compare it with the case study evaluation. The categorisation of PM’s usefulness and applicability in each DMAIC phase was discussed in the group and is summarised in Table 17-3. Some participants pointed out, that the evolution of PM software capabilities could change this Table’s judgements, especially if the enhancement type of PM becomes more powerful in the future.

Table 17-3: Six Sigma experts’ evaluation of PM types and the DMAIC

PM Aspects	Define	Measure	Analyse	Improve	Control
Discovery	medium	high	high	low	low
Conformance	low	medium	high	low	high
Enhancement	low	low	low	medium	low
Potential Benefits	low	high	high	low	medium

17.3.3 Case Study Evaluation

The use of real data (or field data) can be seen as a minimum requirement for empirical research (Fisher et al. 2020). After already using field data for the technical experiment, we planned to expand this aspect with a (multi) case study. The aim of executing case studies in DSR is to apply an artefact to a real-world situation and to evaluate its effect (Peffers et al. 2012a). Furthermore, using a case study for evaluation is the most popular way for the design artefact type 'method' (Peffers et al. 2012a). A second purpose was to evaluate the impact and applicability outside of theoretical development and expert opinions. We chose a multi case study in a cooperating company for this purpose, to directly compare a 6S project including PM support with a classical 6S project. We therefore intended to keep as many project characteristics the same as possible between the two to reduce external disturbances in our case experiment (Yin 2018).

Based on our previous evaluation cycles, we required a suitable cooperation partner that already was very process driven and used information systems in most of its main process steps. For a valid evaluation of our method, we also needed pre-existing 6S know-how in the company to not mix our own experiment with general 6S pilot project challenges. The chosen case study company was founded through the integration of several companies specialising mainly in copper as well as aluminium and steel alloys. It is a world leader in the production of wires and rods of various copper-based alloys and in heavy industry, such as aerospace, oil and gas, energy, rail, and small-scale equipment and manufacturing. Particularly interesting for our research was that in this context the company has a fully integrated manufacturing process. All products are manufactured in 10 complementary production plants, which all offer industrial technologies (foundry, extrusion, forging, hot forming, wire drawing, finishing). This specificity guarantees a comprehensive traceability and thus a very data-intensive software solution for resource planning. Further case study information is summarised in Table 17-4.

Table 17-4: Case study company overview

Aspect	Description
Employees (Full time equivalents)	~1,100
Turnover	~220 million EUR
Production Volume	30,000 tonnes of foundry capacity, 20,000 tonnes of press capacity, more than 100 mechanical machining centres
Experience with Six Sigma	Four years. Used in two departments with six employees each. 119 processes were analysed by using 6S. 38 6S projects and 17 Lean projects successfully completed before the 6S-PM-experiments started.
Experience with Process Mining	Only brief discussions about PM before starting the experiments. Initiated by three employees as PM experts who subsequently modelled and analysed 85 processes during less than a year.

Instead of implementing PM software systems of commercial market leaders like *Celonis* or *Lana Labs*, we decided to use *ProM*, an academic open source solution originally developed by the team of professor van der Aalst. Main reasons for this decision were that we did not want to be bound by license restrictions or slowed down by purchasing processes. Our experiment should also only be a proof-of-concept which would not prevent the company from later licensing a commercial solution.

Suitable 6S project candidates were identified together with the company management in a preliminary selection process. The internal control of the projects was maintained by a central project champion who was the common contact person for both project teams. The teams consisted of two green belts each. Depending on the requirements and progress of the project, the project members individually selected the appropriate 6S methods and tools. For the PM project though, a PM software introduction came first, providing them with most important functionalities of *ProM*.

We conducted semi-structured interviews to periodically keep in contact with the current progress and experiences during all project (DMAIC) phases. To cross-check personal impressions and evaluations from the project teams, we examined the applied PM methods like sequence diagrams, working time analyses and process visualisation changes during improve iterations. Interview partners included the project teams, the projects' champion, and the head of lean management. When both projects came to an end, we added validation and retrospective interviews until we found that our incremental learnings from the cases became minimal and were saturated (Eisenhardt and Graebner 2007; Glaser and Strauss 2017).

The overall feedback for the PM evaluation was very positive and the employees were highly motivated to experiment with the new methods and tools in their project. The software training phase took about one week, before the PM project could start with their 6S work. The IT department struggled at first, when they could not clearly define what results the new PM software was supposed to deliver. In many cases, only the process owners usually know best which results they consider valid and beneficial. We learned from these experiences that if PM technology is to be integrated, the process owners should be involved in the implementation from the start. Their early participation also can increase the acceptance of this new project approach.

Because of the PM training and configuration, the classical 6S project had a head start. They were 'caught up' during the improve phase though, when the other team could use the PM functionalities to quickly test changes in the process structure and the effect of changes of influential factors. The team that followed the 6S approach was very much oriented towards the activities and procedures of the actual processes and used only established and predefined concepts. This team worked according to a waterfall-like method with clearly defined phases and milestones (traditional DMAIC, see Figure 17-4). In comparison to PM, the classical 6S team was not able to analyse several potential optimisation scenarios. Also, the interactions between the optimisations, the influences on decisions and the significance of all factors for the result could not be mapped holistically in this project. This 6S team simply lacked the ability to determine the indirect effects of an optimisation in real-time. In contrast, the PM team was able to prescriptively visualise the effects of an optimisation by comparing several possible optimisation scenarios. But the project using classical 6S tools was successful and found an important bottleneck in the process which led to long throughput times. The static Work-in-Process (WIP) analysis is a classical tool for analysing the amount of process instances in the different steps of the overall process.

Generally, PM could be used to analyse the WIP dynamically in every possible state of the process for the entire period stored in the databases. Surprisingly, the PM project team did not immediately find the same bottleneck. First, it was overwhelmed by the mass of data and huge number of possible analyses. They could reconstruct the workflow through PM between an ERP system, a business intelligence system, and ordinary office software. The PM software found many process flows ending in ways and places that were not defined or intended by the process owners. That enabled us to identify the phenomenon of the so-called mass fragmentation of enterprise data in the company for the first time. Here, a lot of secondary data had been stored in backups and archives, multiple copies on data storage mediums or in the ERP system. This unused data, which remains hidden in the depths of the different storage platforms, is also known as 'dark data', a topic of special interest in the field of big data analytics (Gartner 2019; Lugmayr et al. 2017).

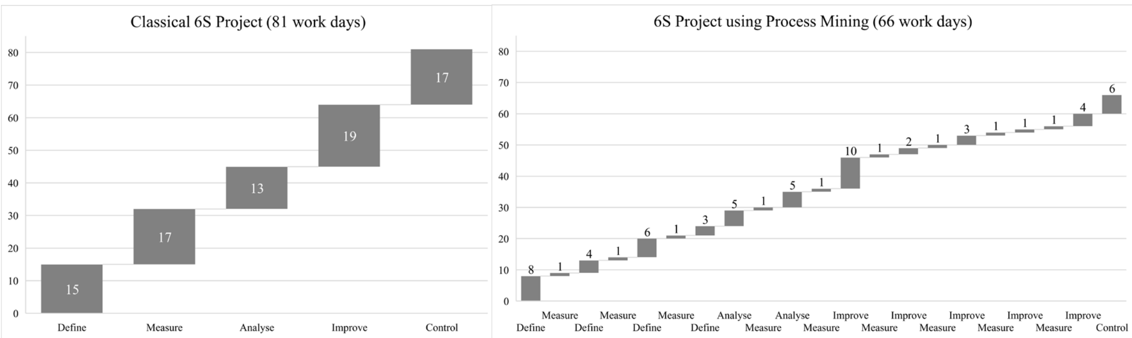

Figure 17-4: Project structure comparison

In contrast to the classical 6S project, the PM project followed an agile approach as shown in Figure 17-4. Instead of a static waterfall model, the project members repeatedly switched back and forth between phases such as Measure and Improve. This behaviour demonstrated a digital design of experiments where the project team quickly tested changes and their potential outcomes in several quick iterations (Alblas and Notten 2020). The company explicitly welcomed these short-loop experiments in comparison to traditional 6S projects that usually take several months. The total sum of work days spend with the projects also shows that the PM project was faster and therefore needed less worktime. The project benefits also exceeded the expectations, as the PM team could reduce the number of (machine) process steps necessary to handle copper-based products. Two production lines were involved that caused different costs. Even though the number of process steps on the low cost production line slightly increased by about 12%, these additional costs were more than compensated by 74% less steps necessary in the high cost production line. The box plot diagram in Figure 17-5 visualises these situations before and after the PM project.

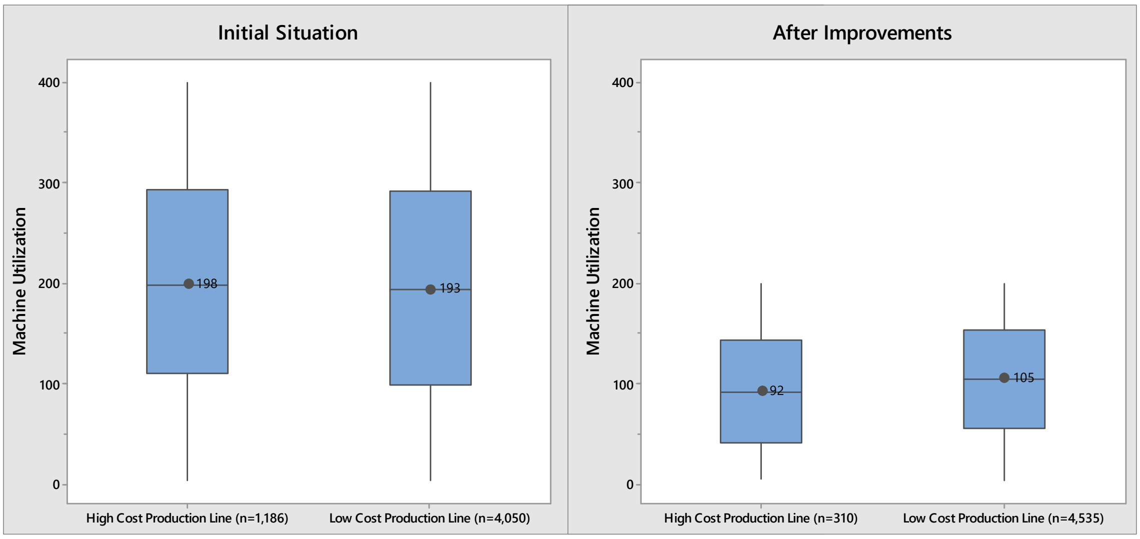

Figure 17-5: Box plot analysis of processes before and after improvement

In comparison, the PM project turned out to be more explorative in nature. It led to more information that had not been known before, compared to a more predictive and descriptive classical 6S project. PM can therefore be even more useful for processes which are not known in all details and variants. However, PM often offers a level of granularity which can be way too detailed, and the users can lose the overview quickly. It is especially important to stick to the 6S philosophy, identify cause and effect, create hypotheses, and test or verify them. The project team ignored this procedure frequently and seemed to view PM as an (too) easy way to manage the entire DMAIC cycle. A few individual analyses were supposedly sufficient to describe a situation and identify developments in the 6S project. The project members believed that they understood the key figures and their influencing variables from PM well enough and were thus able to evaluate them. We learned from this observation, that PM used in 6S projects can lead the risk of simplifying the presentation of complex content. Therefore, PM should never stand as the sole source of process performance information or project benefit control. A process mining analysis must always be combined with an opportunity to provide much more comprehensive information.

After completing both case study projects, we asked all project members as well as the head of IT and the head of process improvements to critically assess PM's use for 6S and the DMAIC. Their evaluation results are summarised in Table 17-5, showing different opinions regarding the three PM types and the potential benefits of PM in the DMAIC phases. During these interviews, the head of IT compared PM to a *contrast medium* for microscopes. It helps to track all detailed paths of a process, but you also have to know what to look for. If not, you could miss the linkages or influences on the paths and could 'get lost in data'. Another visual comparison was made by the company's head of process improvement. He spoke about PM as an *x-ray machine* for the process flow. The company should use it to compare as-is processes during the measure phase with the improved processes during the control phase to re-measure the WIP, the performance, and the achieved benefits of improvement activities.

Table 17-5: Case study participants' evaluation of PM types and the DMAIC

PM Aspect	Define	Measure	Analyse	Improve	Control
Discovery	low[3] / high[1,2]	high	high	low[3] / medium[2] / high[1]	low
Conformance	medium	high	high	low[3] / medium[2] / high[1]	high
Enhancement	low[3] / medium[1,2]	high	medium[3] / high[1,2]	high	low[1,2] / high[3]
Potential Benefits	low[3] / medium[1,2]	high	high	medium[2,3] / high[1]	medium

[1]: Project team members; [2]: Head of IT; [3]: Head of Process Improvement

17.4 Conclusion

We developed a method for integrating PM into the DMAIC cycle, evaluated and improved it with the help of an expert workshop, a technical experiment and, finally, used a case study to proof its practical applicability. The implementation results and the discussions with 6S experts show that PM is well suited to enrich the 6S toolset. The digital event logs proved to be very valuable sources for 6S improvement projects. PM supports and expedites the documentation, improvement and control of processes, which may leave project managers with more time for improving processes rather than preparing manual analyses. Therefore, we recommend the integration of PM into the 6S toolset. It can be a very useful enhancement for projects where PM software is already available in an organisation, or if the project allows time for its initial implementation.

The analysed process must be executed in digital systems like workflow management or enterprise resource planning systems to create the needed digital traces. The case study interviews showed that PM can requires quite complicated introduction mechanisms and a wide range of previous knowledge. In particular, the expansion possibilities of PM if it is to be used for 6S must necessarily be adapted to the individual circumstances of an organisation or even a project. We also found several concerns reoccurring during our research project. The data quality is of utmost importance for valid 6S hypotheses as well as PM and big data analytics in general. Also, a comprehensive data and IT architecture significantly influences the potential and success of PM. Human factors form another major aspect. Project leaders always have to keep in mind, how to use PM as a tool in their overall 6S project agenda, how to 'ask' the right questions, formulate hypotheses and test them. They should not use PM as the single source of information and benefit control.

One major outcome of our evaluation cycles is the assessment of PM's potential and applicability during each DMAIC phase. The 6S workshop experts often gave different answers than the case study participants. The opinions within the two groups differed as well. Most potential for PM is seen in the measure and analyse phases. As they are the core of 6S and data analytics, PM can support 6S in quantifying process problems, identifying causes and finally quantifying their effect. A major difference of opinion can be found about the improve phase. The 6S workshop participants currently see only low potential for PM here, with a potentially more positive future, when the enhancement type of PM is developed further. However, the case study showed, that PM can already be used to test and verify improvement activities and therefore directly support and accelerate a successful improve phase. Applying PM in the define and control phases has consistently been rated to be of low or medium value.

17.4.1 Limitations and Outlook

Our design science project demonstrates the potentiality of our idea (Iivari 2007) and can only mark the beginning of research about the combination of 6S and PM. The presented method's maturity should still be categorised as a proof-of-concept (Gregor and Hevner 2013), an early stage design science object. Our method was only applied in a first company and its unique process environment. Furthermore, we used *Lana PM* in our technical experiment and the case study project team used selected features of the *ProM* software. We did not systematically test all of their functionalities or those of competing software products. We could demonstrate positive feedback by 6S experts as well as a successful implementation of our method. However, even after careful evaluation, our work shows many opportunities for further tests and applications: ‘Building valid theories requires empirical testing and, usually, reiteration of the research cycle’ (Meredith 1993).

Future research should therefore extend the analysis scope and diversity in dimensions such as new application domains. For this purpose, researchers could use case studies or action research to observe or execute further real cases of PM and 6S in companies. The goal of our method is to create value for organisations to increase their performance in ways that cannot be reached by classical methods or only with higher cost. Specifying and quantifying this value therefore can be another aspect of future research. When evaluating and comparing software products, their individual effect and potential for 6S could be assessed. Furthermore, we see PM as a valuable connection to process automation activities. A combination with robotic process automation (RPA) was also recommended in a recent study by Gartner (2018) and promises a good fit with the DMAIC cycle to be implemented during a 6S project. PM could help to prioritise the process steps and identify those where the return on investment (ROI) of an automation solution is highest (Leno et al. 2020).

18 PEPA: Entwicklung eines Scoring-Modells zur Priorisierung von Prozessen für eine Automatisierung

Table 18-1: Fact sheet publication P13

Titel:	PEPA: Entwicklung eines Scoring-Modells zur Priorisierung von Prozessen für eine Automatisierung
Publication Type	Journal
Publication Outlet	HMD Praxis der Wirtschaftsinformatik
Ranking[1]	**D**
Authors	**Name** Plattfaut, Ralf Koch, Julian Trampler, Michael Coners, André
Status	Published
Full Citation	Plattfaut, R.; Koch, J.; Trampler, M.; Coners, A. (2020): PEPA: Entwicklung eines Scoring-Modells zur Priorisierung von Prozessen für eine Automatisierung. In: *HMD 57* (6), S. 1111-1129. DOI: 10.1365/s40702-020-00670-3.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

PEPA: Entwicklung eines Scoring-Modells zur Priorisierung von Prozessen für eine Automatisierung

Zusammenfassung

Robotic Process Automation (RPA) bezeichnet eine Technologie, die die einfache Erstellung von Computerprogrammen (sogenannten Bots) zur Automatisierung von IT-gestützten Geschäftsprozessen über die graphische Benutzeroberfläche ermöglicht. Aktuelle Forschungsbemühungen im Themenfeld RPA haben gezeigt, dass der erfolgreiche Einsatz von RPA allem voran ein realistisches Erwartungsmanagement und eine ausgiebige Prozessaufnahme erfordert (Asatiani and Penttinen 2016; Enriquez et al. 2020; Syed et al. 2020). Diese Resultate zeigen die Notwendigkeit von Bewertungsmethoden zur Bestimmung und Klassifizierung von Prozessen im Hinblick auf ihre Verwendbarkeit im Rahmen von RPA (van der Aalst et al. 2018a).

In der Arbeit werden Ergebnisse eines mehrstufigen Design-Science-Research-Projekts im Kontext eines mittelständischen Industrieunternehmens vorgestellt. Genutzt werden dafür strukturierte mehrstufige qualitative Expertenbefragungen mit dem Ziel der Modellbildung. In diesem Projekt wird demnach ein neues Bewertungsmodell zur Messung der Eignung für eine RPA-Implementierung und eine detailliertere Potenzialanalyse entwickelt (PEPA, Prozesseignung und -Priorisierung für Automatisierung). Das PEPA-Modell, von der Konzeptualisierung bis zur Implementierung, konzentriert sich auf seine verallgemeinerbare Anwendung und bietet ein systematisches Vorgehen zur Eignungsanalyse von Prozessen. Es berücksichtigt dabei wirtschaftliche, technologische und prozessuale Kriterien und ermöglicht eine anschließende Priorisierung der Prozesse in Bezug auf ihre Eignung für eine RPA-Implementierung. Damit geht das vorgeschlagene PEPA-Modell über bestehende Modelle aus der Praxis hinaus.

Abstract (Englische Zusammenfassung des Artikels)

Robotic Process Automation (RPA) is a technology that allows the easy development of computer programs (i.e., bots) which automate computerized business processes through the usage of Graphical User Interfaces. Current publications show that successful RPA implementations especially require a realistic management of stakeholder expectations and an in-depth process analysis (Asatiani and Penttinen 2016; Enriquez et al. 2020; Syed et al. 2020). These results underline the need for decision support models to estimate impact of RPA on business processes, and, as such, prioritize business processes for RPA implementation (van der Aalst et al. 2018a).

In this article we present results of an iterative Design Science Research project. The project was conducted in the context of a medium-sized industrial company. The overall aim is to create and evaluate a new scoring model for the prioritisation of business processes for automation. The created model offers systematic support in evaluating different processes, ranks these processes with regards to monetary, technological and process-oriented criteria and, thus, allows a prioritisation of processes.

18.1 Einleitung

Automatisierung von Geschäftsprozessen hat einen enormen Einfluss auf die Effizienz in Unternehmen. In einer Studie des McKinsey Global Institute wird postuliert, dass bis zu 50% aller heute ausgeführten Tätigkeiten automatisiert werden können (Manyika et al. 2017). Die Untersuchung von Prozessautomatisierung in der Wirtschaftsinformatik ist nicht neu. Van der Aalst und Kollegen nennen die Automatisierung von Geschäftsprozessen eine grundlegende Frage der Wirtschaftsinformatik (van der Aalst et al. 2018a). In der Tat sind in den vergangenen Jahrzehnten durch Produktionsplanungs- und steuerungssysteme, Warenwirtschaftssysteme, Enterprise Resource Planning (ERP) Systeme und weitere Technologien wie Workflow Management oder Business Process Management (BPM) Systeme hohe Anteile von heute ablaufenden Prozessen automatisiert worden (Mohapatra 2009; Sumner 2005; van der Aalst et al. 2018a).

Robotic Process Automation (RPA) ist ein vergleichsweise neuer, leichtgewichtiger Ansatz zur Automatisierung von Geschäftsprozessen (Lacity et al. 2015; Øvrelid and Halvorsen 2018; Plattfaut 2019). Auch wenn es noch keine einheitliche Definition von RPA gibt, ist doch klar, dass ein Kernbestandteil von RPA die Automatisierung von Geschäftsprozessen durch einfach zu erstellende Software-Roboter (Bots) ist, die die Graphische Nutzerschnittstelle (Graphical User Interface, GUI) von existierenden Systemen bedienen. Diese Bots imitieren so die Interaktion von Nutzern mit Anwendungssystemen und ermöglichen eine Automatisierung ohne Veränderung der zu automatisierenden Anwendungssysteme. Dadurch können mit RPA Automatisierungslösungen für Geschäftsprozesse schneller und kostengünstiger entwickelt werden, als mit traditionellen Methoden (Czarnecki et al. 2019; Lacity et al. 2015; Mendling et al. 2018; Penttinen et al. 2018).

Grundsätzlich sind verschiedene Prozesse zum Einsatz von RPA geeignet. Die Literatur stellt hier insbesondere repetitive und regelbasierte Prozesse in den Vordergrund (Czarnecki et al. 2019; Hofmann and Günther 2019; van der Aalst et al. 2018a). Gleichzeit scheint auch klar, dass mit Hilfe von RPA die Automatisierung von bisher vernachlässigten Prozessen lohnenswert erscheint (Plattfaut 2019; van der Aalst et al.

2018a; van der Aalst et al. 2018b). Hierdurch kommen in Unternehmen eine Vielzahl von möglichen Prozessen in Frage. Die aktuelle Forschung stellt dabei heraus, dass noch ungeklärt ist, „*welche Charakteristiken einen Prozess geeignet für RPA-Unterstützung machen*" (van der Aalst et al. 2018a).

Dieser Artikel berichtet von einem praxisnahen Forschungsprojekt zur Entwicklung des Scoring-Modells PEPA (Prozesseignung und -Priorisierung für Automatisierung) für genau diese Fragestellung. Mit PEPA kann die Eignung von Prozessen für eine RPA-Implementierung vergleichend gegenübergestellt und eine erste Priorisierung der Prozesse für eine RPA-Implementierung ermittelt werden. PEPA berücksichtigt dabei wirtschaftliche, technologische und prozessuale Kriterien und ermöglicht eine anschließende Priorisierung der Prozesse in Bezug auf ihre Eignung für eine RPA-Implementierung. Dieses Vorgehen ist angelehnt an etablierte Verfahren zur Entscheidungsfindung und entsprechende Vergleichsmethoden (Wei et al. 2005). Das PEPA-Modell wurde dem Design-Science-Research-Ansatz (Hevner et al. 2004) folgend in verschiedenen Build-/Evaluate-Zyklen in enger Zusammenarbeit mit einem Industrieunternehmen entwickelt und getestet.

Der verbleibende Artikel ist wie folgt strukturiert: Zuerst wird das Themenfeld RPA genauer erläutert. Danach wird auf Scoring-Modelle als Gegenstand des Design Science Research eingegangen. Das konkrete Forschungsdesign und der Fallstudienhintergrund werden kurz erläutert. In Kapitel 5 werden die Ergebnisse aus der Entwicklung und Anwendung von PEPA vorgestellt. Der Beitrag schließt mit den Schlussfolgerungen, Implikationen für Forschung und Praxis sowie möglichen anschließenden Forschungsfragen.

18.1.1 Robotic Process Automation

Wie in der Einführung erläutert, ist die Optimierung und Automatisierung von Geschäftsprozessen eines der Kerngebiete der Wirtschaftsinformatik (van der Aalst et al. 2018a). Die Automatisierung von Geschäftsprozessen hat eine direkte Verbindung zu den aktuellen Digitalisierungsherausforderungen von Unternehmen, die beispielsweise unter dem Schlagwort „*Arbeitswelt 4.0*" oder „*Digitale Transformation*" behandelt werden (Czarnecki et al. 2019; Hofmann and Günther 2019; Meier et al. 2019; Niesen et al. 2019). Dabei reicht die Automatisierung von Geschäftsprozessen von der einfachen Automatisierung von einzelnen Aufgaben oder Aktivitäten bis hin zur Automatisierung von vollständigen Ende-zu-Ende-Geschäftsprozessen (Dumas et al. 2018).

In den vergangenen Jahrzehnten wurden Geschäftsprozesse auf vier verschiedene Arten automatisiert (Mohapatra 2009; Penttinen et al. 2018): Erstens werden Kernanwendungssysteme, z.B. ERP-Systeme, um regelbasierte automatisierte Verarbeitung von Anwendungsfällen erweitert. Zweitens werden BPM-Systeme zur automatischen Steuerung von Prozessen eingeführt. Drittens können mit Hilfe von Middleware-Systemen verschiedene Anwendungssysteme über definierte Schnittstellen verknüpft werden. Viertens werden spezialisierte Werkzeuge zur Automatisierung von klar definierten Anwendungsfällen eingesetzt.

Im Gegensatz zu diesen eher traditionellen Methoden der Geschäftsprozessautomatisierung ist RPA ein leichtgewichtiger Ansatz, der es erlaubt, ohne Eingriffe in bestehende Anwendungssysteme Prozesse zu automatisieren (Lacity et al. 2015; Plattfaut 2019). Dabei werden mit Hilfe von RPA-Systemen sogenannte Bots erstellt, die über die Präsentationsschicht/GUI existierende Systeme bedienen. Diese Bots imitieren die Interaktion von Nutzern mit den Anwendungssystemen (Lacity et al. 2015; Mendling et al. 2018; Penttinen et al. 2018). Hierbei werden Bots hauptsächlich in regelbasierten und repetitiven Prozessen eingesetzt (Czarnecki et al. 2019).

Die Besonderheit bei RPA ist die einfache Erstellung der Bots weitestgehend ohne manuelle Programmierung. RPA-Systeme ähneln Skripten, Screen-Scraping oder Makros (Czarnecki et al. 2019) und greifen auf vorgefertigte Standardbausteine zurück. Die Erstellung von RPA Bots gilt dementsprechend als einfach, benötigt wenig Fachwissen und wird als No-Code oder Low-Code bezeichnet (Lacity et al. 2015).

Durch diese einfache Erstellung ist RPA für die Automatisierung einer zweiten Welle von Prozessen geeignet. Während durch die oben erwähnten, eher traditionellen Ansätze vor allem jene Prozesse automatisiert wurden, die bei maximaler Häufigkeit der Prozessdurchführung großen Wert für das Unternehmen generieren (van der Aalst et al. 2018a), wird durch RPA die Automatisierung von Prozessen wirtschaftlich, die bisher aufgrund der geringeren Häufigkeit unwirtschaftlich war (Penttinen et al. 2018; van der Aalst et al. 2018a). Van der Aalst und Kollegen verdeutlichen diesen Zusammengang graphisch (vgl. Abbildung 18-1): In der Abbildung sind schematisch alle Aufgaben einer Organisation in absteigender Häufigkeit der Durchführung abgetragen. Die häufig auftretenden Aufgaben sind in vielen Fällen schon durch traditionelle Methoden der Automatisierung angegangen. In den weniger häufig auftretenden Aufgaben ist eine traditionelle Prozessautomatisierung zu teuer. Hier kann mit RPA jetzt der mittlere Bereich der Aufgaben angegangen werden. Dies sind Aufgaben, die eine mittlere Häufigkeit haben und wo sich ein entsprechender RPA-Einsatz rentiert. Es verbleiben jedoch weiterhin Aufgaben, die von Menschen durchgeführt werden (van der Aalst et al. 2018a; van der Aalst et al. 2018b)

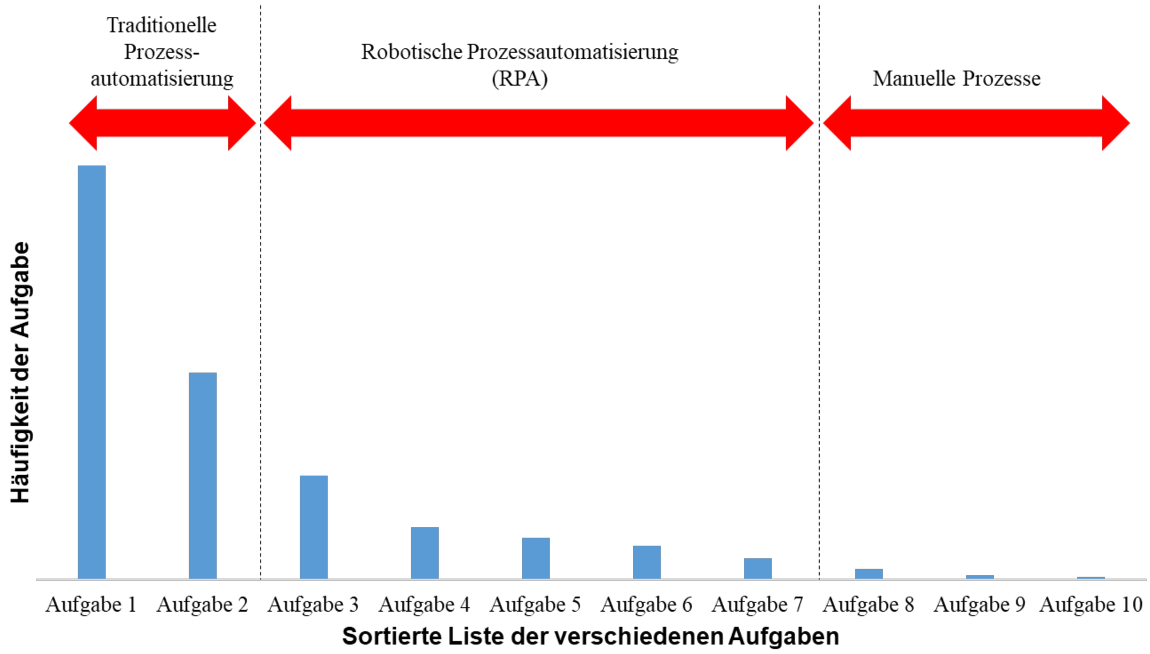

Figure 18-1: Schematische Darstellung von Aufgaben, deren Häufigkeiten und einer Eignung für Automatisierung nach van der Aalst (2018a)

Während die Identifikation der häufigsten Aufgaben in Unternehmen vergleichsweise einfach ist, fällt gerade im mittleren Bereich die Auswahl und Priorisierung für RPA häufig schwer. Die obige schematische Darstellung berücksichtigt darüber hinaus nur die Häufigkeit der Aufgaben. Andere Autoren fordern aber auch, dass in dieser Entscheidungssituation Effektivitäts- und Effizienzziele sowie nichtmonetäre, intangible Nutzeffekte Berücksichtigung finden müssen (Czarnecki et al. 2019). Es bedarf eines Priorisierungsmodells zur Identifikation geeigneter Aufgaben und Prozesse für die Automatisierung mit RPA (Czarnecki et al. 2019; van der Aalst et al. 2018a).

18.1.2 Scoring-Modelle als Gegenstand des Design Science Research

Scoring-Modelle sind als ein Erkenntnisgegenstand der Wirtschaftsinformatik etabliert. So wurden beispielsweise Scoring-Modelle zur Auswahl von geeigneten IT-Projekten entwickelt (Gerogiannis et al. 2010; Muralidhar et al. 1990). Grundsätzlich sind Scoring-Modelle, zum Beispiel in Form der Nutzwertanalyse, auch für die Auswahl von zu beschaffenden Anwendungssystemen geeignet (Bensberg 2019). In den jüngeren Jahren wurden aus der Forschung heraus häufig Reifegradmodelle zur Bewertung von spezifischen Situationen und Unternehmen und zur Entsprechenden Präskription von Entwicklungspfaden entwickelt (Becker et al. 2009; Poeppelbuss et al. 2011).

Design Science Research ist ein gestaltungsorientiertes Forschungsparadigma zur strukturierten Entwicklung von Artefakten, die auf wissenschaftliche Theorien aufbauen und real existierende Probleme lösen (Becker et al. 2020; Hevner et al. 2004). Dabei besteht die Forschung aus verschiedenen Build-/Evaluate-Zyklen. In diesen Zyklen werden aufbauend auf konkreten Fragestellungen von Organisationen (Relevanz der Forschung) sowie wissenschaftlichen Grundlagen, Theorien und Methoden (wissenschaftlicher Rigour) Artefakte entwickelt und evaluiert. Aufbauend auf den Evaluationsergebnissen können dann die entwickelten Artefakte wieder weiterentwickelt werden, womit der nächste Build-/Evaluate-Zyklus startet. Zur Evaluation der Artefakte können neben analytischen Überlegungen auch andere empirische Verfahren wie Fallstudien oder Feldstudien eingesetzt werden (Hevner et al. 2004).

Die Untersuchung und Entwicklung von Scoring-Modellen im Design Science Research hat Tradition in der nationalen und internationalen Wirtschaftsinformatik (Becker et al. 2009; Mettler 2011). Dabei werden Scoring-Modelle aufbauend auf bestehenden wissenschaftlichen Veröffentlichungen entwickelt und dann in der Realität in Fallstudien getestet. Die Erkenntnisse der Fallstudie tragen dann zu einer Verfeinerung des Scoring-Modells bei. Ein ähnlicher Ansatz wird in dem hier vorliegenden Beitrag durchgeführt.

18.2 Forschungsdesign

Das hier vorgestellte Forschungsprojekt zur Entwicklung des Scoring-Modells PEPA folgt dem Design Science Research-Ansatz (Hevner et al. 2004). Mit dem PEPA-Modell kann die Eignung von Prozessen für eine RPA-Implementierung transparent beurteilt und eine erste Abschätzung der Priorisierung der Prozesse erstellt werden. In diesem konkreten Fall startet die Entwicklung mit empirisch gesammelten Evaluationsergebnissen aus der Anwendung eines existierenden Priorisierungsmodells eines Beratungsunternehmens in der Praxis. Darauf aufbauend werden iterativ vier der oben dargestellten Build-/Evaluate-Zyklen durchlaufen (vgl. Abbildung 18-2).

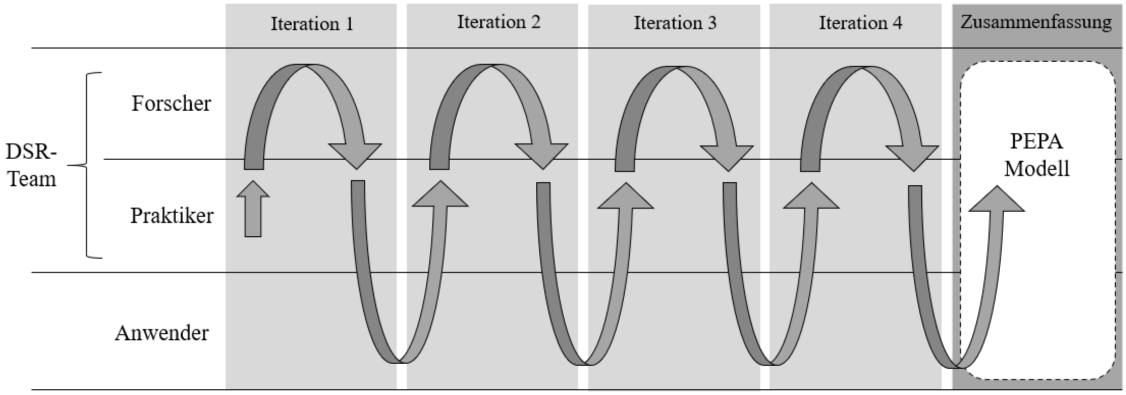

Figure 18-2: Build-/Evaluate-Zyklen zur Entwicklung des PEPA-Modell in Anlehnung an Sein et al. 2011

Zur Entwicklung des Scoring-Modells wird ein integriertes DSR-Team aus Praktikern und Hochschulangehörigen gebildet. Dieses DSR-Team übernimmt die Evaluation und Weiterentwicklung des Modells. Iterativ wird das Modell von Anwendern getestet - die Ergebnisse dieser Anwendungen dienen dann zusammen mit weiteren Daten als Grundlage für den nächsten Evaluationsschritt des DSR-Teams. Details zu den einzelnen Entwicklungsschritten finden sich in Tabelle 18-1.

Die Praktiker und Anwender sind dabei Mitarbeiter eines Unternehmens im Bereich der Metallverarbeitung. Das untersuchte Unternehmen beschäftigt weltweit 800 Mitarbeiter und produziert jährlich mehr als 500.000 Tonnen gewalzte Stahlbänder und -profile an Standorten in Europa, Nord- und Südamerika und Asien. Das Unternehmen ist ein unabhängiges, mittelständisches Unternehmen in Familienbesitz, das ein nachhaltiges und kontinuierliches Wachstum in den Märkten der Zukunft anstrebt. Damit kann das Fallstudienunternehmen als typisches mittelständisches Unternehmen, wie es Daten in Deutschland häufig anzutreffen ist, bezeichnet werden. Parallel zur fortschreitenden Internationalisierung wurden die deutschen Standorte in den letzten Jahren systematisch weiterentwickelt. Hierbei setzt das Unternehmen überwiegend auf das ERP-System SAP ohne individuelle Programmierung oder Customizing. Diese Rahmenbedingungen wurden von uns bewusste gewählt, um eine größtmögliche Generalisierbarkeit erreichen zu können.

Sowohl die Investition in innovative Technologien als auch die damit verbundene zunehmende Vernetzung der Prozesse tragen dazu bei, dass die Forcierung von Prozessautomatisierung im Unternehmen zu einer strategischen Priorität geworden ist. Hier sollen durch den Einsatz von RPA neue Kapazitäten geschaffen werden, indem Mitarbeitern, die bisher mit der Sachbearbeitung betraut waren, mehr Freiraum gegeben wird und diese sich somit auf wertschöpfende Tätigkeiten konzentrieren können. Als Hauptschwächen wurden bereits die mangelnde Anpassung der Prozesse an die sich ändernden Anforderungen an die Fertigung im internationalen Kontext, die geringe Prozessqualität und die geringe Anpassungsfähigkeit der Prozesse festgestellt. Als vorrangiges Handlungsziel wurde anschließend die Reduzierung von Fehlerquellen definiert, was wiederum zu weniger Nachbearbeitung im Prozess und damit zu geringeren Prozesskosten führen soll.

Die Anwender rekrutieren sich aus direkt beteiligten RPA-Nutzern und RPA-Entwicklern. Wir haben darauf geachtet, Benutzer und Entwickler nacheinander zu befragen, um im Interview auf ihre Ansichten eingehen zu können. Auch aus dem Gesichtspunkt der Vorerfahrung eignen sich die gewählten Anwender gut: fünf Teilnehmer haben eine Ausbildung zum operativen Prozessmanager, ein Teilnehmer eine Weiterbildung im Prozesscontrolling und die übrigen Teilnehmer eine Grundausbildung in Geschäftsprozessmanagement und „*Control Objectives for Information and Related Technology*“ durchlaufen. 7 Teilnehmer haben Erfahrung in der Entwicklung von RPA-Bots, wobei 3 Teilnehmer derzeit abteilungsübergreifend Roboter für das gesamte Unternehmen entwickeln.

Table 18-2: Entwicklungsschritte des Forschungsprojekts

Entwicklungs-schritt	Aktivitäten	Ergebnis
Anwendung eines bestehenden Modells	• Eigenständige Anwendung eines bestehenden Modells zur Priorisierung aus einem Beratungsunternehmen durch das Praxisunternehmen	Modell wurde für nicht geeignet befunden, Start des gemeinsamen Forschungsprojekts
Evaluate I	• Evaluation des bestehenden Modells und Ableitung von Ex-Ante-Anforderungen durch gemeinsamen Workshop mit Wissenschaftlern und Mitarbeitern des Praxisunternehmens (Controller Geschäftsbereich Services, Head of Finance and Controlling)	Identifiziertes Verbesserungspotential für das Scoringmodell PEPA
Build I	• Erstellung eines ersten Prototypens für PEPA (PEPA 0.1) aufbauend auf den Evaluationsergebnissen sowie Erkenntnissen aus der Literatur	PEPA 0.1 mit 12 Attributen in zwei Kategorien
Evaluate II	• Anwendung von PEPA 0.1 auf 16 Prozesse (u.a. Validierung von Verbrauchsstellen, Abrufen intervallgemessener Energieverbräuche, Abrechnung und Abrechnungsgenehmigung) • Analyse von Kopfdaten von 36 Abschluss- und Zwischenberichten vergangener Prozessoptimierungen zur Vorbereitung der Experteninterviews und Identifikation von Merkmalsausprägungen. Kopfdaten enthielten Information zu Fachbereich, Laufzeit, Projektkategorie enthielten und wurden durch Daten zu Arbeitspaketen, Ressourceneinsatz,	Identifiziertes Verbesserungspotential für PEPA 0.1, insb. in Bezug auf die Ausgestaltung der Attribute sowie deren Bewertung

	Abweichungen/Qualitätsschlussfolgerungen angereichert. Analyse erfolgt sowohl qualitativ im Forscherteam und automatisiert durch text mining und Topic Modeling. • Durchführung von 16 semistrukturierten Experten-Interviews mit Anwendern von PEPA 0.1. • Analyse von 672 Standardprotokolldateien zur Ex-post-Evaluierung der zugrundeliegenden Prozesse. Diese Standardprotokolle werden automatisch bei Start und Beendigung sowie Auftreten von Systemfehler durch den Roboter erzeugt. Analyse erfolgte mit Hilfe von Text-Mining-Algorithmen, die eine regelbasierte Klassifikation von Fehlermeldungen, eine Ontologie/Taxonomie-Modellierung der Fehler und eine entsprechende Informationsvisualisierung beinhalteten. • Analyse von 144 Debugging-Protokollen mit Aktivitätsnamen, Datentypen, Variablenwerten, Argumenten usw. zur weiteren Abschätzung der Merkmalsausprägungen.	
Build II	• Erstellung eines zweiten Prototypens für PEPA (PEPA 0.2) aufbauend auf den Evaluationsergebnissen	PEPA 0.2 mit 12 definierten Attributen mit klar abgegrenzten Merkmalsausprägungen in zwei Kategorien
Evaluate III	• Anwendung von PEPA 0.2 auf dieselben 16 Prozesse • Durchführung von 11 semistrukturierten Experten-Interviews mit Anwendern von PEPA 0.2 (u.a. Junior SAP-Berater SD / Geschäftsprozesse, SAP Key User / weltweite Projekte, Ingenieur Software-Prozesse und -Tools, Controller für den Geschäftsbereich Service)	Identifiziertes Verbesserungspotential für PEPA 0.2, insb. in Bezug auf die Gewichtung der Attribute
Build III	• Erstellung eines dritten Prototypens für PEPA (PEPA 0.3) aufbauend auf den Evaluationsergebnissen	PEPA 0.3 mit 12 definierten Attributen mit klar abgegrenzten Merkmalsausprägungen und entsprechenden Gewichtungen in zwei Kategorien
Evaluate IV	• Anwendung von PEPA 0.3 auf dieselben 16 Prozesse • Durchführung von 12 semistrukturierten Experten-Interviews mit Anwendern von PEPA 0.3 (u.a. Controller Geschäftsbereich Services, Head of Finance/Controlling)	Notwendige Anpassungen der Attributgewichte von PEPA 0.3
Build IV	• Anpassung der Attributgewichte und Erstellung von PEPA 1.0	PEPA 1.0 mit überarbeiteten Attributgewichtungen

18.3 Entwicklung und Anwendung des Scoring-Modelles

18.3.1 Bewertungskriterien und -Attribute

In der Praxis unterliegt die Auswahl der Bewertungskriterien naturgemäß der Subjektivität (Bhushan and Rai 2004). Die bisher verfügbaren Bewertungskriterien der Beratungsunternehmen waren im untersuchten Unternehmen zu „*diffus*“ und „*nicht differenziert genu*g“ (Head of Finance and Controlling), zu „*intransparent*“ (Ingenieur Software-Prozesse und -Tools) sowie zu „*abstrakt*“ (Controller Geschäftsbereich Services). Für den Anwender stellte das bestehende Modell keine Entscheidungshilfe dar, ob der Prozess mithilfe von RPA, automatisierungsfähig ist.

Im Rahmen von Interviews wurden die Mitarbeiter zunächst unter Zusicherung von Anonymität nach ihrer persönlichen Einschätzung zu möglichen, wichtigen Kriterien befragt. Bereits in der ersten Befragungsrunde hatte sich ein Konsens der Befragten herauskristallisiert, auf welche Kriterien sich das Modell stützen sollte. Dabei zeigte sich, dass die Automatisierbarkeit und die wirtschaftlichen Auswirkungen für die Entscheidungsfindung von besonderer Bedeutung sind. Diese beiden Hauptkriterien der Automatisierungseignung und der wirtschaftlichen Auswirkungen wurden aus der ersten Interviewrunde herausgearbeitet und im Laufe der Entwicklung durch das DSR-Team und die Anwender weiter verfeinert. Dabei wurde das Hauptkriterium der Automatisierungseignung in drei neue Hauptkriterien (Ausschlusskriterien, Gütefaktoren und Stärkungskriterien) zerlegt. Ausgehend von diesen (in Summe vier) Hauptkriterien entwickelten sich im Laufe der Iterationszyklen 12 Bewertungskriterien. Ausgangslage war dabei eine Überprüfung der bisherigen Literatur (Bu and Xu 2009; Lacity et al. 2011; Mahmoodzadeh et al. 2009; McIvor 2008; Wang and Yang 2007; Wreford 2017; Yang et al. 2007) und in Summe 39 semi-strukturierte Interviews mit Mitarbeitern aus relevanten Abteilungen wie Controlling, Organisation, Personalwesen und Verwaltung. Auch die so verfeinerten Bewertungskriterien wurden in Gruppendiskussionen im Anschluss an jede Interviewrunde iterativ immer wieder voneinander abgegrenzt und so mit jedem Entwicklungszyklus eindeutiger definiert.

In Summe wurden so vier Hauptkriterien mit jeweils zwei bis vier Kriterien erarbeitet. Dabei werden die Hauptkriterien in ihrer Reihenfolge bearbeitet. Zuerst werden Prozesse auf vorliegende Ausschlusskriterien überprüft. Danach werden Kriterien erhoben und in das Modell eingepflegt, die die Effektivität und Effizienz der Automatisierung maßgeblich beeinflussen (Gütefaktoren). Als nächstes werden mit Stärkungskriterien Faktoren erfasst, die die Vorteile von RPA in den Prozessen verstärken können. Schließlich werden unter dem Punkt wirtschaftliche Auswirkungen, die bis dahin gesammelten Informationen über Kostenfaktoren und die damit verbundenen Kosteneffekte erfasst. Die einzelnen Kriterien werden im Folgenden detailliert vorgestellt:

- Ausschlusskriterien sind Kriterien, welche zur effektiven Automatisierung zwingend notwendig sind
  - Prozessart: RPA kann nur in Prozessen, die weitgehend regelbasiert sind, effektiv eingesetzt werden. Der Roboter ist nicht in der Lage, eigene Entscheidungen zu treffen oder zwischen zwei Alternativen abzuwägen.
  - Datenquelle: Der Roboter arbeitet absolut fehlerfrei, solange die auszuwertenden Daten in der Computerumgebung zur Verfügung stehen. Dazu müssen die Daten in strukturierter Form vorliegen.
  - Automatisierungsaufwand in anderen Systemen: Die Implementierung einer RPA-Automatisierung lohnt sich nur, wenn der Prozess nicht bereits in anderen Systemen automatisiert wurde. RPA als Brückenlösung ist ebenfalls möglich.
- Gütefaktoren sind Kriterien, welche die Effektivität und Effizienz der Automatisierung maßgeblich beeinflussen
  - Datentyp: Der Roboter verfügt über eine vergleichsweise gute Bilderkennung, die jedoch nicht 100%ig genau ist. Systembrüche, wie das Lesen gescannter Dokumente, sind zu vermeiden.
  - Stabilität: Der Software-Roboter arbeitet über die Benutzeroberfläche wie ein Mensch. Eine Veränderung dieser, z.B. durch Updates, muss vermieden werden, da sonst der Programmablauf des Roboters überarbeitet werden muss.
  - Standardisierung: Ein standardisierter Prozess hilft bei der Umsetzung von RPAs und der Verbesserung der Prozesse im Allgemeinen. RPA stärkt den Standardisierungsprozess, indem immer das gleiche Verfahren angewendet wird. Dabei spielt es bei der Standardisierung keine Rolle, ob ein Prozess viele Varianten oder eine komplexe Ausführungstiefe hat. Hier ist die Existenz von durchgängigen, eindeutigen und systemisch abbildbaren Geschäftsregeln zur Identifizierung der richtigen Prozessvariante von primärer Bedeutung.

  - Risiko: Prozesse, die im Falle eines Ausfalls des RPA-Systems nicht kritisch in den Betriebsablauf eingreifen, sind immer vorzuziehen.
- Stärkungskriterien verstärken die Vorteile von RPA
  - Komplexität: Geeignete Prozesse können gestrafft werden und dürfen nicht zu viele verschiedene Varianten oder Zweige haben. Viele Ausführungsalternativen führen zu einem geringeren Grad der Automatisierungstauglichkeit.
  - Fehleranfälligkeit (manuelle Bearbeitung): Wo Menschen Fehler machen, arbeitet der Roboter fehlerfrei, was die Qualität der Ergebnisse des automatisierten Prozesses verbessert.
  - Beteiligte Anwendungen und Systeme: RPA ist überall dort sinnvoll, wo viele verschiedene Anwendungen und Systeme eingesetzt werden müssen, da hier keine Schnittstellen programmiert werden müssen.
- Wirtschaftliche Auswirkungen sind Kriterien, die zur monetären Bewertung eines Prozesses hinzugezogen werden
  - Bearbeitungsdauer: Die Durchlaufzeit für die Bearbeitung des Prozesses. Je länger die Bearbeitungszeit, desto größer ist das Einsparpotenzial durch die Automatisierung.
  - Fallhäufigkeit: Die Häufigkeit der Prozessdurchführung in einem bestimmten Zeitraum. Je regelmäßiger ein Prozess vorkommt, desto größer ist das Einsparpotenzial durch die Automatisierung.

Im nächsten Schritt wurde für jedes der Kriterien Bewertungsskalen erzeugt. Diese wurden ebenfalls in den verschiedenen Build-/Evaluate-Zyklen schrittweise überarbeitet.

18.3.2 Bewertungsskalen der Kriterien

Die Bewertungskriterien kommen in der Praxis in unterschiedlicher Ausprägung vor. Diese Ausprägungen geben an, in wie fern ein Kriterium erfüllt ist. In den Build-/Evaluate-Zyklen hat es sich als vorteilhaft herausgestellt, die Extrempunkte der Skala zu beschreiben und dazwischen eine numerische Bewertungsskale mit 1 bis 5 Punkte einzuführen. Die Leistungsbeurteilung der Mitarbeiter spiegeln die Extrempunkte in den Skalen wider (vgl. Tabelle 18-3). Bei der späteren Bewertung können Ermessensspielräume vorliegen, und somit empfiehlt es sich, die Punktvergabe durch ein Team durchzuführen.

Table 18-3: Erklärung der Extremwerte der Bewertungsskalen

Kriterien	Bewertungsskalen	
Ausschlusskriterium: Prozessart	entscheidungsbasiert - Die Prozesse erfordern mehr als 50% manuelle Entscheidungsfindung, die durchlaufen werden müssen. Es gibt keine binären Entscheidungswege oder die Bearbeitung durch einen Sachbearbeiter ist obligatorisch, weil keine Entscheidungsregeln gefunden werden können	regelbasiert - Strukturierter Prozessablauf, für den es wiederkehrende Regeln und klare Handlungsanweisungen gibt
Ausschlusskriterium: Datenquelle	unstrukturiert und analog - Mehr als 50% der im Prozess genutzten Datensätze hatten mindestens einen Fehler, der nicht durch Plausibilitätsprüfungen entdeckt werden kann. Mehr als 50% der im Prozess genutzten Datensätze müssen digitalisiert oder in ein anderes Format übertragen werden	strukturiert und digital - Alle für den Prozessdurchführung benötigten Daten liegen in geordneter, strukturierter und plausibilisierter Form vor
Ausschlusskriterium: Automatisierungs-aufwand in anderen Systemen	niedrig - Abbildung des Prozesses im bestehenden Workflow-Management-System und Ausführung als modellierter Workflow möglich. Die Prozessabbildung ist unter Verwendung der Entscheidungslogik und der Verarbeitungslogik eines bestehenden Business Rule Management Systems (BRMS) möglich	hoch - Bis dato existieren keine Workflow-Management-Systeme, Business Rule Management-Systeme oder integrierte Automatisierungslösungen im Unternehmen
Gütefaktor: Datentyp	Bilderkennung - Die erforderlichen Daten müssen zunächst durch Texterkennung aus verschiedenen Dokumenten, wie gescannten Papierdokumenten, PDF-Dateien oder digitalen Bildern, in Textinformationen umgewandelt werden	zahlenbasiert - Die Daten liegen vollständig in maschinenlesbaren und formatierten Formaten vor
Gütefaktor: Stabilität	häufige Updates - In der Vergangenheit wurde der Prozessablauf mindestens alle 8 Wochen angepasst, modifiziert, überarbeitet oder ergänzt	wenige Veränderungen - In der Vergangenheit gab es innerhalb von 24 Wochen keine Anpassungen oder Ergänzungen für mehr als einem Prozessschritt
Gütefaktor: Standardisierung	gering - Es gibt mehr als 5 Prozessvarianten, die sich in ihrer Umsetzung erheblich unterscheiden. Die Auswahl der Prozessvariante basiert nicht auf einer zu definierenden Logik oder die Prozessdynamik lässt keine Standardisierung zu	hoch - Standardmäßig wird der Prozess nur in einer Variante ausgeführt. Er ist vollständig dokumentiert und bereits optimiert
Gütefaktor: Risiko	hoch- Kritischer Geschäftsprozess, der bei einem Systemausfall nicht rechtzeitig	gering - Geringe Kritikalität, mit einer maximal tolerierbaren

	aufrechterhalten oder wiederhergestellt werden kann	Ausfallzeit von 48 Stunden und unkritischen Wiederanlaufverfahren
Stärkungskriterium: Komplexität	komplex - Der Prozessfluss hat mehr als 5 Ausführungspfade, oder nicht alle verwendeten Ausführungspfade sind ausreichend erfasst und dokumentiert. Es ist nicht uneingeschränkt möglich, eine funktionale Logik für die Pfadauswahl zu definieren.	einfach - Der Prozessfluss ist vollständig modelliert und dokumentiert und folgt einfachen und transparent ohne Variationsmöglichkeiten der Abläufe. Ein vollständiger und konsistenter Satz von Prozessregeln steht zur Verfügung
Stärkungskriterium: Fehleranfälligkeit (manuelle Bearbeitung)	gering - Geringe Fehleranfälligkeit (weniger als 1 Fehler in 1000 Prozessdurchläufen), z.B. durch robustes Benutzerkonzept, unterstützende Benutzeroberflächen oder vorhandene Plausibilitätsprüfungen	hoch - Mehr als 5 Fehler pro 100 Prozessausführungen, die auf menschliche Faktoren wie fehlerhafte Datenübertragung und Benutzerfehler zurückzuführen sind
Stärkungskriterium: Beteiligte Anwendungen & Systeme	wenige - Nur ein beteiligtes System	viele - Mehr als 4 Systeme oder Medienbrüche in primären Prozessen und sekundäre Prozesse im ERP-System und anderen Unternehmensinformation ssystemen
Wirtschaftliche Auswirkung: Bearbeitungsdauer	gering - Der Prozess erfordert 7% der monatlichen Arbeitszeit pro Prozessverantwortlichen	hoch - Der Prozess erfordert mehr als 20% der monatlichen Arbeitszeit pro Prozessverantwortlichem
Wirtschaftliche Auswirkung: Fallhäufigkeit	selten - Unter 4 Prozessdurchführungen pro Monat	oft - Über 20 Prozessdurchführungen pro Monat

Im Verlauf der Entwicklung von PEPA hat sich gezeigt, dass die Kriterien eine unterschiedlich hohe Gewichtung für die Einschätzung der Gesamteignung eines Prozesses für eine Automatisierung mit RPA haben. Diese Gewichtung wurde im letzten Schritt in mehreren Build-/Evaluate-Zyklen entwickelt.

18.3.3 Gewichtung der Kriterien

Nachdem die einzelnen Zielkriterien festgelegt worden waren, wurden diese gewichtet. Die Gewichtung zeigt dabei die relative Bedeutung der einzelnen Kriterien für die entsprechende Frage nach einer Automatisierungseignung oder den wirtschaftlichen Auswirkungen.

Zur Ermittlung der Gewichte wurden die verschiedenen Kriterien jeweils paarweise verglichen. Dieser Erhebungsprozess fand anonym und schriftlich in einem mehrstufigen Editierprozess statt, der teilweise mit Rückmeldungen der Befragten verbunden war. Die befragten Mitarbeitenden verglichen die verschiedenen Kriterien paarweise in mehreren Runden individuell mittels einer schriftlichen Umfrage. Dort wurde ebenfalls abgefragt, ob die Kriterien völlig unabhängig voneinander seien, um eine mögliche doppelte Gewichtung der Kriterien zu vermeiden. Als Diskussionsgrundlage erhielten die Mitarbeitenden dann die anonymisierten Gesamtergebnisse jeder Runde zur Kenntnisnahme. Diese Ergebnisse wurde für jedes Kriterium jeweils anhand einer Durchschnittswertberechnung ermittelt.

Daran schloss sich dann eine weitere Runde zur weiteren Diskussion, Klärung und Verfeinerung der Gewichtung an. Die unterschiedlichen Angaben der befragten Mitarbeiter hinsichtlich der individuellen Gewichtungen wurden dann einander gegenübergestellt. Nach drei Runden konnte die Spannweite der Gewichtungen im Konsensverfahren reduziert und verfeinert werden, sodass ein Endergebnis erzielt wurde. Da die Gewichte im DSR-Prozess empirisch ermittelt wurden, werden diese abschließend auf 100 normiert, um einen Gesamteignungsgrad in Prozent zu erhalten.

In der Version 0.3 des vorgestellten PEPA-Modells konnte demnach in der letzten Iterationsstufe für jeden Prozess durch Bestimmung der Eigenschaften der Attribute festgestellt werden, inwieweit der jeweilige Prozess das jeweilige Kriterium erfüllt. Durch Multiplikation des Erfüllungsgrades eines Attributs mit den in Version 0.3 für die jeweilige Organisation definierten Gewichtungsfaktoren kann dann für jeden untersuchten Prozess die Automatisierungseignung bzw. die wirtschaftlichen Auswirkungen ermittelt werden.

18.3.4 Gesamtmodell und Anwendung

Zur Vereinfachung der Anwendung von PEPA wurden die dargestellten Überlegungen in Bezug auf Kriterien, Bewertungsskalen und Gewichtungen in ein Software-Tool überführt. Dieses Tool ermöglicht die graphische Eingabe der Einschätzungen je Prozess und berechnet dann automatisiert die Gesamteignung in Prozent (vgl. Abbildung 18-3).

Scoring-Modell Prozessauswahl für RPA-Einsatz								
Kriterium		**Bewertungsskala**						
Ausschlusskriterium		**1**	**2**	**3**	**4**	**5**		
Prozessart	entscheidungsbasiert	☐	☐	☐	☐	☑	regelbasiert	
Datenquelle	unstrukturiert und analog	☐	☐	☐	☐	☑	strukturiert und digital	
Automatisierungsaufwand in anderen Systemen	niedrig	☐	☐	☐	☑	☐	hoch	
Gütefaktor		**1**	**2**	**3**	**4**	**5**		
Datentyp	Bilderkennung	☑	☐	☐	☐	☐	zahlenbasiert	
Stabilität	häufige Updates	☐	☐	☑	☐	☐	wenige Veränderungen	
Standardisierung	gering	☐	☑	☐	☐	☐	hoch	
Risiko	hoch	☐	☐	☐	☐	☐	gering	
Stärkungskriterium		**1**	**2**	**3**	**4**	**5**		
Komplexität	komplex	☐	☐	☑	☐	☐	einfach	
Fehleranfälligkeit (man. Bearbeitung)	gering	☐	☐	☐	☐	☑	hoch	
Beteiligte Anwendungen & Systeme	wenige	☐	☐	☐	☐	☑	viele	
Wirtschaftliche Auswirkung		**1**	**2**	**3**	**4**	**5**		
Bearbeitungsdauer	gering	☐	☐	☑	☐	☐	hoch	
Fallhäufigkeit	selten	☐	☑	☐	☐	☐	oft	

Figure 18-3: Grafische Benutzeroberfläche des Scoring-Modells zur Prozessauswahl für einen RPA-Einsatz

Bei der Anwendung von PEPA in einer Organisation werden typischerweise fünf Schritte durchlaufen. Zuerst werden einmalig die Gewichtungen der Kriterien angepasst. In ersten Diskussionen und Anwendungen von PEPA mit weiteren Organisationen stellte sich heraus, dass die Priorität der Kriterien je nach Lage der Organisation unterschiedlich ist. Als nächstes müssen für jeden Prozess die Kriterien bewertet werden. Dazu dienen die in Kapitel 5.1 und 5.2 dargestellten Beschreibungen und Skalierungen. Das Modell berechnet dann drittens automatisch ein Gesamtergebnis je Prozess (vgl. Abbildung 18-4) und bildet darauf aufbauend viertens einen Entscheidungsvorschlag in Form einer Rangfolge der einzelnen Prozesse. Als letztes muss dieser Entscheidungsvorschlag diskutiert und verabschiedet werden.

Kriterium	Punkte	Gewichtung	Ergebnis
Automatisierungseignung			
Prozessart	5	2	10
Datenquelle	5	1,5	7,5
Datentyp	4	1	4
Automatisierungseignung			
Stabilität	1	1	1
Komplexität	3	0,75	2,25
Standardisierung	2	1	2
Risiko	4	1	4
Automatisierungseignung			
Beteiligte Anwendungen & Systeme	3	0,5	1,5
Fehleranfälligkeit (man. Bearbeitung)	5	0,5	2,5
Automatisierung in anderen Systemen	5	1,5	7,5
Wirtschaftliche Auswirkung			
Bearbeitungsdauer	3	3	9
Fallhäufigkeit	2	3	6
Ergebnisse			
Automatisierungseignung	**50 / 65%**		
Wirtschaftliche Auswirkung	**18 / 35%**		
Gesamt-Ergebnis	**68 / 100%**		

Figure 18-4: Grafische Benutzeroberfläche des Scoring-Modells zur Prozessauswahl für einen RPA-Einsatz

18.4 Zusammenfassung, Fazit und Ausblick

Dieser Artikel stellt die Ergebnisse eines DSR-Projekts zur Entwicklung des Scoring-Modells PEPA für die Eignung von Prozessen für die Automatisierung mittels RPA dar. Ursprünglich baut PEPA auf existierenden, in der Praxis verwendeten Modellen sowie wissenschaftlicher Literatur zu RPA auf. In vier Build-/Evaluate-Zyklen wurde das Modell dann schrittweise bei einem Fallstudienpartner aus der Industrie verfeinert.

Die Vorteile der Anwendung von PEPA für das Fallstudienunternehmen lagen zunächst in den formalen Entscheidungsstrukturen und der standardisierten Kommunikation über die ausgewählten Prozesse. Die Anwendung von PEPA bedeutete jedoch zunächst auch einen höheren Aufwand, da die benötigten Informationen zwar vorhanden waren, aber gesammelt und geordnet werden mussten. Durch die Anwendung bei dem Fallstudienunternehmen konnte sich aber trotzdem zeigen, dass die Rolle von PEPA in der Praxisanwendung eher für RPA-Projekte mit geringeren Budgets relevant ist, bei denen bisher wenig oder keine strukturierte Entscheidungsfindung verwendet wurde. Das hier vorgestellte Scoring-Modell unterstützt dabei in der Praxis die Unternehmensführung zusätzlich zu den traditionellen finanziellen Methoden des Entscheidungsfindungsprozesses.

Durch die Anwendung beim in Bezug auf Größe und eingesetzte Kernsysteme durchaus als typisch für den deutschen Mittelstand zu bezeichnenden Fallstudienunternehmen konnte das Bewertungsmodell evaluiert werden. Um eine erste Generalisierung über diesen „*typischen*“ deutschen Mittelstand hinaus zu untersuchen wurde PEPA zusätzlich erfolgreich auf 7 Verwaltungsprozesse einer deutschen Kommunalverwaltung angewendet. Sowohl in Bezug auf Organisationskultur und Größe als auch auf eingesetzte IT-Systeme konnte eine große Kontrastierung zum eigentlichen Fallstudienunternehmen realisiert werden. Die Zielrichtung beider Organisationen, Prozesse untereinander in Bezug auf ihre Eignung für einen RPA-Einsatz zu vergleichen und zu priorisieren wurde dabei stets erfüllt. Besonders bemerkenswert ist, dass in beiden Organisationen die formalen und informellen Entscheidungsprozesse, die in der Vergangenheit für die Auswahl solcher Projekte verwendet wurden, zum ersten Mal vollständig erfasst wurden. Allerdings wurden bei der Anwendung die Gewichte der Kriterien branchenspezifisch angepasst.

Aus der Evaluation in beiden Organisationen konnten die folgenden Vor- und Nachteile von PEPA herausgearbeitet werden. Erstens bietet PEPA einen konsistenten Überblick über den Auswahlprozess und über die Metriken, die die Priorisierungsentscheidung beeinflussen. Zweitens ermöglicht PEPA einen systematischen Ansatz der Informationssammlung und Auswertung über verschiedene Attribute und Ebenen. Dadurch wurde neben der reinen Priorisierungsentscheidung in vielen Fällen auch eine Vielzahl neuer Informationen über den tatsächlichen Prozessablauf hervorgebracht. Drittens konnten die Fallstudienorganisationen durch PEPA die Auswahl bestimmter Prozesse begründen und haben im Verlauf der RPA-Implementierungsprojekte auch mit Verweis auf PEPA an den Entscheidungen festgehalten. Viertens konnten keine logischen Fehler oder intransparenten Priorisierungen identifiziert werden. Hierzu wurden alle in der Praxis generierten Ergebnisse des Modells von den jeweiligen Anwendern und

Experten und anschließend vom Forschungsteam gegengeprüft. Alle untersuchten Prozessgrößen konnten in der erstellten Priorisierungssequenz rekonstruiert und als inhaltlich und formal korrekt eingestuft werden.

PEPA ist insbesondere durch diese Entwicklung mit der Praxis geeignet, auch auf andere Unternehmen transferiert zu werden. Es ermöglicht so Praktikern verschiedener Branchen eine schnelle Priorisierung von Prozessen für die RPA-Automatisierung und spart so trotz kurzfristig höherer Priorisierungsaufwände mittelfristig Kosten durch Vermeidung der Automatisierung von niedrig-prioren Prozessen.

Nichtsdestotrotz ist die Anwendung von PEPA zurzeit noch limitiert. Zum einen ist die Objektivität der Ergebnisse von PEPA als Scoring-Modell eingeschränkt. PEPA beruht auf einer Auswahl von nicht-metrisch skalierten Kriterien und Gewichten, die gegebenenfalls eine Scheinobjektivität erzeugen. In der Anwendung müssen also getroffene Annahmen für Attributsausprägungen hinterfragt werden. Selbst in der letzten Iteration des zugrundeliegenden Modells konnten subjektive Einflüsse der Anwender während der Bewertung der Kriterien nicht immer vollständig transparent dargestellt werden. Um diese Nachteile zu verringern, sollen im weiteren Verlauf unserer Forschung korrelierende Plausibilitätsbeziehungen aus Vergangenheitswerten entwickelt werden, die es ermöglichen sollen, Inkonsistenzen in der Bewertung zu erkennen und zu beseitigen.

Zum anderen ist das Modell zwar aufbauend auf wissenschaftlichen Publikationen in enger Zusammenarbeit mit einem Praxisunternehmen entwickelt und in einer zweiten Organisation angewendet worden, ein skalierter Test über die beiden Organisationen hinaus steht allerdings noch aus. Um eine weitere, größere Verallgemeinerbarkeit zu gewährleisten, müssen Evaluierungen, auch über längere Zeiträume, in Zukunft gemeinsam mit anderen, insbesondere von den betrieblichen Gegebenheiten abweichenden Unternehmen durchgeführt werden.

Zukünftige Forschung könnte sich auch mit der Anpassung des Modells auf eine stärkere Integration von Cognitive Automation und Künstlicher Intelligenz (KI) in RPA befassen. So kann ein Zusammenwachsen von RPA mit diesen fortgeschrittenen Methoden der Prozessautomatisierung beobachtet werden (Kannan 2018). Beispielsweise kann RPA dann Methoden zur Zeichenerkennung (Optical Character Recognition) einsetzen, um auch aus unstrukturierten Bild-Daten strukturierte Informationen abzuleiten. In diesem Fall wird sich möglicherweise die Gewichtung des Gütefaktors Datentyp verändern und der Faktor weniger stark in die Gesamtpriorisierung einwirken. Ähnliche Verschiebungen von Gewichtungen oder Extremwerten der Kriterien können sich auch durch die Integration von anderen fortgeschrittenen und KI-näheren Methoden ergeben.

Abschließend ist das Modell zwar ein Schritt, die von van der Aalst und Kollegen aufgeworfene Forschungslücke zu schließen (van der Aalst et al. 2018a). Hierzu benötigt es jedoch noch weiterer anwendungsorientierter empirischer Forschung, um eine Allgemeingültigkeit des Modells auch für andere Industrien und Branchen sicherzustellen. Außerdem können die verwendeten Gewichte einer weiteren Untersuchung unterzogen werden. Hierzu würden sich beispielsweise Delphi-Studien oder quantitative Umfragen anbieten.

19 'Don´t Believe Your Eyes' - The Problem of Process Mining in Auditing

Table 19-1: Fact sheet publication P14

Titel:	'Don´t Believe Your Eyes' - The Problem of Process Mining in Auditing
Publication Type	Conference Proceedings
Publication Outlet	Proceedings of the 29th Annual European Operations Management Association Conference
Ranking[1]	**n. R.**
Authors	**Name** Koch, Julian Koch, Jannis Vollenberg, Carolin Coners, André
Status	Accepted
Full Citation	Koch, Ju.; Koch, Ja.; Vollenberg, C.; Coners, A. (2022): Don´t Believe Your Eyes - The Problem of Process Mining in Auditing. In: *Proceedings of the 29th Annual European Operations Management Association Conference*.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

‘Don´t Believe Your Eyes’ - The Problem of Process Mining in Auditing

19.1 Introduction

Auditing 2.0, as defined by van der Aalst et al. (2010), is one of the main topics addressed in current research on auditing processes (Austin et al. 2021). In this context, auditors validate information about organisations and their business processes using algorithmic process analysis tools, including AI-based process data analysis (Kogan et al. 2019).

To do this, they need reliable information to determine whether these processes are performed within certain legal and regulatory parameters. In practice, auditors assess the effectiveness of process controls, and if those controls are not in place or not functioning as expected, they typically perform a more in-depth audit (Jans et al. 2014). However, as more detailed information about processes becomes available in high-quality event logs, auditors no longer need to rely on a small number of random samples. Instead, Process Mining (PM) techniques have been increasingly used in auditing in recent years to quantitatively and quasi-integratively assess all events in a business process (Alles 2015; Kogan et al. 2019).

The ubiquity of electronically captured business events combined with PM technology subsequently enables a new form of auditing that has changed and will continue to change the role of auditors. These IT-enabled audit processes also shorten contact and audit times and reduce audit costs (Santis and D’Onza 2021; van der Aalst et al. 2010). Many auditors and companies are aware of this and are increasingly leveraging the power of these technology-based analytics approaches to optimise their audit processes across the board. However, the high use of algorithm-based analytics and the associated aggregation and consolidation of data streams is not without its problems.

The widespread use of PM not only makes it difficult to achieve true objectivity but also opens new possibilities for manipulation that are far more difficult to see through than with traditional audit methods. Audited companies are aware of this and seek to minimize the risks of audit errors in their audit processes. This can lead to the exploitation of certain points of attack by PM methods to suggest apparent objectivity and make manipulation much easier and at the same time much more difficult to detect. With this motivation, our research paper addresses the following two research questions:

RQ1: *What are the ways to detect manipulations in PM data?*

RQ2: *What are the derived design principles to prevent these manipulations?*

19.2 Background

19.2.1 Process Mining

Based on the processing of event data, PM can be used to automatically detect, verify, or improve real processes. PM is associated with many different terms in the literature. Wil van der Aalst sees PM as the connecting element between Data Science and Process Science, combining data-oriented approaches with process-oriented approaches (Leno et al. 2021; van der Aalst et al. 2012a; van der Aalst 2018b). This positioning needs to be followed by a closer look at the two scientific fields mentioned. PM itself is a broad field and encompasses several scientific disciplines with the claim to generate knowledge from existing process data. It is irrelevant in which form the data is available and in which way the knowledge is realized (vom Brocke et al. 2021).

The data source for the reconstruction of retrievable process activity logs are usually information systems used in companies to handle operational business processes (e.g., ERP or MES systems) (Martin et al. 2021; van der Aalst 2018b). In PM, process data extracted from the systems are processed by algorithms and then represented in the form of rules (van der Aalst 2018b). The algorithms are used to evaluate this data in a process-oriented manner, thus closing the gap between the data world and the process world (Grisold et al. 2020a; vom Brocke et al. 2021).

The result is an unadulterated, transparent, traceable data-based representation of reality that makes a decisive contribution to process transparency (Thiede et al. 2018). The claimed added values that can be generated using PM are manifold and range from the determination of throughput times, error sources, or bottlenecks to time or cost forecasts (Grisold et al. 2020b).

PM methods can generally be divided into three main types, with different forms of input and output and relationships between an event log and a process model. PM is applied to discover, check conformance, and enhance real processes (van der Aalst et al. 2012a).

Type one is process discovery (van der Aalst 2018b). It is the best-known process mining method, where event log data is used as input and a true conceptual process model is created and derived from it (Martin et al. 2021). This is done without using any prior information. In this way, a process model can be built based on real event log data alone (vom Brocke et al. 2021).

PM main type two is conformance testing. This involves comparing an existing process model with real event log data of the same process type to check the conformance between the reality, which is documented in the event log data, and the theoretical model, guidelines, or work instructions. The existing theoretical model can either be taken from a previous process discovery or from a manual production (Grisold et al. 2020a). With this type of PM, deviations can be detected and from this point, further analysis can be performed to determine missing process steps or reworks (Ghasemi and Amyot 2016).

The main type three is enhancement, which includes process improvement. An existing process model is adjusted based on information obtained from event log data (van der Aalst et al. 2012a). Adaptation includes both improvement and enhancement of an existing process model. This type is also referred to as performance analysis (Grisold et al. 2020a). This type aims to extend, change or modify the predefined process model (van der Aalst et al. 2012a).

In the scientific community, the application of PM has been classified according to different perspectives in addition to the three types mentioned above (Martin et al. 2021). The corresponding perspectives and views of the data are realized through the development of various PM algorithms (vom Brocke et al. 2021). However, in practice, these perspectives often overlap. In the control flow perspective, all execution paths and their sequence of activities are determined. In scientific works, PM is usually associated with this perspective (Grisold et al. 2020a; van der Aalst 2018b). In addition, there is also the organisational perspective. Here, resource information and the associated assignment of actors to the corresponding roles and organisational units are usually considered. The resulting relationships are thus made visible. The temporal perspective represents another view, where information about the frequency of occurrence and the time frame of events is answered (van der Aalst 2018b; vom Brocke et al. 2021).

In operational practice, so-called preconfigured database connectors (Santos et al. 2020; Ullrich et al. 2021) form an interface from the system world of ERP and MES data to the PM solution (Grisold et al. 2020b). Via the connectors, they provide the process data required for PM from the existing operational database systems (van Dongen et al. 2005). However, when it comes to using „*Connectors*" in the PM implementation, there are, however, major challenges (Mans et al. 2009; Thiede et al. 2018; vom Brocke et al. 2021). These challenges can be summarized into three main issues: Data quality (Garcia et al. 2019), data evaluation (A. Berti et al. 2019), and the interfaces between information systems that have mutual potentials and dependencies but are not visible to the user (Grisold et al. 2020a; Martin et al. 2021; vom Brocke et al. 2021).

19.2.2 Process Mining in Auditing

During the scientific discourse, it is generally agreed that PM can be regarded as a highly effective methodology for uncovering compliance-relevant facts throughout a company and as visual support for forensic data analysis (Jans et al. 2014; Kogan et al. 2019; van der Aalst et al. 2010).

Following on from this, a key part of the audit is indeed the audit of the internal control system. The purpose of this is to ensure that risks of error concerning the company's financial reporting are identified or avoided (Austin et al. 2021; Jans et al. 2014). In practice, the internal control system is usually based on a business process-oriented understanding. However, before business processes can be audited or evaluated, the auditor must develop an understanding of how they function in the company and what internal controls are implemented. Traditionally, this is done based on interviews or process descriptions from the customer's site (Appelbaum et al. 2018). With these classic methods for auditing the internal control system, defined target processes and individual process transactions can be traced via so-called walkthroughs. However, the literature shows that these methods fail in identifying the entire process and any deviations that occur, as companies digitize more and more business processes and implement increasingly complex business processes. Manual auditing is becoming increasingly time-consuming and inefficient (van der Aalst et al. 2010). This also means that individual sub-processes can also be automated, so respondents do not have all the relevant information from the automated process (Alles 2015; van der Aalst et al. 2010). This also reduces the reliability of the information. According to the literature, PM as a technology should enable auditors to quickly understand processes in an unbiased manner during internal control system audits (Kogan et al. 2019; van der Aalst et al. 2010). Through the included analysis capabilities, the essential aspects, and tests, such as testing for separation of duties conflicts or completeness of processes, should be performed in this process.

Following the literature, the PM technology thus makes a tangible contribution for auditors to gain a more comprehensive understanding of processes within the framework of the internal control system (Santis and D’Onza 2021; van der Aalst et al. 2010), to be able to assess processes, to achieve greater audit certainty while saving time, and to relieve the burden of further audits.

19.3 Research Design

In this research, we used an action research approach, which is defined as an inquiry process conducted by and for those who act. The main reason for conducting action research is to help the actor in this case, the research team improve or refine their actions.

One of the main differences with traditional research methods, especially behavioural case study research, is the main goal of this method. Action research is used to generate knowledge and solve problems through the direct involvement of the actors. In recent years, action research in information systems research has focused on business process management (BPM) topics such as process outsourcing, robotic process automation, workflow management systems (Chiasson et al. 2009; Kitchenham et al. 2002; Mathiassen et al. 2009; Vollenberg et al. 2021). However, there are only a limited number of studies on PM in auditing. Therefore, the main objective of this paper is to support the utility of a PM application system in detecting possible manipulations in event logs. According to Peffers et al. (2007), for this purpose, an action research approach is the most appropriate method to perform this type of study. The research design presented here borrows from Pries-Heje et al. (2008) and Davison et al. (2004) and consists of the following 4 main steps - plan-action-evaluation-reflection, shown in Figure 2.

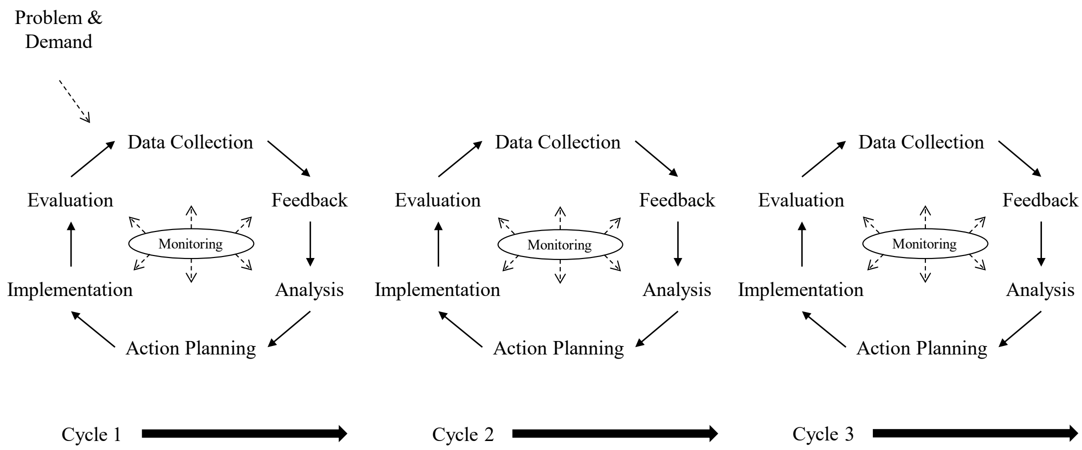

Figure 2: Action research approach

19.3.1 Step 1: Action Planning

The research team included the participation and expertise of an auditor, as well as key contributions from several researchers in BPM and data science. In this phase of the project, team members were tasked with gathering and analysing information about existing manipulations in event logs. Based on the information gathered and the conclusions drawn, the team, with user support, developed a prototype that is the focus of this research.

19.3.2 Step 2: Implementation

In this phase of the study, through regular exchanges between the researchers and practitioners involved, different processes within the target areas were presented, zanalysed, and, if necessary, corrected by the authors. The task in this phase was as follows:

- *Collect and prepare information relevant to the review process.* This group was responsible for collecting and reviewing the existing literature on manipulation evidence in process mining to produce easily understandable formats and simple graphical representations.
- *Expert interview and data extraction.* In this step, experts from auditing and audit-related fields were interviewed to gather information about their experiences with manipulation evidence in databases and data structures. The information collected was then analysed using qualitative content analysis to understand users' attitudes towards the process of manipulation detection and to identify possible patterns. The attitudes and possible patterns were an important part of the next step, which was to design the content of the tool.
- *Designing the tool*. In this step, the prototype version of the tool was designed. This included the representations, semantic modeling, and visual representation of the data structure and data linkage information, as well as the corresponding database schemas. The next step was the programming of the prototype. This step was responsible for the informatics work associated with the programming.

19.3.3 Step 3: Evaluation

After the preliminary prototype of the tool was completed, it was evaluated in a multi-stage process. The participants in the evaluation were three reviewers, two subject matter experts, and two members of the research team. The evaluation of the prototype was conducted using three different methods:

1. Individual interviews and focus groups with audit experts who were not involved in the implementation.
2. Individual and group interviews with members of the research team.
3. Internal assessments during regular team meetings.

All relevant information were recorded in meeting minutes.

19.3.4 Step 4: Data collection, feedback and analysis

The reflection step consisted of a regular exchange format between the team members during each phase of the research process. Team members communicated with each other and shared their views from their different perspectives. This enabled the researchers to retrospectively review their role during this action research and to develop different ways of thinking about the needs of business auditors during the audit process with PM. This in turn became the basis and motivation for the next plan-action-evaluation-reflection circle.

19.4 Findings

The study showed that the auditors interviewed, who had to evaluate the PM results without further context based on the usual evaluation possibilities of existing tools, had problems distinguishing the correct information from the fictitious data. Irregularities were usually not detected. If they were detected, then only by the control group, which had further information from the event logs and, above all, in-depth knowledge of the information systems, especially the database management systems.

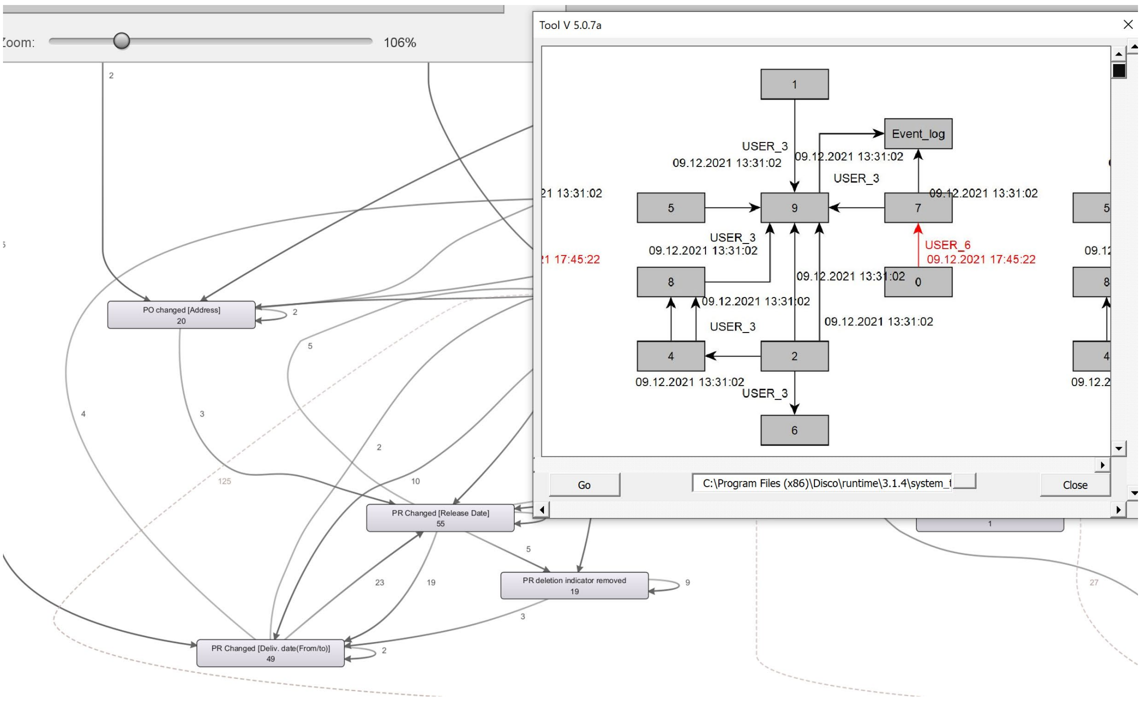

Figure 19-1: Extract from the use of the tool and a detected anomaly in the Event-Logs

However, against the background of the remote audit, which formed a large part of the auditor's thesis, it was criticized that the auditor did not or could not include access to the systems as well as human interaction in his decision-making. Picking up on this, the primary design process of the study presented here addressed the problem that event logs, by their very nature, cannot be verified and validated and therefore do not provide systematic information about manipulations.

The paper also shows that the techniques investigated for historical analysis of processes in organisations are well supported by existing academic and commercial PM tools. However, it becomes clear that the analysis of business processes in the audit environment is not fully covered by current tools. The PM application systems used, require either knowledge of forensic database techniques or deeper data structures of networked information systems at the base level. This paper presents a tool for PM that generates, models, and visualizes the event data of a process directly in the form of a data schema from the source code of the connector used in the PM environment.

The presented tool generates an easy-to-use representation of a data model for the PM application tool *Disco* from the vendors *Fluxicon*, which is based on the prefabricated data, i.e., event log interface. This simplified the PM applications of the cross-system processes for the users in this environment in the company under consideration. The result was a derived design principle of how event logs can be secured against manipulation.

This design principle consists of three building blocks:

- First, *the presentation of the underlying scheme of event log data for the selected process step.*
- Secondly, *the presentation of the time and user data of the last database manipulations.*
- Thirdly, *showing possible inconsistencies or irregularities in the metadata of the database tables used.*

19.5 Conclusion

The research project presented here contributes to the rather underrepresented research area of IT usage risks and in particular the risks of PM technologies in auditing. It demonstrates a design- and application-oriented research approach, which is necessary because new technologies also lead to new audit risks. Thus, on the one hand, the article has high practical relevance for auditing with new technologies but also contributes to the existing design theory for the use of technologies with Big Data and pseudo-objectivity, which have not yet been sufficiently considered by research in this context.

It turns out that almost all information systems record a certain history that is stored in a log - the manipulation of this data is usually not detectable at all or very difficult to detect and leads to a possible false objectification or pseudo-objectivity when examined superficially. The resulting need to minimize usage risks can be considered on two different levels. Firstly, by providing and processing information stored at the meta-level about the information system itself. Secondly, at the less abstract level of reconciling the stored information about the number, timing, and executing users of IT-supported business transactions.

Regardless of the level considered by auditors, the event log records everything that happens in a given environment and, most importantly, it contains contextual data that is beyond the control of the person entering the input data. The added value of the tool presented here lies in the user-oriented provision and processing of this context data and thus ultimately in the possibility of uncovering anomalies that would otherwise remain undetected. As we have shown in this paper, manipulations made subsequently can be detected much better by using the tool on the event data than before.

The results presented here aim to generate prescriptive design knowledge to improve data integrity for PM applications. Our article describes the need for accuracy, completeness, and consistency of data across the PM application span. This also means that the design must ensure that data cannot be changed without being noticed and that the focus is on the traceability of these data changes. Strong integrity means that no data can be changed unnoticed. In this context, we were able to generate knowledge that can help users to recognize the validity and correctness of an event log. The research project presented here contains, in particular, initial findings from practice in this regard and resulting approaches on how exactly the validity and correctness of event logs can be ensured.

However, for a deeper understanding, the approach presented here needs to be further developed and more design science needs to be done on the subject of PM in auditing.

Of course, there are some limitations of this research that we should point out. In an action research setting, which is characterized by holistic participation, the researcher is naturally very subjective. For this reason, accompanying methods such as focus groups or individual interviews should also be used in future research. Future research should also focus on longitudinal studies where researchers follow examiners over a longer period of time to assess their examination practices during the examination process.

As we only focused on a very small group, the results may not be transferable to other fields and application areas, even within auditing, as the context may be different. Therefore, for future research, it would be useful to explore our ideas in other industries to see how the results can be replicated and generalized in other contexts. Further, we only used a single case study, a method that has been criticized, and questioned in terms of the validity and reliability of the findings, as the results often only apply to the specific study and therefore have limited generalisability. Nevertheless, the use of action research was an unconventional and innovative methodological approach, which was characterized by a very flexible approach and provided new contributions to knowledge.

20 Die Entwicklungsbeschleunigung von Robotic Process Automation Lösungen - Fallstudie einer deutschen Gesundheitsbehörde

Table 20-1: Fact sheet publication P15

Titel:	Die Entwicklungsbeschleunigung von Robotic Process Automation Lösungen - Fallstudie einer deutschen Gesundheitsbehörde
Publication Type	Journal
Publication Outlet	HMD Praxis der Wirtschaftsinformatik
Ranking[1]	**D**
Authors	**Name** Vollenberg, Carolin Koch, Julian Bade, Friederike Maria Trampler, Michael Plattfaut, Ralf Coners, André
Status	Published
Full Citation	Vollenberg, C.; Koch, J.; Trampler, M. Bade, F. M.; Coners, A.; Plattfaut, R. (2021): Die Entwicklungsbeschleunigung von Robotic Process Automation Lösungen - Fallstudie einer deutschen Gesundheitsbehörde. In: *HMD* 58 (5), S. 1244-1263. DOI: 10.1365/s40702-021-00764-6.

[1] Ranking according to VHB-JOURQUAL3 of the Verband der Hochschullehrer für Betriebswirtschaft e.V.

Die Entwicklungsbeschleunigung von Robotic Process Automation Lösungen - Fallstudie einer deutschen Gesundheitsbehörde

Zusammenfassung

Krisen erfordern flexibles Handeln und schnelle Anpassungen sowohl von Menschen als auch von öffentlichen Institutionen. Die öffentliche Hand und insbesondere die deutschen Gesundheitsbehörden sind während der Covid-19-Pandemie, beginnend im März 2020, massiv herausgefordert. Die Bewältigung des teilweise exponentiell wachsenden Prozessvolumens durch kurzfristige Infektionsereignisse muss in kürzester Zeit fachgerecht erfolgen und unterliegt einer permanenten Reaktion und Anpassung an sich ändernde Rahmenbedingungen. Bestehende Strukturen und ineffiziente Prozesse erschweren diese notwendige Skalierung der Bearbeitung zunehmend. In diesem Beitrag werden mittels Aktionsforschung Ansätze für eine beschleunigte und flexible Entwicklung von Robotic Process Automation (RPA)-Lösungen zur Automatisierung bestehender Verwaltungsprozesse innerhalb einer betroffenen Gesundheitsbehörde in Deutschland untersucht. Als Ergebnis wurden Ansätze für eine schnellere und weniger komplexe Entwicklung von RPA-Lösungen in einer sehr schnell skalierenden und gleichzeitig stark heterogenen IT-Systemlandschaft erarbeitet und bewertet.

Abstract

Crises require flexible action and quick adjustments from both people and public institutions. The public sector and especially the German health authorities are massively challenged by the Covid-19 pandemic, starting in March 2020. The management of the partially exponentially growing process volumes due to short-term infection (superspreading) events must be carried out professionally in the shortest time possible and is subject to permanent reaction and adaptation to changing conditions. Existing structures and inefficient processes make this necessary scaling of processing increasingly difficult. In this article, approaches for an accelerated and flexible development of Robotic Process Automation (RPA) solutions for the automation of existing administrative processes within an affected health authority in Germany are investigated by means of action research. As a result, approaches for a faster and less complex development of RPA solutions in a very fast scaling and at the same time heterogeneous IT system landscape were elaborated and evaluated.

20.1 Einleitung

Die Wichtigkeit der Digitalisierung und Modernisierung von Verwaltungsprozessen im öffentlichen Gesundheitssektor steigt rasant. In der Krisensituation der Pandemie, die in Deutschland im März 2020 begann, wird diese notwendige Anpassung noch einmal präsenter und gibt einen zusätzlichen Impuls. Die Beteiligten werden mit der bisher ausgebliebenen Digitalisierung konfrontiert. Es müssen schnelle Reaktionen erfolgen. Diese erfordern von den öffentlichen Verwaltungen und Gesundheitsbehörden eine kurzfristige Realisierung und Umsetzung neuer Aufgaben und Prozesse (Hoppe et al. 2020). Dabei erfordert die Pandemie von der öffentlichen Hand flexibles und vor allem reaktionsschnelles Handeln. In dieser Zeit wird besonders deutlich, wie wichtig ein ganzheitlich funktionierendes öffentliches System ist. Bei der Erfassung und Nachverfolgung von akuten Krankheitsfällen stoßen die kommunalen Verwaltungen, insbesondere die Gesundheitsbehörden, zunehmend an ihre Kapazitäts- und Belastungsgrenzen. Zusätzlich stellen sich die fehlende informationstechnische Aufbereitung und der Einsatz uneinheitlicher elektronischer Systeme als Herausforderungen dar und erschweren die Arbeit der beteiligten Verwaltungen (Hoppe et al. 2020; Piwernetz and Neugebauer 2020). Häufig wird weiterhin mit Zettel und Stift gearbeitet und Fallzahlen sowie Testergebnisse müssen händisch, teilweise mit Faxgeräten, weitergeleitet werden (Hoppe et al. 2020). Die aktuelle Pandemie zeigt, dass vor allem die öffentlichen Verwaltungen schnell handeln müssen, um ihre Arbeitsfähigkeit zu sichern (Piwernetz and Neugebauer 2020). Dies beschleunigt wiederum die Digitalisierung . Was zuvor ein eher behäbiger Entwicklungsprozess war, hat nun an Dynamik gewonnen. Die Erfahrungen mit virtuellen Konferenzen, Webinaren, leichtgewichtigen IT-Tools usw. ermutigen viele Verwaltungsmitarbeiter, selbst neue Methoden zu nutzen, um ihre eigenen digitalen Kompetenzen auf- und auszubauen. Aktuelle Untersuchungen zeigen auch, dass sich der durch die Pandemie erzeugte Druck positiv auf die Experimentier- und Veränderungsbereitschaft der öffentlichen Verwaltungen auswirkt.

Dies zeigt aber auch, dass die disparaten IT-Infrastrukturen in den öffentlichen Verwaltungen es erschweren, schnell zu reagieren und flexibel und proaktiv zu agieren. Aufgrund des in Krisenzeiten erhöhten Prozessvolumens werden die Personalkapazitäten zunehmend erweitert und neue Mitarbeiter werden eingestellt. Dieses erforderliche aber enorme Wachstum an Mitarbeitern und das damit verbundene hohe Aufkommen neuer IT-Systeme steigert die heterogenen Strukturen in den öffentlichen Verwaltungen. Hinzu kommt der Einsatz von ständig wechselnden verwaltungsfremden Mitarbeitern, die unter anderem aus dem Ruhestand oder der Bundeswehr hinzu kommen (Augustin 2020; Fricke 2021; Jakobi 2020; Steppat 2021). Der Einsatz von alten Laptops mit unterschiedlichen

Betriebssystemen, veralteten Ordnerstrukturen, variablen Laufwerksstrukturen und die Ausstattung der Mitarbeiter mit neuen Laptops führt zu einer Vielzahl von Problemen und verhindert eine stabile, effiziente und sichere Prozessabwicklung. Neben den heterogenen Systemen arbeiten die Mitarbeiter in unterschiedlichen Verwaltungsgebäuden und im Homeoffice. Die gezwungenermaßen schnell wachsenden IT-Infrastrukturen, das stark abweichende Know-How der neuen Mitarbeiter und das zusätzlich fehlende IT-Infrastukturmanagement in öffentlichen Verwaltungen begünstigen diese Heterogenität weiter und machen eine ganzheitliche Homogenisierung aller Systeme und der gesamten IT-Infrastruktur innerhalb kürzester Zeit unmöglich. Im Gegensatz dazu können sich Organisationen, die zu Beginn der Krise über die entsprechende technische Ausstattung, IT-Infrastruktur und Personal verfügten, schnell auf die neuen Gegebenheiten einstellen und die plötzliche hohe Prozessbelastung zum Teil mit technischen Hilfsmitteln kompensieren (Fricke 2021; Jakobi 2020).

Daraus ergibt sich auf der Forschungsseite ein Begleitbedarf für die Entwicklungsprozesse von Automatisierungslösungen, die in kürzester Zeit direkt auf die Pandemie-Situation skaliert werden müssen. Die Pandemie erfordert hierbei schnelle Reaktionen, so dass der Druck zur Implementierung neuer Prozesse steigt. Die hier erforschte Technologie der Robotic Process Automation (RPA) bringt an dieser Stelle die entsprechenden Voraussetzungen für eine schnelle Automatisierung von Unternehmensprozessen mit und ist somit geeignet für eine entsprechende Entlastung der Mitarbeiter zu sorgen (Asatiani et al. 2019; Penttinen et al. 2018).

Dieser Artikel fokussiert anhand von Aktionsforschung im öffentlichen Sektor zu Krisenzeiten (hier: Pandemie) die Ableitung notwendiger Ansätze, um RPA-Lösungen ad-hoc und mit sehr geringem Aufwand zu entwickeln. Dabei können wir anhand der Automatisierung verschiedener IT-basierter Verwaltungsprozesse aufzeigen, welche Formen der Aufgabenteilung und Kombinationen aus RPA-Lösung mit menschlicher Assistenz personelle Engpässe sinnvoll kompensieren und die Effizienz und Qualität eines Prozesses nicht nur steigern, sondern ihn auch in kürzester Zeit krisensicher machen können.

Zusammengefasst wird damit eine Hauptforschungsfrage angesprochen: „*Wie können RPA-Lösungen unter hohem Zeitdruck und mit sehr geringem Zeitaufwand qualitativ ausreichend entwickelt werden?*“

Der weitere Verlauf dieses Artikels ist wie folgt gegliedert. Zuerst stellen wir die aktuelle Situation der rapide gewachsenen Prozess- und IT-Landschaft innerhalb der Gesundheitsbehörden in Zeiten der Pandemie dar und erläutern die Technologie der RPA. Anschließend erläutern wir die angewandte dreiteilige Aktionsforschungsmethodik und stellen die Datenquellen und das Verfahren der Datenerhebung vor. Der vierte Abschnitt enthält die Ergebnisse unserer Aktionsforschung. Wir schließen den Artikel in Abschnitt fünf mit einer Zusammenfassung unserer Forschung, in der wir die Limitationen unserer Forschung sowie die Implikationen für die Praxis und Theorie ansprechen.

20.2 Hintergrund

Aufgrund der Notwendigkeit der kontinuierlichen Verfolgung von Infektionsketten führt die Pandemie zu einem exponentiellen Anstieg des bürokratischen Aufwands innerhalb der kommunalen Gesundheitsbehörden (Karl 2020; Steppat 2021). Mit dem Beginn der Lockerung der weitreichenden Kontaktverbote im April 2020 wird die Sicherstellung einer flächendeckenden Kontaktverfolgung durch die Gesundheitsbehörden von zentraler Bedeutung. Das Bundesministerium für Gesundheit hat am 1. Mai 2020 ein Konzept und einen Umsetzungsplan zur Kontaktverfolgung vorgelegt, der die Grundlage für das Handeln in den Kommunen bildet (Korzillus 2020). Die geforderte Dokumentation von Quarantänefällen und die daraus resultierenden wiederkehrenden Anfragen von Patienten und potenziellen Patienten belasten die Gesundheitsbehörden zunehmend und führen zu einem hohen Prozessaufkommen und steigenden Prozessaufwänden, die in der Summe manuell nicht zu bewältigen sind (Korzillus 2020). Bei einer gleichzeitigen raschen Aufstockung der Ressourcen ist dies jedoch problematisch. Neue Prozesse müssen parallel zu den bestehenden verwaltet werden, und zwar zu einem großen Teil von neuen und fachfremden Mitarbeitern (Zimmermann 2021). Hinzu kommen die Komplexität und die Vielfalt der Regelungen, welche technischen Hilfsmittel, insbesondere Software, eingesetzt werden dürfen und welche nicht. Zugleich sind viele Verwaltungen sequenziell-hierarchisch organisiert, was Sprunginnovationen verhindert und die Effektivität reduziert (Korzillus 2020).

Prozessautomatisierung stellt eine bewährte Methode zur Optimierung von Abläufen dar, um die Effizienz und Effektivität von Unternehmen und Prozessen zu steigern (Plattfaut 2019). Eine Möglichkeit der Prozessautomatisierung, die in der untersuchten Kommune bereits vor der Pandemie in geringem Umfang genutzt wurde, ist der Einsatz von RPA.

Bei RPA handelt es sich um Software-Roboter, die es ermöglichen, repetitive und regelbasierte Aufgaben zu automatisieren (Syed et al. 2020). Typischerweise findet RPA Anwendung in Prozessen, in denen die Mitarbeiter vor einer Prozessautomatisierung beispielsweise Daten aus unterschiedlichen digitalen oder analogen Medien entgegennehmen, diese verarbeiten, um sie anschließend in bestehende Systeme einzugeben (Willcocks et al. 2015). RPA imitiert die menschlichen Interaktionen auf den Bedieneroberflächen der IT-Systeme und automatisiert die Dateneingabe und den

Datenaustausch systemübergreifend (Syed et al. 2020). RPA verfolgt das Ziel „*in konstanter Art und Weise bessere Resultate mit weniger Aufwand zu erbringen*“ (D’Onofrio and Meinhardt 2020). Mithilfe von RPA wird die flexible Anpassung an Kapazitätsbedarfe und Arbeitsbelastungen angestrebt (Plattfaut 2019). Diese Technologie kann dabei vergleichsweise niedrigschwellige, schnell zu implementierende und kostengünstige Lösungen bieten (Syed et al. 2020). Durch die Vorteile von RPA - Kosteneinsparungen, Schnelligkeit, Erhöhung von Genauigkeit bei der Ausführung von wiederkehrenden Prozessen - werden Mitarbeiter entlastet, Fehlerquellen reduziert und mögliche Geschäftsverluste kompensiert (Koch et al. 2020). Darüber hinaus können plötzliche Bedarfsschwankungen, die seitens der Pandemie durch unvorhersehbare Maßnahmen auftreten, mittels einer hohen Skalierbarkeit von RPA abgefangen werden (Plattfaut 2019). Administrative Aufgaben werden schneller, genauer und unermüdlicher erledigt (Koch et al. 2020).

RPA wird in vielen Anwendungsbereichen zunehmend vertieft wissenschaftlich untersucht und ist Gegenstand zahlreicher Fallstudien, zum Beispiel im öffentlichen Sektor (Koch et al. 2020), Bildung (Herbert 2016), Finanzindustrie (Willcocks et al. 2017), Telekommunikation (Lacity et al. 2015), Recht (Herbert 2016), Personalwesen (Hallikainen et al. 2018) oder IT (Plattfaut et al. 2020). Trotzdem besteht weiterhin Forschungsbedarf in Bezug auf Faktoren, die die technische RPA-Implementierung in diversen Kontexten beschleunigt (Syed et al. 2020).

In der Literatur existieren verschiedene Kriterien, die das Automatisierungspotential von Geschäftsprozessen durch RPA bewerten. Prozesse mit geringem kognitivem Anteil, hohem Anteil an Routineaufgaben und vergleichsweise hohem Personaleinsatz bieten Potential zur Automatisierung mithilfe von RPA (Asatiani und Penttinen 2016). Sogenannte Hintergrundprozesse, also IT-gestützte Bearbeitungsprozesse, die für den Mitarbeiter mit monotoner, repetitiver Arbeit verbunden sind, werden häufig mit Hilfe von RPA abgebildet (Syed et al. 2020). Diese Hintergrundprozesse sind im öffentlichen Sektor in großem Umfang vorzufinden (Balka et al. 2018): Eingabemasken ausfüllen, Auslesen und Aktualisieren von Einträgen in Datenbanken und Datenextraktionen aus Formularen sind nur einige Beispiele, die einen relativ großen Anteil der Arbeiten in der öffentlichen Verwaltung ausmachen. So könnten in den deutschen Behörden bis zu 62 Prozent aller Arbeitsstunden automatisiert ablaufen (Balka et al. 2018). Im aktuellen wissenschaftlichen Diskurs, bezogen auf unseren Fallkontext, werden die Anwendungsmöglichkeiten und die Vorteile von RPA als zeit- und ressourcensparende Automatisierung von Geschäftsprozessen dargestellt, um Mitarbeiterausfälle bei unvorhersehbaren Umstrukturierungen und Verläufen zu kompensieren (Lacity et al. 2015; Syed et al. 2020).

20.3 Methode

Die gewählte Methode für die vorliegende Forschungsarbeit ist die Aktionsforschung. Aktionsforschung ist ein Ansatz, bei dem der Forscher und Mitglieder der Organisation zusammenarbeiten, um Probleme zu diagnostizieren und zu lösen. In diesem Artikel wird die Aktionsforschung verwendet, um ein Phänomen zu beschreiben und zu analysieren, während der Forscher selbst beteiligt ist und die Eigenschaften beeinflusst (Baskerville 1999; Davison et al. 2004). Ein Hauptmerkmal der Aktionsforschung ist es, dass Wissen nicht nur durch Beobachten und Analysieren, sondern auch durch Beeinflussen und Mitwirken gewonnen wird (Coughlan and Coghlan 2002b) Dieser dynamische Ansatz erlaubt der Forschung, sich flexibel von den Bedürfnissen der Mitarbeiter und der Arbeitsumgebung leiten zu lassen. Zudem bietet dieser reaktionsfähige Ansatz die Möglichkeit, dynamische und ad-hoc geforderte Änderungen in Prozessen reaktionsschnell zu realisieren. Die Relevanz und der Bedarf an Aktionsforschung ist forschungsseitig durch die sehr volatilen und hohen Prozessmengen sowie manuellen Prozessaufwände in dieser Forschungsarbeit definiert.

Wir wenden das Konzept der Aktionsforschung an, um die Anwendbarkeit von RPA im öffentlichen Sektor zu analysieren. Während wir die Mitarbeiter in RPA ausbilden und die Methoden und Werkzeuge verbreiten, beeinflussen wir den Fortschritt der RPA-Entwicklung. Die Autoren begleiten dabei die RPA-Entwicklung aktiv und sind in das Projektteam integriert. Diese generieren sowohl eigene Lösungen als auch gemeinsame Lösungen mit den Mitarbeitern im Entwicklerteam. Der Entwicklungsprozess ist anhand von verschiedenen Dokumentationen wie die RPA-Ausführungsprotokolle, Projektstatusberichte, Entwicklungshistorien der RPA-Lösungen und Projektdokumentationen aufgezeichnet. Die Datenerfassung spiegelt die Metaphase der Aktionsforschung wider und wird kontinuierlich innerhalb der Forschungszyklen realisiert. Sobald eine RPA-Lösung für einen Prozess vorliegt, wird der Entwicklungsprozess durch Interviews mit den Mitarbeitern reflektiert und die Datenbasis ergänzt. Die vorhandenen Dokumentationen werden dann einer qualitativen Inhaltsanalyse unterzogen (Mayring 2004).

Die RPA-Ausführungsprotokolle, die standardmäßig von der Entwicklungsplattform während der Ausführung von RPA generiert werden, werden hinsichtlich der verwendeten Erweiterungsimplementierungen (z.B. Plug-ins), Laufzeiten und Fehlertypen, Ausnahmebehandlung, Absprünge oder anderer Ausführungsstopps analysiert und bewertet. Auf diese Weise werden deutlich quantifizierbare Qualitätsmetriken gewonnen, die erste objektivierbare Einblicke in das jeweilige Entstehen von RPA-Lösungen und mögliche Entwicklungsbarrieren geben.

Die Projektstatusberichte werden mit diesen oben genannten Erkenntnissen auf der Ebene der Entwicklungszyklen analysiert, um mehr Kontext über die Inhalte und mögliche Verbesserungen oder Umstrukturierungen der jeweiligen RPA-Lösung, auch im Hinblick auf die betrachteten RPA-Ausführungsprotokolle, zu erhalten.

Die Entwicklungshistorien der RPA-Lösungen werden zude, ergänzend herangezogen, um die Veränderung der Entwicklungsqualität besser nachvollziehen zu können und so eine etwas detailliertere Aussage über die Überarbeitungen, Ergänzungen und Umstrukturierungen der RPA-Lösungen zu erhalten. Die so erstellte Historie wird auch genutzt, um erste Lernkurven nachzuzeichnen und so den Einfluss und die Wirkung bestimmter Entwicklungsparadigmen von RPA besser zu verstehen.

Im Rahmen von gemeinsamen Workshops werden diese oben genannten Erkenntnisse in den Entwicklungsprozess eingearbeitet. Der Entwicklungsprozess der RPA-Lösungen wird anhand von drei Zyklen, die jeweils die Hauptphase der Aktionsforschung darstellen, realisiert (vgl. Abb. 1).

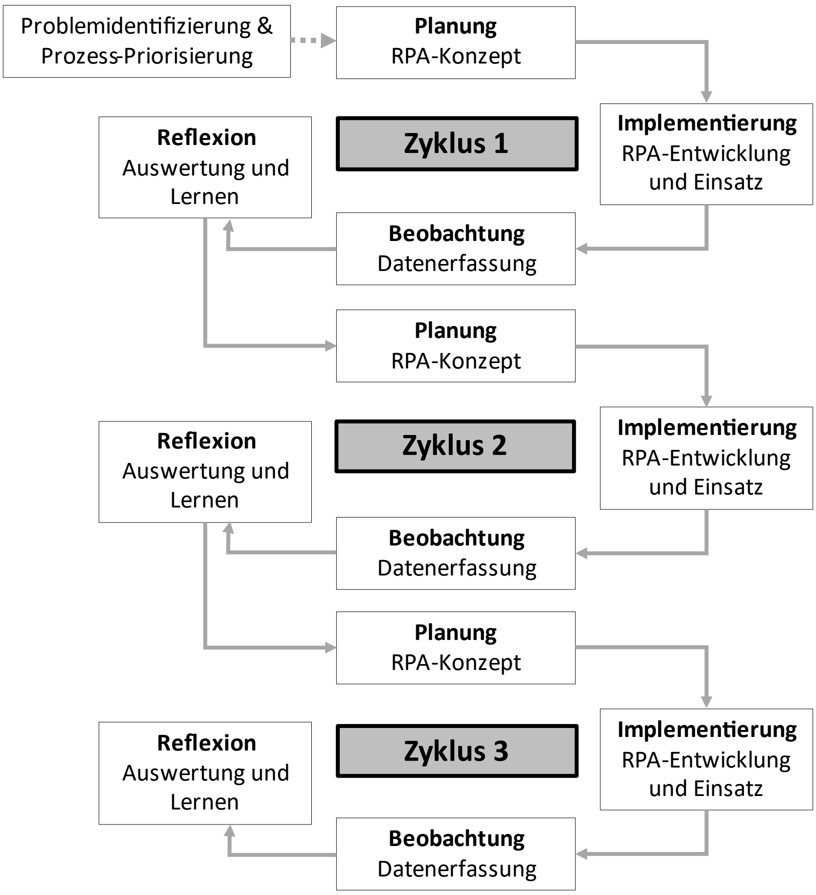

Figure 20-1: Aktionsforschung in Anlehnung an Davison et al. (2012)

Konkret durchlaufen wir die in Abbildung 20-1 dargestellten Entwicklungszyklen für die Automatisierung mithilfe von RPA wie folgt:

Zunächst werden die Probleme identifiziert und die zu automatisierenden Prozesse priorisiert. Anschließend folgt im *ersten Zyklus* die Konzepterstellung. Darauf folgt die Entwicklung einer jeweiligen RPA-Lösung durch Mitarbeiter in Zusammenarbeit mit den Autoren. Dabei werden Daten in Form von Interviews mit Mitarbeitern, Projektdokumentationen aus den Projektstatusberichten und RPA-Ausführungsprotokollen aus der RPA-Entwicklungsumgebung zusammengetragen (vgl. Abschnitt 3.2). Identifizierte Fehler während der Entwicklung sowie Fehler der RPA-Lösung im Einsatz werden in drei Fehlerarten eingeteilt. Anschließend folgt eine gemeinsame Reflexion mit Feedbackschleifen zur RPA-Entwicklung und dem Einsatz der RPA-Lösung sowie die Auswertung aller Daten.

Im *zweiten Zyklus* arbeiten die Autoren mit einem festen Projektteam der Gesundheitsbehörde an der Konzepterstellung, in der RPA-Entwicklung und dem RPA-Einsatz sowie der Datenerfassung und -auswertung. Anschließend erfolgt eine vertiefte Datenerhebung über die Entwicklung und den Einsatz der RPA-Lösung. Daten über die vorhandenen und korrigierten Fehlerarten werden erneut gesammelt und verglichen, um eine Lösungsbewertung durchzuführen. Analog zum vorherigen Zyklus folgen Feedbackschleifen und Datenanalysen in Form von Interviews, Auswertung von Projektstatusberichten und RPA-Ausführungsprotokollen zur RPA-Lösung.

Im *dritten Zyklus* erfolgt die Vorgehensweise analog zu den vorherigen Entwicklungszyklen. Die Mitarbeiter überführen die Schwachstellen und Fehlerarten in das Konzept und verbessern die RPA-Lösung. Der Einfluss der Autoren beschränkt sich auf Schwachstellen in der Performance der RPA-Lösung.

20.3.1 Teilnehmer und Fallbeschreibung

Die in diesem Artikel untersuchte Kommune ist eine Großstadt in Westdeutschland mit etwa 200.000 Einwohnern. Diese weist seit Beginn der Pandemie sehr hohe Inzidenzraten und Infektionen auf und wurde demnach kontinuierlich als Hochrisikogebiet eingestuft. Die Gesamtzahl der Mitarbeiter der Gesundheitsbehörde betrug 64, davon 39 in Vollzeit und 25 in Teilzeit. Als Einrichtung des öffentlichen Gesundheitsdienstes sind die Aufgaben der untersuchten Gesundheitsbehörde in erster Linie durch das Gesetz über den öffentlichen Gesundheitsdienst definiert. Vorrangiges Ziel ist die Daseinsvorsorge und, als ein unverzichtbarer Dienstleister, die Gesundheit der Bevölkerung zu fördern und zu schützen (Reisig and Kuhn 2016).

Zwei Autoren arbeiteten bereits vor der Pandemie in anderen Kontexten erfolgreich mit der öffentlichen Verwaltung an der Prozessoptimierung und Prozessautomatisierung und wurden explizit um Unterstützung während der Krise gebeten. Die hier dargestellte Gesundheitsbehörde ist von den Entscheidungsträgern der öffentlichen Verwaltung und dem Autorenteam auch deshalb ausgewählt worden, weil viele Mitarbeiter Schwierigkeiten haben, belastbare Prozesse auszuführen oder auf das deutlich gestiegene Prozessvolumen sowie die dynamischen Prozessänderungen während der Pandemie zu reagieren. Personalkapazitäten zur Bewältigung bestehender sowie neuer Prozesse und Aufgaben, die durch die Pandemie eingeführt werden, reichen nicht mehr aus. Daher werden zum Teil neue, teilweise fachfremde Mitarbeiter eingestellt. Zusätzlich weist diese Kommune eine hohe Heterogenität in den bestehenden IT-Systemen auf.

Die Teilnehmer dieser Aktionforschung sind Sachbearbeiter (n = 6) in der untersuchten Gesundheitbehörde in der Abteilung für Infektionsschutz, die speziell als Reaktion auf die Pandemie geschaffen wurde. Keiner von ihnen hat zuvor Erfahrungen mit der RPA-Technologie oder sonstiger Prozessautomatisierungstechnologien gemacht. Zudem beteiligen sich die Autoren ergänzend durch Begleitung der Teilnehmer bei der selbstständigen Entwicklung von RPA-Lösungen.

In dem vorliegenden Artikel werden RPA-Lösungen für die IT-gestützten Verwaltungsprozesse der Gesundheitsbehörde untersucht. In Summe sind dies 42 Subprozesse, die aufgrund der Krisensituation neu implementiert werden, sowie 13 bestehende Verwaltungsprozesse, die bisher manuell durch händische Dokumentation umgesetzt werden. Wir haben in diesem Artikel einen Subprozess immer als einen Teil eines darüber liegenden komplexen Prozesses definiert, der logisch abgeschlossen ist und von einem anderen Prozess oder Subprozess aufgerufen werden kann. Ein Beispiel für einen Subprozess ist die Extraktion und Transformation von Personenstammdaten aus einer Datenbankanwendung in eine Excel-Datei und die anschließende regelbasierte Archivierung und Kennzeichnung dieser Datei. Diese Prozesse lassen sich übergeordnet in diesem Artikel durch das Neuanlegen von Personen, die Pflege von Ansprechpartnern sowie die Eingabe und Aktualisierung der zugehörigen Adressdaten spezifizieren. Des Weiteren fokussieren sich diese neuen Verwaltungsprozesse auf die Pflege von Kontakthierarchien und Kontaktbeziehungen zur Sicherstellung einer adäquaten Nachverfolgung sowie den Import, Export und Abgleich von Daten aus Portalen der Behörde.

20.3.2 Datenerfassung

Die Datenerhebung erfolgt durch drei Datenquellen während und parallel zu den Aktionsforschungszyklen, die sowohl die Entwicklung der RPA-Lösungen (Projektstatusberichte und Entwicklunghistorien) als auch die Bewertung der Lösungen (durch Interviews mit Mitarbeitern und RPA-Ausführungsprotokolle) integrieren. Dazu haben wir im ersten Entwicklungszyklus zunächst drei Fehlerarten in Zusammenarbeit mit den Mitarbeitern und durch die Analyse der RPA-Ausführungsprotokolle, Projektstatusberichte und Entwicklungshistorien identifiziert, die zum einen zu Problemen bei der Ausführung der RPA-Lösung führen und den Prozessablauf verhindern. Zum anderen werden Fehler identifiziert, die aus Sicht der Mitarbeiter zu einem Problem bei der Ausführung der RPA-Lösung werden können oder eine schnellere RPA-Lösungsentwicklung generell verhindern werden:

- *Reale Fehler*: Tatsächliche Probleme, die die Entwicklung oder Ausführung einer RPA-Lösung verhindern
- *Emergente Fehler:* Performance- oder Skalierungsprobleme bei der RPA-Lösung, wobei aber die Ausführung funktioniert
- *Testfehler*: Hypothetische Fehler, die zu einem Problem bei der RPA-Lösung führen können

Bezogen auf diese drei möglichen Fehlerarten werden in den oben beschriebenen Aktionsforschungszyklen kontinuierlich Fehlerdaten gesammelt, analysiert und vor diesem Hintergrund neue Konzepte und RPA-Lösungen geplant, umgesetzt und evaluiert.

Die Entwicklung der RPA-Lösung wird im jeweiligen Zyklus zunächst geplant. Der zu automatisierende Prozess wird anhand der im Abschnitt 3.1 dargestellten Mitarbeiter als realer, emergenter und hypothetischer Fehler identifiziert, notwendige Konfigurationen, Software und Datenquellen werden ermittelt. Anschließend erfolgt die Entwicklung der jeweiligen RPA-Lösungen zur Automatisierung. Die jeweilige Entwicklung wird anschließend in der praktischen Anwendung analysiert und bewertet. Am Ende jedes Entwicklungszyklus werden die Teilnehmer erneut in einem halbstrukturieren Interview befragt. Zu diesem Zweck haben wir die Inhalte der RPA-Ausführungsprotokolle ergänzend analysiert. Die RPA-Ausführungsprotokolle werden standardmäßig innerhalb der RPA-Entwicklungsumgebung erzeugt und lassen Rückschlüsse auf bestimmte Entwicklungsprobleme und -fortschritte zu. Diese Erkenntnisse können wir in die Befragung der Teilnehmer (n = 6) mit einbeziehen. Konkret bitten wir die Teilnehmer in den halbstrukturierten Interviews (39 Interviews mit einer Gesamtdauer von 24,9 Stunden), die RPA-Einsätze sowie die Entwicklungsansätze dieser zu beschreiben, ihr Vertrauen in die Belastbarkeit der Ansätze, die zur Beschleunigung solcher Einsätze verwendet werden sowie ihr Vertrauen in die Lösung von Beschleunigungsproblemen verschiedener Art. Die Fragen im Interview befassen sich mit den Eindrücken der Mitarbeiter vom beschleunigten RPA-Entwicklungs-Ansatz, ihrer wahrgenommenen Nützlichkeit für ihre zukünftigen Einsatzanforderungen und ihrem allgemeinen Vertrauen in die Technologie. Die Interviews werden in den Diskussionskanälen jeweils am Ende des Forschungszyklus in der Reflexion (29) und unmittelbar nach der Implementierungsphase (8) und immer im Vorfeld des nächsten Entwicklungszyklus (2) geführt. Mit Ausnahme des ersten Forschungszyklus werden die Interviewthemen dabei auf Basis der gesammelten Fehlerdaten und der Dokumentation der RPA-Entwicklung (bestehend aus Projektstatusberichten, RPA-Ausführungsprotokollen, Entwicklungshistorien) zusammengestellt und vom Forschungsteam ausgearbeitet. Durch das Reflektieren der Ergebnisse können die gemachten Erfahrungen der Teilnehmer im nächsten Zyklus aufgenommen und eingearbeitet werden. Dadurch wird sowohl der Entwicklungsansatz als auch die RPA-Lösung sukzessive und kontinuierlich verfeinert. Zum direkten Vergleich der qualitativen Erhebungen werden zusätzlich Projektstatusberichte gesammelt, die während des jeweiligen Entwicklungszyklus generiert und in Form einer Dokumentenanalyse ausgewertet werden. Die Ergebnisse werden mit den Aussagen aus den jeweiligen Interviews verglichen und dienen ergänzend dazu, um missverständliche Zusammenhänge zu identifizieren und weitere Fragen für nachfolgende Befragungsrunden zu entwickeln.

Nach jeder Datenerhebung stellen die Autoren die Antworten zusammen und entscheiden gemeinsam mit den Mitarbeitern, wie mit jedem RPA-Entwicklungsschritt bis zur nächsten Datenerhebung verfahren werden soll. Es erfolgt im nächsten Zyklus eine erneute Planung des Entwicklungsprozesses, die sich jeweils auf die am Ende des vorherigen Zyklus durchgeführten Reflektion bezieht.

20.3.3 Datenanalyse

Die Daten werden sowohl *formativ* (um detaillierte Informationen über spezifische Änderungen im Entwicklungsansatz als direkte oder indirekte Auswirkung auf die RPA-Lösung zu erhalten) als auch *summativ* (als Vergleich zwischen postuliertem und erreichtem Sollzustand der RPA-Lösung) erhoben (Petersen et al. 2014). In Übereinstimmung mit den Praktiken der Aktionsforschung treffen sich die Autoren nach jedem der Datenerhebungsereignisse (sowohl Entwicklungsereignisse als auch Interviews), um in einem fortlaufenden Analyseprozess aufkommende Erkenntnisse und Änderungen für den nächsten Forschungszyklus zu diskutieren.

Ein Teil des Autorenteams führt eine offene Kodierung der Mitarbeiterbefragungen (der halbstrukturierten Interviews) durch, um deren Nutzung der evaluierten RPA-Lösungen und ihr Verständnis der beschleunigten Entwicklungsschritte zu erfassen. Die Triangulation über mehrere Datenquellen, insbesondere über die Interviews, die Projektstatusberichte, die Entwicklungshistorien der RPA-Lösungen und die RPA-

Ausführungsprotokolle, unterstützt, die Validität sicherzustellen und Bereiche mit Übereinstimmungen oder Konflikten zu identifizieren. Insbesondere durch die Projektstatusberichte und RPA-Ausführungsprotokolle, die den Reifegrad der RPA-Lösung ausmachen, können wir während des gesamten Forschungprozesses Daten sammeln, untersuchen und reflektieren. Als Teil des Entwicklungsteams treffen sich die Autoren regelmäßig (alle 3-6 Tage) mit den teilnehmenden Mitgliedern des Entwicklungsteams, um mögliche Diskrepanzen und Probleme in den Entwicklungsansätzen der RPA-Lösung zu besprechen, bis ein Konsens über den Entwicklungsfortschritt und die Implementierungshindernisse erreicht ist.

20.4 Ergebnisse

Anhand der dargestellten Aktionsforschung im öffentlichen Sektor in einer Krisensituation (hier: Pandemie) können wir Lösungsansätze ableiten, die eine schnelle Entwicklung von RPA-Lösungen fördern.

Vorerst betrachten wir die Ergebnisse aus den einzelnen Entwicklungszyklen (vgl. Abb. 1). Nach dem ersten *Zyklus* sind bereits Schwachstellen sowie Fehlerarten der RPA-Lösung identifiziert worden und Lösungsmöglichkeiten können auf Basis der eingeteilten Fehlerarten abgeleitet werden. Es wird deutlich, dass die Rahmenbedingungen für die RPA-Entwicklung und den spezifischen Einsatz der RPA-Lösung angepasst werden müssen. Durch das ständige Projektteam werden so bereits aufgetretene Fehler vermieden, was die Entwicklung in den weiteren Phasen erleichtert.

Im zweiten *Zyklus* können wir durch eine verbesserte Kommunikation innerhalb des Projektteams die bereits identifizierten und korrigierten Fehlerarten vergleichen. Somit führt die Lösungsbewertung zur Entwicklung einer besseren RPA-Lösung.

Im letzten (dritten) *Zyklus* ist die Vorgehensweise bereits bekannt und das Verständnis für die jeweiligen Entwicklungsphasen im Zyklus ist gefestigt. Die Mitarbeiter sind mit der Entwicklung der RPA-Lösung vertraut, sodass diese die Schwachstellen selbständig identifizieren. Durch die Anwendung in der Gesundheitsbehörde werden ausreichend Erfahrungen für die Übertragung von RPA-Lösungen auf andere Organisationseinheiten gesammelt. Im Ergebnis wird eine Sammlung von automatisierten Prozess-Inkrementen zusammengestellt, die allen Mitarbeitern zur Verfügung gestellt wird. Diese sind dadurch in der Lage, die benötigten komplexeren Prozessabläufe „[…] *schneller aus der Sammlung fertiger Prozessschritte*“ (Mitarbeiter 3) zusammenzustellen.

Durch das enorme Wachstum der Mitarbeiterzahl aufgrund der Pandemie und das damit verbundene Aufkommen an IT-Systemen ist in kurzer Zeit eine sehr große Anzahl an disparaten Einzelsystemen entstanden, die eine unübersichtliche und heterogene betriebliche IT-Systemlandschaft darstellen. Aufgrund dieser Unterschiede in den Voraussetzungen der Arbeitsplatzsysteme identifiziert unsere Forschung zwei Ansätze, um RPA-Lösungen unter hohem Zeitdruck mit geringem Zeitaufwand zu entwickeln. Die gemeinsame Erarbeitung und Entwicklung der RPA-Lösungen von und mit den Mitarbeitern unter Einbezug aller gemachten Erfahrungen beim Einsatz einer jeweiligen RPA-Lösung, der eruierten Fehlerdaten und der Dokumentationen (bestehend aus Projektstatusberichten, RPA-Ausführungsprotokollen, Entwicklungshistorien) lässt die Ableitung der nachfolgend dargestellten Lösungsansätze zu:

1. Einsatz einer RPA-Lösung als Übersetzungsschicht
2. InkrementelleRPA-Entwicklung

20.4.1 RPA-Lösung als Übersetzungsschicht

Der erste Ansatz beschreibt den Einsatz einer RPA-Lösung, die die Umgebungsvariablen des jeweiligen Betriebssystems erfasst und um eine Übersetzungsschicht ergänzt. Diese Übersetzungsschicht wird als eigenständige RPA-Lösung entwickelt und wirkt als notwendige Bedingung für den Einsatz aller anderen RPA-Lösungen. Mit Hilfe dieser RPA-basierten Übersetzungsschicht werden erste Fehlerquellen, wie inkonsistente Softwareversionen, unterschiedliche Ordnerstrukturen oder Laufwerksbenennungen, identifiziert. Die Übersetzungsschicht erzeugt dann eine Schicht mit einheitlichen Abhängigkeiten, Verknüpfungen und Konfigurationen für Betriebssystem-Umgebungsvariablen.

Die Schaffung einer Übersetzungsschicht zwischen dem Originalsystem und den eigentlichen RPA-Lösungen zur Automatisierung von Subprozessen hat den Effekt, dass eine schnellere Skalierung dieser RPA-Lösungen mit geringem Zeitaufwand möglich ist. Zum Teil werden „[…] *schwerwiegende Konflikte, Einrichtungsfehler und Systemabstürze vermieden*“ (Mitarbeiter 1), so dass die jeweiligen RPA-Lösungen „*[…] ohne Hindernisse und ohne Nachbesserungen*“ (Mitarbeiter 2) arbeiten können. „*Die Eigenständigkeit* […]“ der RPA-Anwendung wird sichergestellt und „*[…] ein kontinuierliches Arbeiten ohne zeitlichen Ausfall unter hohem Zeitdruck*“ (Mitarbeiter 1) gewährleistet.

Die folgende Abbildung 20-2 visualisiert den Einsatz der RPA-Übersetzungsschicht. Die linke Seite spiegelt die Gegebenheiten in der heterogenen Systemlandschaft wider und verdeutlicht, dass eine Anwendung von RPA-Lösungen zur Automatisierung der Verwaltungsaufgaben nicht ohne ganzheitliche Systemumstrukturierungen funktionieren kann. Diese ganzheitlichen Umstrukturierungen und Anpassungen in der IT-Landschaft würden enorm viel Zeit in Anspruch nehmen. Daher verdeutlicht die rechte Seite den Benefit unseres Lösungsansatzes einer RPA-basierten Übersetzungsschicht zum Einsatz weiterer RPA-Lösungen. Durch die dort vorzufindende Übersetzungsschicht wird ein schneller und erfolgreicher Einsatz weiterer RPA-Lösungen ermöglicht.

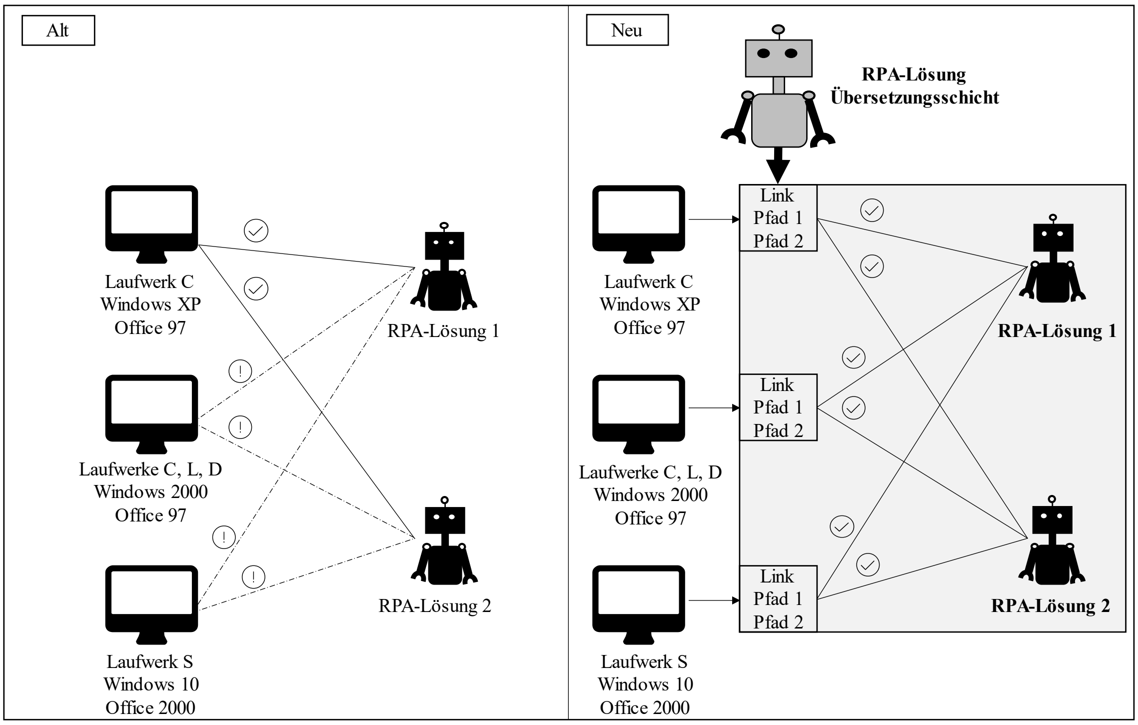

Figure 20-2: Vergleich der Entwicklungsansätze für RPA-Lösungen

Die weiterführende Entwicklung von RPA-Lösungen auf dieser Basis ermöglicht es, die verschiedenen RPA-Lösungen für die Managementprozesse in unterschiedlichen Systemumgebungen mit geringem oder gar keinem Änderungs- und Installationsaufwand schnell einzusetzen. Auf diese Weise wird eine valide und einheitliche Arbeitsumgebung generiert, auf der dann eine direkt lauffähige Entwicklung von RPA-Lösungen gewährleistet ist.

Der vorgestellte Lösungsansatz wird hier am Beispiel der RPA-basierten Erstellung einer Übersetzungsschicht für die vom Mitarbeiter verwendeten Systemvariablen dargestellt: Die RPA-Lösung führt zunächst einen Scandurchlauf der Microsoft Office-Version auf dem Betriebssystem des Mitarbeiters durch und unterscheidet zwischen den installierten Office-Versionen (Office 365, Office 2016, Office 2010), die unterschiedliche Installationspfade haben und auch unterschiedliche Anwendungsaufrufe innerhalb der Skriptsprache der RPA-Entwicklungsumgebung verwenden. Die RPA-Lösung legt eine einheitliche Sammlung von Verknüpfungen im Stammverzeichnis der jeweiligen RPA-Lösung an, über die die jeweilige Office-Anwendung, z.B. Excel, aufgerufen werden kann. Im nächsten Schritt werden die eingebundenen Netzlaufwerke hinsichtlich ihres gemappten Pfades bzw. Laufwerksbuchstabens stadartisiert, so dass in diesem konkreten Beispiel auch Speicher- und Archivordner als Verknüpfungen im Wurzelverzeichnis der RPA-Lösung angelegt werden. Es gibt dabei zahlreiche solcher Anpassungsvorgänge der Systemumgebung, etwa für die Pfade der jeweiligen Verschlüsselungssoftware, Aufrufe der SharePoint-Komponenten oder des Dokumentenmanagements.

Bei dem vorgestellten Lösungsansatz ist anfangs mehr Aufwand in die Erfassung, Identifizierung und Abbildung der beschriebenen Fehlertypen, insbesondere der unterschiedlichen Umgebungsvariablen und Betriebssystemparameter, notwendig. Im weiteren Verlauf reduziert die RPA-basierte Übersetzungsschicht jedoch den Aufwand für Änderungs-, Installations-, Skalierungs- und Deployment-Prozesse auf anderen Systemen deutlich.

Dies ermöglicht mit Fortschreiten der Aktionsforschung einen schnelleren Entwicklungsprozess sowie qualitativ hochwertigere RPA-Lösungen (im Hinblick auf die Fehlerproduktion) und Anwendungen mit mehr Flexibilität (im Hinblick auf die Anpassungsfähigkeit) sowie weniger Ausfallzeiten (im Hinblick auf den Ressourcenverbrauch).

20.4.2 Inkrementelle RPA-Entwicklung

Der zweite Ansatz zur beschleunigten Entwicklung von RPA-Lösungen beschreibt die inkrementelle Entwicklung von RPA-Lösungen und das Management dieser. Dieser Ansatz beinhaltet zum einen die bewusste Auswahl und Teilautomatisierung von Prozess-Inkrementen, also einzelner Subprozesse, sowie die gezielte Bereitstellung und der ausgewählte Einsatz dieser RPA-Lösungen.

Beim initialen Deployment von RPA-Lösungen auf dem Betriebssystem des Mitarbeiters werden die beschriebenen Systemanpassungsprozesse zunächst konsequent mit einer entsprechenden RPA-Lösung umgesetzt. Danach erst kann eine Priorisierung der zu entwickelnden RPA-Lösungen auf Subprozessebene vorgenommen werden. Aufbauend auf der RPA-basierten Übersetzungsschicht zur Systemvereinheitlichung werden anschließend Prozessautomatisierungen implementiert, die nach Fertigstellung zwischen den Endnutztersystemen kompatibel sind und somit auch zwischen Organisationseinheiten ausgetauscht werden können. Anstatt also einen Prozess in seiner Gesamtheit mittels RPA zu automatisieren, werden, wie zuvor erwähnt, die einzelnen Prozessabschnitte, also die Subprozesse, betrachtet und zur Automatisierung priorisiert. Wie zuvor bereits aufgegriffen wird unter anderem der Prozess zur

Kontaktnachverfolgung in der Pandemie in seine einzelnen Subprozesse zerlegt. Der gesamte Prozess wird in die einzelnen Prozessabschnitte unterteilt. Insgesamt können 7 Subprozesse identifiziert werden. Diese lassen sich unterteilen in die Erstellung des Excel-Eingabeformulars, die Generierung der zentralen Datenbank, die Analyse des Bezirks, die Online-Datenabfrage, die Mitarbeiteranalyse, die Tagesberichte und die Quarantäne-Benachrichtigungen. Um die Informationen aus den generierten und analysierten Daten zu verwalten, muss RPA über verschiedene Schnittstellen und Graphical User Interfaces (GUI) kommunizieren.

Die imkrementelle RPA-Entwicklung und die Automatisierung eines Prozess-Inkrements lässt sich am Beispiel der Erstellung des Erfassungsbogens (als Prozess-Inkrement) im Kontaktnachverfolgungsprozess veranschaulichen und näher erläutern. Anstelle der durchgängig manuellen Datenerfassung wird der Erfassungsbogen mit Hilfe von RPA teilautomatisiert. Die Excel-basierten Erfassungsbögen werden von den Hotline-Mitarbeitern ausgefüllt und gespeichert. Am Ende des Arbeitstages verarbeitet die RPA-Lösung alle neu erstellten Erfassungsbögen und speichert deren Inhalte in einer Excel-Datenbank. Diese bildet die Grundlage für eine Datenauswertung (z.B. eine Bezirks- oder Mitarbeiteranalyse) und die Quarantänebescheide. Um die Fehleranfälligkeit dieses Prozesses bei der Dateneingabe zu verbessern, werden in der RPA-Lösung Kontrollregeln implementiert, die bestimmte Datenfelder (z.B. Postleitzahl) auf Plausibilität prüfen. Nach einem festen Zeitplan beginnt die RPA-Lösung, die neu erstellten Erfassungsformulare in ein strukturiertes Datenbankdokument zusammenzuführen. Dieses wird dann in das Dokumentenmanagementsystem der Behörde importiert und direkt in der entsprechenden Ordnerstruktur auf dem Netzlaufwerk abgelegt, im vorgegebenen Archivierungsformat verschlüsselt und mit einem Aufruflink und Metadaten wie dem Erstellungszeitpunkt auf der Intranet-Plattform angelegt. Der Subprozess zur Datenerfassung und -auslesung aus den Erfassungsbögen wird für die Automatisierung als Prozess-Inkrement aufgrund von hohen Aufwänden priorisiert und daher inkrementell eine RPA-Lösung entwickelt. Die zugehörige RPA-Lösung wird anschließend organisationsweit zur Verfügung gestellt.

Diese Teilautomatisierung der einzelnen Subprozesse in Form von Prozess-Inkrementen sowie die frei zur Verfügung stehenden RPA-Lösungen und dessen Management ermöglicht eine organisationsweite Nutzung dieser Ressourcen. Somit wird ein schnellerer Einsatz der jeweiligen RPA-Lösung bei unvorhersehbarem und plötzlichem Bedarf gewährleistet.

20.5 Diskussion und Implikationen

Die Pandemie, die im März 2020 begann, ist unbestreitbar eine der größten Herausforderungen, mit denen die kommunalen Gesundheitsbehörden je konfrontiert werden. Die kurzfristige Aufstockung von Arbeitsplätzen und Personal ist durch die ad-hoc aufgetretene Notsituation in dem untersuchten Fallbeispiel enorm. Der Anpassungsdruck an steigende Prozessvolumina und die damit verbundene Notwendigkeit, neue IT-Infrastruktur bereitzustellen, führt zu einer weiteren Divergenz der eingesetzten Systemkonfigurationen in der ohnehin uneinheitlichen IT-Landschaft. Die vorgestellten Lösungsansätze können die Entwicklung von RPA-Lösungen mit sehr geringem Zeitaufwand gewährleisten. Das bedeutet, dass zunächst alle relevanten Umgebungsvariablen und Betriebssystemparameter auf allen Systemen mittels einer RPA-realisierten Übersetzungsschicht abgeglichen und harmonisiert werden. Anschließend gilt es relevante Prozess-Inkremente zu identifizieren und jeweilige RPA-Lösungen zu entwickeln, die durch die Übersetzungsschicht auf allen IT-Systemen und für jeden Mitarbeiter ad-hoc einsetzbar sind.

Mit den untersuchten RPA-Entwicklungsprozessen und den damit entwickelten zwei Lösungsansätzen, die einen solchen Prozess beschleunigen, kann sowohl die Projekteffizienz als auch die Eignung zur aktiven Beteiligung der Mitarbeiter an der RPA-Entwicklung eingehend analysiert werden. Der Fokus der Projektabwicklung in diesem Artikel liegt auf der effizienten und schnellen Fertigstellung der RPA-Lösungen unter Einhaltung aller prozessualen Anforderungen und unter besonderer Berücksichtigung aller durch Umgebungsbedingungen dynamisch ausgelösten Änderungen, insbesondere derjenigen, die spät im Entwicklungsprozess auftreten.

Das Foschungsdesign in diesem Artikel, ist eines, bei dem Praktiker und Forscher im Forschungsprozess zusammenarbeiten. Die Art und Weise, in der die hier genutzte Aktionsforschung die Entwicklung von integrativen Praktiken und Denkweisen erleichtert, bezieht sich auf drei miteinander verbundene Bereiche: Die Zusammenarbeit zwischen den Mitarbeitern der Gesundheitsbehörde, die reflektierende Praxis und die aktive Teilnahme der Forscher. Ähnlich dem theoretischen Modell von Davison et al. (2012), in dem die Reflexion mit dem Handeln in einem zweiseitigen Prozess verbunden ist, können wir in dieser Aktionsforschung sehen, wie die Mitarbeiter ihre Entwicklungsprozesse von RPA-Lösungen durch die Aktionsforschung reflektieren und sich entsprechend verändern. Gleichzeitig führen nicht nur die Zusammenarbeit der Mitarbeiter und die reflektierte Praxis zu Handlungen, sondern die aktive Teilnahme der Forscher ermöglicht auch eine weitere Reflexion und Veränderung der aktuellen Entwicklungspraktiken.

Allerdings sind vor allem in der Anfangsphase von Zyklus 2 Schwierigkeiten aufgetreten, valide Einstiegs- und Anknüpfungspunkte mit dem vorhandenen Mitarbeitern in dem besonderen volatilen Umfeld zu finden, da diese meist überlastet sind. Daher greifen die Abteilungsleitung und wir als Forscher, wie in den Reflexionsschleifen in Abbildung 20-1 dargestellt, auf die Einrichtung eines regelmäßigen Kommunikations- und Diskussionskanals zurück, der feste Zeitfenster für die Mitarbeiter reserviert, um einen kontinuierlichen Austausch zu garantieren. Dies eröffnet den Mitarbeitern die Möglichkeit, ihr Wissen regelmäßig in einem festgelegten Raum auszutauschen und zu aktualisieren. Auf diese Weise können wir beobachten, wie sich das Wissen der Mitarbeiter festigt. Kombiniert mit der aktiven Teilnahme an den Entwicklungsprozessen der Anderen, können wir feststellen, dass sich das Wissen und die Fähigkeiten der Mitarbeiter im Bezug auf die RPA-Entwicklung und RPA im Allgemeinen verfestigt. Durch die Gestaltung der zeitlich begrenzten Termine erhalten die teilnehmenden Mitarbeiter nicht nur Antworten auf ihre eigenen Probleme und Fragen, sondern gewinnen auch ein neues Verständnis für die Probleme der anderen Mitarbeiter, die in diesen Terminen besprochen werden.

So können wir durch den Aktionsforschungsprozess die Arbeitsweisen und Entwicklungsprozesse hinter den RPA-Lösungen genauer beobachten und verstehen. Darüber hinaus ermöglicht der Aktionsforschungsprozess durch die offene Diskussion in den Reflexionsschleifen die konkrete Identifikation von Barrieren rund um die Krisensituation. Es ist auch anzumerken, dass der Grad der Forscherbeteiligung natürlich über die Zyklen hinweg variiert. Wie bereits erwähnt, werden ab Zyklus 2 Verbesserungen in der Forscherbeteiligung durch eine Reihe von Techniken erreicht, die eine gezieltere und effektivere Prozessautomatisierung mittels RPA in Stresssituationen ermöglicht.

Dies wiederum führt ab Zyklus 2 zu Änderungen in den Praktiken, die es den Forschern ermöglicht, aktiver als zuvor an der RPA-Entwicklung teilzunehmen. Gleichzeitig partizipieren die Forscher, die dann auch autarke Entwicklerrollen von RPA-Lösungen übernehmen, somit auf einer tieferen Ebene und auf eine viel authentischere Weise.

Auf Basis der hier vorgestellten multimodalen Untersuchungen lassen sich Handlungsempfehlungen für die Praxis ableiten. So zeigt sich beispielsweise, dass die vorgestellten Entwicklungsansätze in Form einer RPA-Lösung zunächst auf die infrastrukturellen Bereiche der IT-Architektur bzw. Systemlandschaft priorisiert werden sollten. Entsprechend ist dies nach unserer Beobachtung der entscheidende Faktor für die erfolgreiche Umsetzung einer zeitkritischen, skalierbaren Prozessautomatisierung mit möglichst wenig Konfigurationsaufwand in der besonders heterogenen, schnell wachsenden IT-Systemlandschaft der Behörde.

Wie beschrieben, sorgt die RPA-basierte Übersetzungsschicht dabei für eine minimalinvasive Homogenisierung bestehender und nicht standartisierter Systemstrukturen und Umgebungsvariablen. Damit lassen sich einheitliche Voraussetzungen realisieren, die die fehleranfälligen, ressourcen- und zeitintensiven Entwicklungsprozesse der Parametrisierung von RPA-Lösungen in unserer Betrachtung vermeiden. Hierbei können sichtlich auch die komplexen Anpassungszyklen der RPA-Lösungen effektiv vermieden oder reduziert werden.

Natürlich sind solche vorgestellten Lösungen in der Praxis nicht als dauerhaft anzusehen und sollten vor dem Hintergrund der jeweiligen Situation, in der sich die untersuchte Behörde befand, bewertet und kontextualisiert werden. Unser Artikel gibt jedoch Aufschluss darüber, inwieweit, mit welchem Erfolg und warum es sinnvoll ist, zunächst infrastrukturelle Prozesse, wie z.B. die Anpassung der Systemumgebung, durch RPA zu implementieren - statt standardmäßig nur Geschäftsprozesse für die Automatisierung in Betracht zu ziehen.

Demnach ist die Anwendung der vorgeschlagenen Ansätze für eine beschleunigte Entwicklung von RPA-Lösungen zurzeit noch limitiert. Die vorgestellte Aktionsforschung begrenzt sich auf lediglich eine Gesundheitsbehörde einer ausgewählten Kommune. Obwohl nur eine Behörde untersucht wurde, sind die Ergebnisse aufgrund der vergleichbaren Strukturen im öffentlichen Sektor auch auf viele andere Behördenprofile und andere Kommunen übertragbar. Um die aktuelle besondere Situation der IT-Landschaften der untersuchten Behörde richtig zu beurteilen, muss der Kontext der Betriebsbedingungen während der Pandemie berücksichtigt werden. Der öffentliche Sektor und die Pandemie sind durch sehr spezielle Rahmenbedingungen definiert, die im Normalfall nicht als gegeben angenommen werden. Zum einen existieren viele heterogene Systeme und IT-Strukturen sowie eine nicht übliche Heterogenität des Wissenstandes der eingesetzten Mitarbeiter aufgrund der vorherrschenden Pandemie, die unter anderem komplett neu, fachfremd oder auch fluktierend eingesetzt werden. Diese Gegebenheiten müssen durch die Pandemie zunächst als gegeben hingenommen werden. Kennzeichnend für die Arbeitssituation und die abgeleiteten Ansätze während der Pandemie ist, dass bewusst Insellösungen in Kauf genommen werden, um eine schnell einsetzbare und lauffähige IT-Landschaft bereitzustellen. Aufgrund der bisher anhaltenden Auslastungssituation sind Bemühungen zur Konsolidierung dieser IT-Situation noch nicht vorhanden. Viele neu hinzugekommene IT-Arbeitsplätze bestehen nach wie vor aus heterogenen Komponenten, die nur sehr aufwendig und umständlich betrieben und oft gar nicht konsolidiert werden können. Hinzu kommen weiter wachsende Strukturen, die eine Vereinheitlichung in der aktuellen Situation nicht möglich machen.

Darüber hinaus ist die Objektivität der Ergebnisse eingeschränkt. Die vorgestellten Ansätze beruhen auf Daten, die nicht quantitativ erfasst wurden und unterliegen daher naturgemäß einem gewissen Grad an Subjektivität (Kock 2004). An der hier angewandten Methodik der Aktionsforschung wird aber auch kritisiert, dass die Subjektivität durch den beteiligten Forscher und die damit möglicherweise gegebene Voreingenommenheit bei der Analyse der Ergebnisse zusätzlich verstärkt werden kann. Der zyklische Forschungsprozess in der Aktionsforschung ist auf Verstehen und Handeln ausgerichtet, so dass immer eine Abhängigkeit zwischen den beteiligten Mitarbeitern und den Ergebnissen besteht. Dementsprechend sind die vorgestellten Ansätze zwar in der Praxis entwickelt, eine Verifizierung oder gar Reproduktion der Ergebnisse in anderen Kontexten steht aber noch aus.

Die gegebene Situation und Rahmenbedingungen bringen bereits zuvor dargestellte Limitationen und Besonderheiten mit sich. Um diese Gegebenheiten vor dem Hintergrund des Theoriebeitrages richtig zu beurteilen, muss der Kontext der Einsatzbedingungen während der Pandemie berücksichtigt werden. Die spezifischen Bedingungen verstärkt durch die Pandemie - Heterogenität des Wissensstandes von eingesetztem Personal und die steigende Heterogenität der Systeme und IT-Strukturen beispielsweise bedingt durch neue Arbeitsplätze und Laptops - sowie die bestehenden heterogenen IT-Landschaften in der Behörde, müssen daher akzeptiert werden. Wie bereits erwähnt, werden bewusst Insellösungen in Kauf genommen, um eine schnell einsetzbare und lauffähige IT-Landschaft bereitzustellen.

Nichtsdestotrotz liefert dieser Artikel die Erkentnnis, dass RPA, entgegen dem eigentlichen geforderten Zweck und der bisherigen Forschung sowie wissenschaftlichen Betrachtung, nicht nur Geschäftsprozesse (vertikal) automatisieren kann. Wir zeigen, dass der Einsatz von RPA zudem Infrastrukturen sinnvoll optimieren und einen Mehrwert in der (horizontalen) Systemoptimierung liefern kann. Somit liefert dieser Artikel einen neuen Ansatzpunkt zur bestehenden RPA-Forschung und leistet einen essenziellen Theoriebeitrag in Form einer innovativen Anwendung von RPA in einem bisher unerforschten Szenario. Der Artikel kann damit einen Beitrag zum bestehenden Forschungsstrang über den Nutzen und mögliche Einsatzszenarien einer primär nur als Geschäftsprozessautomatisierung klassifizierten Technologie (RPA) leisten. Dementsprechend eröffnet der Beitrag hier den Diskursraum, den möglichen Einsatz von RPA auch für administrative, systembetreibende Tätigkeiten weiter zu reflektieren.

Vor diesem Hintergrund bietet unser Artikel erste Einblicke, wie RPA mit sehr schnell wachsender und hoher architektonischer IT-Komplexität umgeht, widerspricht im Ergebnis aber der allgemeinen Vorstellung, eine standardisierte und homogenisierte IT-Systemlandschaft in einer Organisation zu erreichen (Leal et al. 2019). Es zeigt sich, dass in heterogenen Systemlandschaften durch den Einsatz von systemunterstützenden RPA-Lösungen sichtbare Stabilitäts- und Geschwindigkeitsgewinne erzielt werden können. Es ist jedoch zu erwarten, dass der tatsächliche Nutzen dieser Lösungen umso größer sein wird, je schneller und unkontrollierter die Softwarelandschaft wächst und je komplexer und unüberschaubarer diese damit wird.

Zukünftige Forschungen sollten durchgeführt werden, um die genauen quantitativen Auswirkungen der vorgestellten Ansätze auf den Projekterfolg nachzuweisen und quantifizierbar zu bestimmen. Um eine weitere Verallgemeinerung zu gewährleisten, müssen Evaluierungen in anderen organisatorischen Hintergründen, auch über längere Zeiträume, durchgeführt werden. Insbesondere sollte weiter untersucht werden, wie sich die Umstände, die Bedingungen und der Kontext der Pandemie im öffentlichen Sektor auf die hier gezeigten Ergebnisse ausgewirkt haben könnten.

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