

International Journal of Information Systems and Project Management

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijspm.sciencesphere.org

IJISPM

05

Robotic Process
Automation: a
review of
organizational grey
literature

*Ritesh Chugh
Stephanie Macht
Rahat Hossain*

29

Changes to team
autonomy in large-
scale software
development: a
multiple case study
of Scaled Agile
Framework (SAFe)
implementations

*Tomas Gustavsson
Marthe Berntzen
Viktoria Stray*

49

We have a platform,
but nobody builds
on it – what
influences Platform-
as-a-Service post-
adoption?

*Frederik Wulf
Markus Westner
Susanne Strahringer*

73

Effects of the use of
digital technologies
on the performance
of firms in a
developing country:
are there differences
between creative
and manufacturing
industries?

*Jean Pierre Seclen-Luna
René I. Castro Vergara
Hellen Lopez Valladares*

um



International Journal of Information Systems and Project Management

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijispm.sciencesphere.org

Mission

The mission of the IJISPM - International Journal of Information Systems and Project Management - is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

The IJISPM publishes leading scholarly and practical research articles that aim to advance the information systems management and project management fields of knowledge, featuring state-of-the-art research, theories, approaches, methodologies, techniques, and applications.

The journal serves academics, practitioners, chief information officers, project managers, consultants, and senior executives of organizations, establishing an effective communication channel between them.

Description

The IJISPM offers wide-ranging and comprehensive coverage of all aspects of information systems management and project management, seeking contributions that build on established lines of work, as well as on new research streams. Particularly pursuing multidisciplinary and interdisciplinary perspectives, and focusing on currently emerging issues, the journal welcomes both pure and applied research that impacts theory and practice.

The journal content provides relevant information to researchers, practitioners, and organizations, and includes original qualitative or quantitative articles, as well as purely conceptual or theoretical articles. Due to the integrative and interdisciplinary nature of information systems and project management, the journal may publish articles from a number of other disciplines, including strategic management, psychology, organizational behavior, sociology, economics, among others. Articles are selected for publication based on their relevance, rigor, clarity, novelty, and contribution to further development and research.

Authors are encouraged to submit articles on information technology governance, information systems planning, information systems design and implementation, information technology outsourcing, project environment, project management life-cycle, project management knowledge areas, criteria and factors for success, social aspects, chief information officer role, chief information officer skills, project manager role, project manager skills, among others.

Topics covered

The journal offers comprehensive coverage of information systems management and project management.

The topics include, but are not limited to:

- information technology governance
- information systems planning
- information systems design and implementation
- information technology outsourcing
- enterprise architecture
- information systems governance
- information systems department
- chief information officer role
- information technology leadership role
- chief information officer skills
- information systems management tools
- management of complex projects
- audits
- innovation
- ethics
- project environment
- project management life-cycle
- project initiation
- project planning
- project execution
- project control and monitoring
- project closing
- success criteria and success factors
- project manager role
- project manager skills
- portfolio management
- program management
- managing organization - structure
- tools and techniques
- project evaluation
- project management knowledge areas
- scope management
- time management
- cost management
- quality management
- procurement management
- risk management
- communication management
- human resources management
- performance teams
- social aspects
- conflict management
- managing organization - responsibilities
- project management office
- contracts

Special issues devoted to important specific topics will be evaluated for publication.



International Journal of Information Systems and Project Management

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijispm.sciencesphere.org

Editorial board

Editor-in-Chief:

João Varajão, *University of Minho, Portugal*

Executive Editors:

Dulce Domingos, *University of Lisbon, Portugal*

Ricardo Martinho, *Polytechnic Institute of Leiria, Portugal*

Senior Editors:

Albert Boonstra, *University of Groningen, The Netherlands*

Manuela Cruz Cunha, *Polytechnic Institute of Cávado and Ave, Portugal*

Philip Powell, *University of London, United Kingdom*

Associate Editors:

António Trigo, *Polytechnic Institute of Coimbra, Portugal*

Duminda Wijesekera, *George Mason University, USA*

Janne Härkönen, *University of Oulu, Finland*

Kathryn Cormican, *NUI Galway, Ireland*

Markus Westner, *OTH Regensburg, Germany*

Mirjana Pejić Bach, *University of Zagreb, Croatia*

Ricardo Palacios, *Østfold University College, Norway*

Ritesh Chugh, *Central Queensland University, Australia*

Susan P. Williams, *University of Koblenz, Germany*

International Editorial Review Board:

Anne-Maarit Majanoja, *University of Turku, Finland*

Anabel Montero, *Pontificia Universidad Javeriana, Colombia*

Anca Draghici, *Politehnica University of Timisoara, Romania*

Arash Daemi, *Central Queensland University, Australia*

Bassam Hussein, *Norwegian University of Science and Technology, Norway*

Berislav Žmuk, *University of Zagreb, Croatia*

Dalia Suša Vucec, *University of Zagreb, Croatia*

Dietmar Nedbal, *University of Applied Sciences Upper Austria, Austria*

Eryk Glodziński, *Warsaw University of Technology, Poland*

Furkan Gürsoy, *Boğaziçi University, Turkey*

Grzegorz Greła, *Maria Curie-Skłodowska University, Poland*

Hans-Henrik Hvolby, *Centre for Logistics, Aalborg University, Denmark*

Jan de Vries, *University of Groningen, The Netherlands*

Jeffrey Saltz, *Syracuse University, USA*

José Fernando López-Muñoz, *ESIC Business and Marketing School, Spain*

Khalil Haykal Rahi, *Abu Dhabi University, United Arab Emirates*

Kirsi Aaltonen, *University of Oulu, Finland*

Mariusz Hofman, *Maria Curie-Skłodowska University, Poland*

Mark Stieninger, *University of Applied Sciences Upper Austria, Austria*

Markus Lahtinen, *Lund University, Sweden*

Moutaz Haddara, *Høyskolen Kristiania, Norway*

Oluwayomi K. Babatunde, *University of the Witwatersrand, South Africa*

Robert Pellerin, *Polytechnique Montréal, Canada*

Stéphane Gagnon, *University of Québec, Canada*

Suzana Sampaio, *University of Pernambuco (UFRPE), Brazil*

Wanda Presthus, *Kristiania University College, Norway*

Vicente Montequín, *University of Oviedo, Spain*

Submissions

Researchers and practitioners are encouraged to submit their manuscripts to the IJISPM. The guidelines for submission can be found at the journal's home page: ijispm.sciencesphere.org

Correspondence and questions

All correspondence and questions should be directed to João Varajão (Editor-in-Chief). E-mail: editor.ijispm@sciencesphere.org



Table of contents

SPECIAL FEATURES

01 Editorial

João Varajão, University of Minho, Portugal

RESEARCH ARTICLES

05 Robotic Process Automation: a review of organizational grey literature

Ritesh Chugh, Central Queensland University, Australia
Stephanie Macht, Central Queensland University, Australia
Rahat Hossain, Central Queensland University, Australia

29 Changes to team autonomy in large-scale software development: a multiple case study of Scaled Agile Framework (SAFe) implementations

Tomas Gustavsson, Karlstad University, Sweden
Marthe Berntzen, University of Oslo, Norway
Viktoria Stray, University of Oslo, SINTEF, Norway

49 We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Frederik Wulf, TU Dresden, Germany
Markus Westner, OTH Regensburg, Germany
Susanne Strahringer, TU Dresden, Germany

73 Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

Jean Pierre Seclen-Luna, Pontifical Catholic University of Peru, Peru
René I. Castro Vergara, Pontifical Catholic University of Peru, Peru
Hellen Lopez Valladares, Pontifical Catholic University of Peru, Peru



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.sciencesphere.org

IJISPM



Editorial

The mission of the *IJISPM - International Journal of Information Systems and Project Management* is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

It is our great pleasure to bring you the first number of the tenth volume of IJISPM. In this issue, readers will find important contributions on Robotic Process Automation, SAFe, Platform-as-a-Service post-adoption, and digital technologies adoption.

The first article, “Robotic Process Automation: a review of organizational grey literature”, is authored by Ritesh Chugh, Stephanie Macht, and Rahat Hossain. Research on Robotic Process Automation (RPA) in the last decade has increased but lags behind developments in practice. This study explores the definition, evolution, and categories of RPA, its benefits and challenges, identifies guidelines for implementation, and provides a future outlook. Since there is an evident scarcity of comprehensive grey literature reviews in the area, this study presents an extensive narrative review of organizational grey literature on RPA by analyzing sixty-one organizational reports and white papers. This study provides a unified definition of RPA and groups the many categories of RPA into three types: basic automation, cognitive automation, and artificial intelligence. The study identifies the benefits of RPA and categorizes them into monetary; simplicity; efficiency and productivity; flexibility and scalability; reliability and consistency; compliance and governance; customer satisfaction; employee efficiency; and other long-term organizational benefits. The main challenges of RPA are awareness and perception of RPA; uncertainty about how to prepare for RPA; change management challenges while implementing RPA; and challenges associated with RPA vendors. Three main steps of RPA implementation are highlighted.

The title of the second article is “Changes to team autonomy in large-scale software development: a multiple case study of Scaled Agile Framework (SAFe) implementations”, which is authored by Tomas Gustavsson, Marthe Berntzen, and Viktoria Stray. Large-scale transformations of agile ways of working have received more attention in the industry in recent years. Some organizations have developed their own solutions for scaling, whereas many have chosen trademarked frameworks. In large-scale agile software development, many developers and development teams carry out work simultaneously. When autonomous teams need to coordinate toward a common goal, they must sacrifice some level of autonomy. Development, testing, and integrations need to be coordinated with other teams and aligned with an organization’s programs or portfolio. Through the conducting of 28 interviews and 17 on-site visits, this multiple case study explored how team autonomy changed in three agile software development organizations that implemented the Scaled Agile Framework (SAFe). The positive changes to team autonomy that they experienced as a result included getting a better overview, making better long-term decisions, giving and receiving help, and signaling limitations. The authors found two negative impacts on team autonomy: limited feature choice and enforced refinement.

The third article, authored by Frederik Wulf, Markus Westner, and Susanne Strahringer, is entitled “We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?”. When higher-level management of a company has strategically decided to adopt Platform-as-a-Service (PaaS) as a Cloud Computing (CC) delivery model, decision-makers at lower hierarchy levels still need to decide whether they want to post-adopt PaaS for building or running an information system (IS) – a decision that numerous companies are currently facing. This research analyzes the influential factors of this managerial post-adoption decision at the IS level. A survey of 168 business and Information Technology (IT) professionals investigated the influential factors of this PaaS post-adoption decision. The results show that decision-makers’ perceptions of risks inhibit post-adoption. Vendor trust and trialability reduce these perceived risks. While competitive pressure increases perceived benefits, it does not significantly influence



PaaS post-adoption. Controversially, security and privacy, cost savings, and top management support do not influence post-adoption, as opposed to findings on company-level adoption.

“Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?”, is the fourth article and is authored by Jean Pierre Seclen-Luna, René I. Castro Vergara, and Hellen Lopez Valladares. This paper aims to analyze the effects of the use of digital technologies on firms’ net sales and productivity. The technology adoption approach is applied in empirical research using data from the National Enterprise Survey in Peru. Using the OLS method on a sample of 2,970 firms from creative and manufacturing industries in Peru, the effects of digital technologies on net sales and productivity are determined. Findings indicate that there is a positive relationship. However, these relationships can be different depending on the type of digital technology, the size of the firm, and the manager’s gender proportion.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

João Varajão

University of Minho

Portugal



João Varajão is currently a professor of information systems and project management at the *University of Minho*. He is also a researcher at the *ALGORITMI Research Center* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997), and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are related to Information Systems and Information Systems Project Management success. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst, and software developer, for private companies and public institutions. He has supervised more than 100 Masters and Doctoral dissertations in the Information Systems field. He has published over 300 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor, and member of the editorial board for international journals and has served on numerous committees of international conferences and workshops. He is the co-founder of CENTERIS – Conference on ENTERprise Information Systems and ProjMAN – International Conference on Project MANagement.



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.science.sphere.org

Robotic Process Automation: a review of organizational grey literature

Ritesh Chugh

School of Engineering and Technology, Central Queensland University
120 Spencer Street, Melbourne VIC 3000 Australia
r.chugh@cqu.edu.au

Stephanie Macht

School of Business and Law, Central Queensland University
400 Kent Street, Sydney NSW 2000 Australia
s.macht@cqu.edu.au

Rahat Hossain

School of Engineering and Technology, Central Queensland University
554-700 Yaamba Rd, Norman Gardens QLD 4701 Australia
m.hossain@cqu.edu.au



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.sciencesphere.org

R. Chugh, S. Macht, R. Hossain, “Robotic Process Automation: a review of organizational grey literature”, *International Journal of Information Systems and Project Management*, vol. 10, no. 1, pp. 5-26, 2022.



Robotic Process Automation: a review of organizational grey literature

Ritesh Chugh

School of Engineering and Technology, Central Queensland University
120 Spencer Street, Melbourne VIC 3000 Australia
r.chugh@cqu.edu.au

Stephanie Macht

School of Business and Law, Central Queensland University
400 Kent Street, Sydney NSW 2000 Australia
s.macht@cqu.edu.au

Rahat Hossain

School of Engineering and Technology, Central Queensland University
554-700 Yaamba Rd, Norman Gardens QLD 4701 Australia
m.hossain@cqu.edu.au

Abstract:

Research on Robotic Process Automation (RPA) in the last decade has increased but lags behind developments in practice. This study explores the definition, evolution and categories of RPA, its benefits and challenges, identifies guidelines for implementation and provides a future outlook. Since there is an evident scarcity of comprehensive grey literature reviews in the area, this study presents an extensive narrative review of organizational grey literature on RPA by analyzing sixty-one organizational reports and white papers published between 2015 and 2020. This study provides a unified definition of RPA and groups the many categories of RPA into three types: basic automation, cognitive automation, and artificial intelligence. The study identifies the benefits of RPA and categorizes them into monetary; simplicity; efficiency and productivity; flexibility and scalability; reliability and consistency; compliance and governance; customer satisfaction; employee efficiency; and other long-term organizational benefits. The main challenges of RPA are awareness and perception of RPA; uncertainty about how to prepare for RPA; change management challenges while implementing RPA; and challenges associated with RPA vendors. Three main steps of RPA implementation are highlighted. This study provides practitioners and researchers with an extensive bird's eye insight into RPA from an industry perspective.

Keywords:

bots; business services automation; process automation; robotic automation; Robotic Process Automation; literature review.

DOI: 10.12821/ijispm100101

Manuscript received: 5 February 2021

Manuscript accepted: 22 October 2021

Copyright © 2022, IJISPM. General permission to republish in print or electronic forms, but not for profit, all or part of this material is granted, provided that the International Journal of Information Systems and Project Management (IJISPM) copyright notice is given and that reference made to the publication, to its date of issue, and to the fact that reprinting privileges were granted by permission of IJISPM.

1. Introduction

The integration of information systems in workplaces is not new, but the integration of software tools to automatically carry out business processes is an emerging and growing trend. Most previous automation was limited to the manufacturing sector that used physical robots for labor-intensive tasks (blue-collar robotization). However, now robots, also known as software robots, are proliferating knowledge-intensive tasks (white-collar robotization). Robotic Process Automation (RPA) is the use of software tools to automate or digitize business processes in order to eliminate mundane, tedious, repetitive, and predictable tasks that were previously carried out by humans [1]. The benefits of automating processes are manifold, such as lowering process costs, improved efficiency, error reduction, and employee and customer satisfaction [2]. It is predicted that the RPA market will grow to \$2.9 billion by 2021 from a mere \$250 million in 2016 [3]. The estimated potential economic impact of technologies that will automate knowledge work is forecast between \$5-7 trillion by 2025 [4]. RPA plays a critical role in structuring information systems [5]. In fact, RPA is used to interact with different information systems without replacing existing systems [6]. It can also be argued that RPA provides agility to information systems. Furthermore, RPA can be used to automate many processes, including those in the project management journey [7].

Digital transformation describes the shift from traditional processes to automated ones using digital technologies with the aim of improving operational processes [8], and the importance of information systems in achieving these aims cannot be overstated [9]. RPA is the next step to traditional business process automation as it encompasses elements of rule-driven artificial intelligence and robotics to perform repeatable business processes with speed, quality, and reliability. It is vital for organizations and their business functions to constantly navigate the changing digital landscape in the current digital environment. All organizations and their inherent business functions must continuously innovate, change, and adapt to changing trends to achieve benefits. RPA is one such trend that allows organizations to reap multiple benefits as it enables rule-driven, mundane processes to be automated so that staff can concentrate on other knowledge-intensive tasks. RPA is not just about technology enablement that assists humans but about software automation that replaces the work previously carried out by humans [10, 11]. Moreover, business process management initiatives need to consider the changing boundaries between work done by people and software robots [12].

RPA also delivers a more than 40% increase in full-time-equivalent workload, a 40% reduction in average handling cycle time, and a 30-80% reduction in processing costs [13]. In a similar vein, the National Association of Software and Services Companies highlighted that the use of RPA could yield cost reduction of 35-65% for onshore process operations and 10-30% for offshore delivery, with a short recovery period of investment ranging from 6-9 months from the implementation [14]. A variety of RPA vendors are vying for customer attention in the market, offering varying functionality. There is a surge in demand for RPA tools offered by commercial vendors [6]. Some strong performers and leaders in the RPA market are EdgeVerve Systems, Nice, Kofax, Redwood Software, Pegasystems, WorkFusion, UiPath, Blue Prism, and Automation Anywhere [15].

Business process environments benefit from RPA as it delivers intelligence, flexibility, and adaptability [16]. According to the Institute for Robotic Process Automation [17], an RPA software robot costs one-third the price of a full-time offshore employee and one-fifth the price of an onshore employee. Software robots, an integral part of RPA, can mimic humans and interact with applications on their behalf to perform a range of high-volume, transactional business processes such as collecting data from an online source, triggering activities, processing orders, responding to email queries, processing payroll records, processing insurance claims and registering patients. The examples also demonstrate that RPA has the potential to effectively carry out hundreds of tasks in a variety of different industries, including insurance, healthcare, banking, mortgage, education, and mining. An RPA software robot is capable of carrying out 600 actions in some situations, directly interacting with business applications and process transactions [18]. Process automation technologies could impact nearly 50% of the activities carried out by the global workforce [19].

The term RPA was coined in the early 2000s [20], and industry has displayed significant interest in and uptake of RPA since then. However, academic research on the matter lags, and there is still a dearth of peer-reviewed studies in this domain [1]. Nonetheless, at the time of writing, five RPA literature reviews were found: first, a conference paper that systematically reviewed only the scientific literature until March 2019 [21]; this review identified 36 scholarly papers about RPA and specifically explored the state of scholarly research in this field, the difference between RPA and Business Process Management, and the uses of RPA as discussed in the scholarly literature. While this initial review provides an excellent starting point to explore the current knowledge about this new automation solution, it highlights the lack of scholarly publications in this emerging field. The second available review by Syed and colleagues (2020) expands its literature base by analysing 125 peer-reviewed and white papers on RPA, focusing on the definition of the term, its benefits, organizations' RPA readiness, RPA's potential, methodologies to apply RPA, and RPA technologies. They included only those white papers that were referenced in published academic literature and unfortunately did not specify which white papers this referred to, or which findings emerged from which type of literature. They also failed to outline the timeframe of their literature search, but an investigation of their reference list shows only two sources from 2019, suggesting that their literature search also ended no later than early 2019. The third review by Enríquez et al. [22] presented an in-depth analysis of 54 primary studies from scientific and industrial literature to describe RPA and reviewed 14 commercial tools. However, the focus on industrial literature was inconspicuous. The fourth review by Beetz and Riedl [23] concentrated on developing a process evaluation model to identify RPA-suitable business processes and did not utilize industry-based literature. Finally, the literature review by Santos, et al. [24] also did not look at grey literature; neither did it explore literature beyond 2018.

Given the rapid development in this field and the fact that industry-based knowledge seems to be significantly ahead of academic knowledge, it is essential to explore the concept from an industry literature perspective specifically. Such a perspective can add useful knowledge currently missing in the RPA space. Therefore, to address the gap, it is the purpose of this study to present a narrative review of only the non-academic RPA literature to provide a conceptual, bird's eye overview of RPA from an industry perspective. More specifically, this study focuses on exploring the definition, evolution and categories of RPA, its benefits, and challenges, as well as guidelines for implementation and future outlook for RPA. Given the emerging interest in this field, such a review is timely and warranted to guide future research and inform researchers and industry practitioners. To achieve its aims, this study explores only grey literature in the form of organizational reports and white papers produced by companies that analyze, develop, sell, and recommend RPA and RPA products. In most instances, the companies focus on outlining the trends, impact, vendors, benefits, and challenges of RPA.

The 1997 Luxembourg Convention on Grey Literature defines it as literature "produced on all levels of governmental, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers" [25]. Based on this definition, grey literature examples can include research reports, conference proceedings, white papers, unpublished data, evidence from websites, dissertations, government reports, and fact sheets [26]. Grey literature, which is published outside of the traditional format and does not undergo the typical academic peer-review processes, has increased in the current digital environment [27, 28]. It comprises a diverse body of material and is recognized as a shift from evidence-based to evidence-informed decision making [29]. Moreover, grey literature provides important contextual contemporary information and can reinforce the wisdom of organizational practice not supported by scientific proof [30]. Grey literature can overcome the shortcomings of reliance purely on peer-reviewed literature (e.g., bias towards publishing significant results only) and can make positive contributions to inquiry and practice, especially in fields where a lag of scholarship is evident [28].

The remainder of the paper is organized as follows. The next section sketches the research method. This is followed by a reflection on the evolution of RPA, its various definitions, and categories. In section four, the benefits and challenges of RPA are outlined. Steps for RPA implementation are highlighted in section five, along with a future outlook. Finally, the key premises of the paper have been summarised along with the limitations of this study and avenues for further research in the conclusion section.

2. Research method

In this study, a narrative literature review was conducted. Narrative literature reviews gather, critique, synthesize and summarise literature with an aim to address a subject area and draw conclusions [31]. To ensure the literature search was rigorous and achieved objectivity, inclusion and exclusion criteria were used. To define the literature search limits, only the phrase “robotic process automation” was used. This was to ensure that process automation is not mixed with robotic process automation, as there is a vast difference between the two. As previously mentioned, the scholarly, peer-reviewed literature in this field is scarce, but nonetheless, a few reviews of RPA literature already exist. However, what is missing is the knowledge to be gleaned from industry publications, particularly given that the industry appears to be ahead of academic researchers in the context of RPA. Thus, to address this gap and provide a holistic overview of RPA, this study’s literature review is restricted to grey literature only.

Despite the significant benefits that grey literature can provide to the academic community, it is essential to acknowledge that it is not free from its own shortcomings, which include the diversity of document types that constitute grey literature, the likely bias in some of those documents, the difficulties of evaluating inclusion in studies (as grey literature may not have an abstract), and the fact that search for grey literature may not be entirely replicable [32]. In order to address these main shortcomings, grey literature experts (e.g. [28]) suggest that authors who use grey literature be particular in their explanation of the inclusion criteria and literature search and evaluation processes.

To evaluate which literature to include, the AACODS framework was used [33]: *Authority, Accuracy, Coverage, Objectivity, Date, and Significance*. Following the need to ensure grey literature is accurate and written by an authoritative source (*Authority* criterion), this review focused only on reports and white papers produced by organizations that verifiably work closely with RPA (*Significance* criterion) – these are companies that analyze, develop, sell, and recommend RPA and RPA products. This focus on the otherwise unmanageably large diversity of grey literature ensured the systematic collection of relevant literature and supported the evaluation according to the remaining criteria.

Google’s web search engine was used to search for the organizational reports and white papers as it indexes them and provides relevant search mechanisms [34]. Using the advanced search functionality, the search was constrained to English documents published between 01/01/2015 to 31/12/2020 using the exact phrase “robotic process automation” (*Coverage* criterion). The year limitation was determined through Google Trends for the term “robotic process automation”. Globally, interest over time for RPA was lower than 10 in January 2015 and reached a high of 100 in January 2020, although it dwindled to 67 in December 2020 (see figure 1). A value of 100 demonstrates peak popularity for RPA. Furthermore, the limitation in publication years was also restricted to the last six years because by 2015, RPA was considered to be at the early majority stage of adoption [10], and a lot has been accomplished in this area after 2015 (*Date* criterion). Finally, to make the search manageable and due to a lack of other search fields in Google’s search engine, the search was limited to Adobe Acrobat PDF file types only.

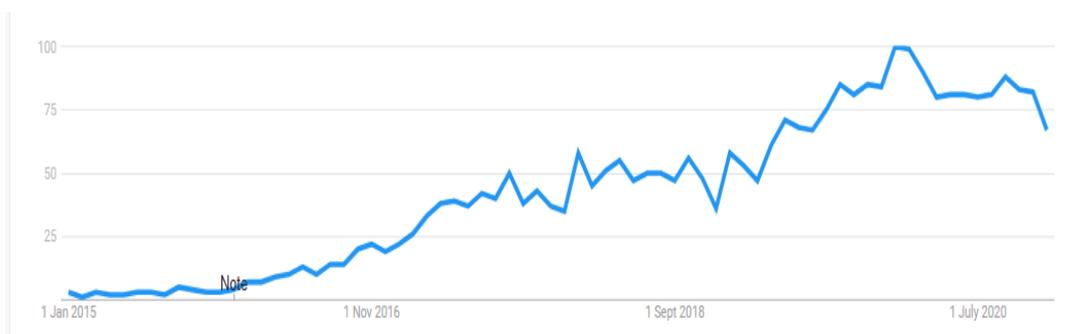


Fig 1. Interest over time for RPA

One of the researchers carried out the above-mentioned search, which another researcher subsequently retested. As a result, Google turned up with 336 items, of which 40 were immediately excluded (7 pages not found; 6 suspicious websites were blocked; and 27 personal reports not related to organizations). To ensure objectivity, only one researcher was initially involved in screening the remaining 296 records so that the inclusion criteria (summarised in table 1) were not interpreted differently by the research team, and no bias was introduced [35]. Subsequently, however, a second researcher verified all records.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Literature from 2015 to 2020	Before 2015
Written in the English language	Other languages
Grey literature in the form of organizational reports and white papers by companies that analyze, develop, sell, and recommend RPA and RPA products	Non-organizational reports, news releases, specific product brochures, and case studies
Literature with a sole focus on RPA	Literature focusing on Intelligent Process Automation (IPA) and Process Automation
Adobe Acrobat PDF file types only	Other file formats

The remaining records were assessed for their fitness and relevance by reading the titles, abstracts (where available), and complete documents where necessary. To comply with the AACODS *Accuracy* and *Objectivity* criteria, only organizational reports and white papers with clear non-promotional aims were considered, and records that could be classified otherwise (e.g., news releases, specific product brochures, and case studies) were eliminated at this stage. This finally led to a shortlist of sixty-one organizational reports and white papers. Table 2 provides a brief description of the shortlisted records (arranged in chronological order) that have been used in this literature review, along with the authoring organization's name and the document's title.

The specific research questions (RQ) that guided the analysis of the shortlisted items are:

RQ1: What is RPA, its evolution, and its categories?

RQ2: What are the benefits and challenges of RPA?

RQ3: What are the implementation guidelines for RPA and its future outlook?

Often Internet-based sources can be challenging to locate because the original documents may have been altered, deleted or the uniform resource locators (URLs) changed, thus making the cited URLs obsolete [36]. To allay these URL decay concerns, the Adobe Acrobat PDF files of the sixty-one shortlisted documents are deposited in the Figshare research digital repository [37].

The shortlisted documents were grouped according to their similarities, and critical analysis was conducted [38] to address the aims and answer the research questions. In the following sections, a discussion of the findings of the documents ensues, along with the summary and commentary.

Table 2. Shortlisted organizational reports and white papers

Name of the authoring organization and year published	Title of the document	Description of the content
Deloitte, 2015 [81]	The Robots are Coming	Examines robotic process automation and its role in shared services and Global Business Services.
Everest Group & NASSCOM, 2015 [47]	Seizing the Robotic Process Automation (RPA) Market Opportunity	Examines the state of the RPA market, lessons learned from early adopters, and its potential in the years ahead.
EY, 2015 [42]	Robotic Process Automation	Focuses on RPA and the benefits and opportunities it can provide to organizations.
Forrester Research, 2015 [75]	The State of Robotic Process Automation: A Poor Man's Business Process Management, Or Possibly Something More	Provides an assessment of the state of the RPA market, reasons for its usage, and outlines a framework for enterprise architects.
Kofax, 2015 [68]	Complete the Productivity Picture: A Guide to Robotic Process Automation	Outlines the drawbacks of 'swivel chair automation' and custom development and makes a case for RPA.
Atos, 2016 [43]	Robotic Process Automation for Smarter and Better Working	Explores practical experience on how organizations can create the conditions for successfully using RPA.
Capgemini Consulting, 2016 [45]	Robotic Process Automation - Robots Conquer Business Processes in Back Offices	Investigates the understanding of RPA, its advantages, sourcing and automation strategies, future outlook and implementation plans for RPA within back-office processes.
Fujitsu, 2016 [40]	If You Can Teach It, You Can Automate It: Robotic Process Automation	Describes software robotics and RPA, provides RPA use cases and reasons to automate.
The Hackett Group, 2016 [69]	Understanding Robotic Process Automation: Value Proposition, Deployment Model and Use Cases	Analyzes RPA's value proposition and how RPA is used.
IBM, 2016 [72]	Robotic Process Automation: Leading with Robotics and Automation in a Fast-Paced, Digitally Disruptive Environment	Outlines the benefits that RPA can deliver.
Infosys, 2016 [50]	Robotic Process Automation (RPA): Now is the Time to be Future Ready	Expands on the scope of RPA with cases and provides the RPA lifecycle.
KPMG, 2016 [77]	Rise of the Robots	Explores the benefits of robots and AI/cognitive automation technology and outlines nine steps for RPA innovation.
Protiviti, 2016 [44]	Looking Deeper into Robotic Automation	Outlines considerations and case studies for robotic process automation and robotic desktop automation.
PwC, 2016 [66]	Robotic Process Automation: Creating a Digital Workforce	Makes a case for creating a digital workforce and identifies suitable processes for RPA.
PwC, 2016 [61]	People, Change... and Robots	Explores how businesses can embrace RPA by engaging with employees to create organizational and cultural change for the successful adoption of RPA.
PwC, 2016 [73]	Organize Your Future with Robotic Process Automation	Outlines the benefits of RPA, along with the steps in end-to-end proof of concept.
Avanade & BluePrism, 2017 [70]	Robotic Process Automation: Your Catalyst for Intelligent Automation	Explains the benefits and challenges of RPA adoption.
Brickendon Consulting, 2017 [78]	Robotic Process Automation (RPA)	Provides the challenges, opportunities, and implementation considerations for RPA.
Capgemini Consulting, 2017 [46]	The Automation Revolution – A Plethora of Opportunities for Organizations and Individuals	Shares expert insights on various aspects of automation.

Name of the authoring organization and year published	Title of the document	Description of the content
Chazey Partners, 2017 [92]	Robotic Process Automation: Enablement through Digital Transformation	Describes RPA, its levels, phases and provides a roadmap along with best practice lessons.
Contextor, 2017 [65]	Robotic Process Automation: A Pragmatic Approach to Digital Transformation	Provides comprehensive information on RPA with success stories, guidance, and impact.
Deloitte, 2017 [62]	The Digital Workforce is Here: Understanding and Exploring Robotic Process Automation (RPA)	Describes the automation spectrum, RPA adoption challenges and critical decision points in the RPA journey.
DXC Technology, 2017 [67]	Robotic Process Automation Brings the Future to Your Workplace	Examines the state of RPA in the Australian and New Zealand market.
EY, 2017 [49]	Insights on Robotic Process Automation	Discusses characteristics for RPA candidacy, its levels, the business functions that can derive benefits, and critical success factors in RPA implementation.
Forrester Research, 2017 [15]	The Forrester Wave™: Robotic Process Automation, Q1 2017, The 12 Providers That Matter Most and How They Stack Up	Provides criteria-based evaluation of RPA providers, grouped into current offering, strategy, and market presence.
Gartner, 2017 [90]	Market Guide for Robotic Process Automation Software	Outlines the differences in technical functionality of RPA tools along with an overview of providers and their offerings.
Initio, 2017 [51]	RPA: The Automation of Automation	Provides an understanding of RPA, what it can do, its benefits, and the application of RPA in the banking, financial services, and insurance industry.
Knowledge Capital Partners (KCP), 2017 [52]	Robotic Process Automation: Benchmarking the Client Experience	Summarises the experience of Blue Prism (a leader in RPA) clients by looking into the attributes and capabilities of RPA software and the value achieved.
Kofax, 2017 [41]	Creating a Digital Workplace	Justifies the importance of eliminating manual tasks with RPA along with the outcomes for different industries.
KPMG, 2017 [79]	Accelerating Automation: Plan Your Faster, Smoother Journey	Outlines principles to accelerate automation, an action plan for the first 100 days of RPA, and operating model considerations.
Now We Comply, 2017 [71]	Robotic Process Automation: The New Engine of Business Innovation	Looks at the types of RPA tools, operational impacts, enabling effects, and use cases across key business domains.
Optimal Corporation, 2017 [48]	The Case for Robotic Process Automation (RPA)	Identifies RPA benefits and strategic and tactical actions for successful implementation of RPA.
PwC, 2017 [88]	Who Minds the Bots?	Identifies risks of RPA along with controls to aid in effective implementation.
The Hackett Group, 2017 [83]	A Blueprint for Getting Started with Robotic Process Automation	Outlines steps for integrating RPA into business services operations.
The Robotic Workforce, 2017 [97]	A Guide to Robotic Process Automation	Describes RPA and what it can do for organizations.
Wipro, 2017 [96]	Robotic Process Automation: Driving Efficiency the Smarter Way	Outlines benefits of RPA along with an approach for deploying RPA.
A.T. Kearney, 2018 [85]	Robotic Process Automation: The Impact of RPA on Finance Back-Office Processes	Assesses the impact of RPA on finance back-office processes, identifies key trends and application areas.
Canon, 2018 [84]	Key Strategies for Implementing. Robotic Process Automation	Examines challenges and strategies in RPA implementation.

Name of the authoring organization and year published	Title of the document	Description of the content
Deloitte, 2018 [89]	Understanding the Challenge of Implementing Your Virtual Workforce: Robotic Process Automation as Part of a New Social-Technological Paradigm	Discusses a change management approach that is focused on closely aligning people, processes, and structure in RPA implementations.
EY, 2018 [86]	Risk and Control Considerations Within Robotic Process Automation Implementations	Provides an insight into risk management in RPA implementations, particularly looking at risk considerations and controls.
Knowledge Capital Partners, 2018 [93]	Keys to RPA Success	Summarises key management practices in RPA deployment.
Kofax, 2018 [74]	The Ultimate Guide to Choosing the Right Robotic Process Automation Solution	Provides a list of key features and functionality that businesses should look for in an RPA solution.
KPMG, 2018 [39]	Robotic Process Automation (RPA): On Entering an Age of Automation of White-collar Work Through Advances in AI and Robotics	Discusses RPA implementation, its classes, and impact and provides a standardized approach to implementation.
KPMG, 2018 [91]	Robotic Process Automation: How to Move on from the Proof of Concept Phase? A RPA Governance Framework	Outlines a structured RPA governance framework to provide guidance and best practices for implementing and operating RPA.
KPMG, 2018 [63]	Delivering Value in Procurement with Robotic Process Automation	Proposes the deployment of RPA bots to enhance procurement processes and reduce costs.
PwC, 2018 [98]	Robotic Process Automation in a Virtual Environment	Outlines the benefits of RPA in a virtual environment, along with the challenges faced by RPA developers.
APQC, 2019 [80]	Leveraging Emerging Tools and Technologies in Finance: Robotic Process Automation	Provides an overview of RPA and its benefits for finance teams.
BPM-D, 2019 [64]	Value-Driven Robotic Process Automation: Enabling Effective Digital Transformation	Discusses the opportunities and challenges of applying RPA as a process improvement approach.
Deloitte, 2019 [87]	Robotic Process Automation (RPA) within Federal Identity Management	Discusses the design of secure digital identification solutions using RPA bots.
FIS, 2019 [94]	Robotic Process Automation Enabled Back Office Operations	Outlines the role of RPA for optimizing back-office processes, along with an approach to create efficiency.
Protiviti, 2019 [82]	Taking RPA to the Next Level	Highlights best practices and lessons learned in RPA adoption.
Skymind, 2019 [95]	Introduction to AI and Robotic Process Automation	Compares RPA and AI as distinct technologies and how they can be merged.
VNC, 2019 [76]	Robotic Process Automation	Provides an overview of RPA, its benefits, tools, and an outlook.
BDO, 2020 [53]	Robotic Process Automation During COVID-19	Highlights why businesses need robotic process automation during COVID-19.
Dell Technologies, 2020 [54]	Bridging Digital Transformations Through RPA	Discusses the adoption strategy of RPA, along with transformation use cases and keys to successful implementation.
Gartner, 2020 [55]	Magic Quadrant for Robotic Process Automation	Examines the market and the leading enterprise vendors for RPA.
Infosys, 2020 [56]	Effective Adoption of Robotic Process Automation in the Enterprise	Outlines the roles and benefits of RPA and implementation pitfalls.
Infosys, 2020 [57]	Security Considerations in Robotic Process Automation	Examines how RPA could increase security risks and how to mitigate the risks.
International Group of Controlling, 2020 [58]	Robotic Process Automation in Controlling - Results of an Empirical Study	Investigates RPA in the context of controlling processes.

Name of the authoring organization and year published	Title of the document	Description of the content
LogiSYM, 2020 [59]	Capitalizing on Supply Chain Digitisation with Robotic Process Automation	Explores areas in which RPA can help in supply chain management.
Macedon Technologies, 2020 [60]	The Role of RPA in Digital Transformation	Provides an overview into RPA, complementary technologies, vendor selection and handling implementations.

3. RPA definition, evolution, and categories

Most pieces of the analyzed grey literature do not clearly define RPA but instead focus on what RPA does (i.e., describing the types of processes that it can automate) and its benefits. To define and describe RPA, all pieces of the grey literature use a wide range of diverse terms and phrases, ranging from generic phrases like “RPA is a particular type of digitization” [39], over definitions of the term robot alone (e.g., robots “actually are software tools” [40]), and metaphors like “RPA creates a digital workforce that works side-by-side with your employees” [41], to detailed explanations of what RPA can do, e.g.:

“The Institute for Robotic Process Automation (IRPA) defines RPA as the application of a technology. This technology allows employees in a company to configure computer software or a robot to capture and interpret the existing applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems.” [42]

While this plethora of definitions for RPA has resulted in ambiguity, it is possible to identify common themes across most of these definitions:

- The use of robots, or ‘bots’, in RPA: bots are software tools, i.e., virtual or digital assets;
- RPA as a software-based approach/application of technology to automate processes;
- Location of processes: office-based, computer-based, software processes;
- Nature of processes: most commonly referred to as rules-based, repetitive, and manual;
- Relationship with humans: bots mimic human activities and automate processes previously carried out by humans.

By combining these common themes into one single, unified definition of RPA, this study proposes and defines RPA as follows:

“RPA is the application of software-based technology to automate repetitive office tasks and rule-based processes, which were previously carried out manually by humans on a computer. RPA does this with the help of robots (‘bots’ for short), which are advanced software tools that mimic human activities and can be described as digital, virtual employees that work alongside the human workforce.”

RPA follows in the footsteps of much earlier advances in machine and manufacturing automation, allowing machines to mimic manual tasks previously carried out by humans [43, 44]. During the 1990s, in order to also achieve cost reduction and standardization of office-based computer processes, organizations have previously looked towards IT systems, such as Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) systems, and labor arbitrage through offshoring, outsourcing, and the generation of centralized global shared services [42, 45-48].

The grey literature still refers to traditional information technology (IT) systems and labor arbitrage as alternatives to RPA. However, both options are fraught with emerging inadequacies: traditional IT systems have their limits, they require extensive IT support, often take a long time to implement, and do not make use of the latest technologies, such

as advancements in Artificial Intelligence (AI) [39, 49-51]. Previous benefits from offshoring/outsourcing, on the other hand, are eroded due to rising labor costs, skill shortages, and increasing turnover in developing countries [39].

Therefore, since the 2000s, organizations have started to look to robotics to automate their processes in an attempt to continue to achieve their cost reduction and standardization objectives [48]. Similar to the development of other new technologies and cost reduction strategies (including outsourcing), the development of RPA has also started with a “Hype and Fear” phase [52], during which RPA adoption has increased [45]. This seems to have ended around 2016 when organizations moved into a return on investment-focused phase, where they combined proof of concept and pilot projects to develop learning and good practice guidelines; this largely focused on back-office processes [45]. Mature organizations have then moved into a “triple win” phase, where they can reap benefits for shareholders, employees, and customers. In 2017, very few organizations moved into phase 4, in which RPA is institutionalized and integrated into the business [52]. The ongoing evolution of RPA demonstrates that organizations are now looking to automate all manner of processes, not merely back-office processes [45]. This development has very recently been expedited through the social distancing and lockdown requirements imposed during the COVID-19 pandemic: many organizations were forced to implement drastic cost-cutting and efficiency-improving measures, such as automation of simple, repetitive tasks to reduce the workforce or free up human resources to execute more value-adding tasks [53-60]. Moreover, the pandemic also required organizations to facilitate remote working – this meant that particularly paper-based legacy systems and associated processes were no longer possible, thus leading to organizations needing to re-think their processes [53-60].

Many of the grey literature pieces analyzed in this study suggest that RPA can be categorized into “types of automation” [49], “levels of automation” [48], “automation classes” [39], or even “stages of RPA” [61]. Deloitte [62] referred to this as the “automation spectrum”, whereby RPA can be categorized according to the level of automation it provides, as defined by the type and amount of data it can process, as well as the nature of activities it can perform. The grey literature suggests that RPA can be classified either into three or five such categories, ranging from Basic Automation, over more Cognitive or Intelligent Automation, to true Artificial Intelligence. Similar to the before-mentioned ambiguity in terms of RPA definitions, the types of RPA presented in the grey literature are also confusing as some reports use different terminology to describe the same types, while others group different types together and use their own terminology to describe those.

Since the purpose of this study is to provide an extensive overview of RPA, we are grouping the literature categories into three overarching types of RPA, which could be placed on the ends and middle of the automation spectrum:

1. *Basic Automation* (also referred to as Class 1, Stage 1, Level 1, or RPA itself): Most of the current RPA falls in this category. Robots make use of structured data, can process large amounts of data at once, are able to operate between different applications, but they merely mimic human action in routine, repetitive, rules-based, simple, and somewhat complex tasks. Humans are required to become involved to deal with exceptions. Some examples of Basic Automation are data entry, document workflow, task scheduling, and procurement [61, 63, 64]. [53-60] refers to these robots as ‘doing bots.’
2. *Cognitive or Intelligent Automation* (also referred to as and/or including Structured Rules, Pattern-based Decisions, Class 2, Enhanced Process Automation, Level 2 and/or Level 3, AI-aware RPA): Some of the currently existing RPA falls into this category. However, in comparison to Basic Automation, robots in this category can carry out more sophisticated processes, can deal with non-routine processes, unstructured data and/or natural language – in [53-60] words, these are ‘thinking bots.’ Robots in this category may start to mimic human judgment and exception handling by relying on machine learning and/or human aid. Examples of Cognitive Automation include speech tagging and language processing [39, 61, 64].
3. *Advanced Automation or Artificial Intelligence* (also referred to as Level 4 and/or Level 5; Multiple Decision Making; Cognitive Intelligence, Computing, or Platform; Autonomous System; Class 3): This category of RPA self-manages, adapts/learns from self-analyzed data and experience (including knowledge external to the specific applications it engages with), and is able to make decisions and improvements that require judgment. It may even go as far as to be able to think and learn like humans, entirely autonomously without human

involvement – hence, [53-60] nomenclature of ‘learning bots.’ However, RPA is not currently at this stage of development (yet). An example of such Advanced Automation is if a bot was to make decisions based on it sensing the mood of the user it interacts with [39, 61, 64].

In addition to these types of RPA, the grey literature also refers to other distinctions of RPA tools, from which organizations can choose:

- *Unattended or enterprise-level RPA* whereby automation takes place at the server level, and bots operate silently in the background without human involvement vs *attended or desktop-level RPA* which operates assisted by a human, often at the individual workstation level, and may be referred to as Robotic Desktop Automation or RDA [62, 65, 66]. There is also a possibility for hybrid RPA, whereby organizations deploy a mix of desktop-based and server-based RPA [53-60].
- *Generic RPA tools* which may be suitable for various different processes vs. *process-specific tools* that are designed specifically to automate very particular processes [62].
- *Do-it-for-me services* whereby organizations purchase bots and potentially also the management of those through RPA vendors and consultants vs *do-it-yourself solutions* whereby organizations build and deploy their own bots [45, 67].

4. Benefits and challenges of RPA

The grey literature highlights a large number of various benefits that RPA can provide to various organizational stakeholders. Although these benefits mutually affect one another, they can be grouped into the following themes: *monetary benefits; simplicity; efficiency and productivity; flexibility and scalability; reliability and consistency; compliance and governance; benefits for customers; benefits for employees; and long-term organizational benefit.*

The main benefits of RPA, as presented in all pieces of grey literature, are of a monetary nature: cost saving in comparison to traditional forms of process optimization and quick return on investment [65, 68, 69] [53-60]. This includes savings in terms of:

- Facilities: bots do not require office space [48, 70];
- Personnel costs: implementing RPA reduces headcount, which also reduces the cost of recruitment, training, and managing Human Resource issues [45, 48, 70];
- IT costs: RPA does not require expensive IT upgrades [67]; and
- Costs of offshoring and outsourcing: bots do not require supervision or negotiation with outsourcing partners [48] and are geographically independent [53-60].

These monetary benefits are seen rapidly, with short payback periods, because RPA is quick to implement due to its second main benefit: simplicity. RPA is non-invasive as it sits on top of and complements existing infrastructure [68]. Organizations do not need to replace, redesign or reconfigure legacy interfaces and systems [67, 71]. Deployment and management of RPA bots do not require extensive involvement from the IT function as its configurations, controls, and interfaces are simple and accessible to non-IT specialists [72, 73]. There is even the option of robotic self-help in case issues need to be remedied [50]. Deployment is non-disruptive to the organization’s day-to-day operations [68], and can thus be considered a low-risk automation option [53-60].

Another benefit mentioned in all pieces of literature is the increased efficiency and productivity that RPA can provide to organizations. Bots do not require time to adapt to a new working environment, there is no learning curve, and they are able to work 24 hours a day, 7 days a week, 365 days a year [45, 68]. By being able to multitask in the background, they can operate side by side with humans and complete the repetitive and low-value tasks that stifle their human co-workers’ productivity [74]. Bots complete these tasks in a fraction of the time that a human would require, thus increasing cycle time, response time, transaction turnaround time, and throughput [45]. RPA integrates data from

different systems, thus replacing the inefficient human ‘swivel chair’ movements of switching between different applications to complete the same process [65, 68]. This integration also enables the automation of processes in the ‘white spaces’ between different technologies as it facilitates collaboration and data sharing between different organizational units and even between organizations and external partners [71-73]. Since RPA is centrally managed, it does not require inefficient maintenance on each individual desktop, and it operates with minimum need for human intervention [52, 74, 75]. The implementation of RPA facilitates standardization of all elements relating to the process (e.g., consistent naming of files) and compression of activities while highlighting other processes, especially those that add little value to the organization, that further deployment of RPA could also improve [68, 73, 76].

This leads to the fourth key benefit of RPA: flexibility and scalability. RPA can be implemented on any scale, allowing organizations to pilot and experiment with bots on individual processes, or even sub-processes, at the start of their RPA journey or at any point of expansion [45, 73]. RPA is easy to scale up and down, and it adapts to changing business needs, which makes it highly useful for organizations that deal with seasonal variations, peak and trough times, data surges, variable labor availability, or uncertain environments [70, 77] – the latter has proved a particular benefit during the recent COVID-19 pandemic, in which many organizations had to deal with unpredictable or even unprecedented demand [53-60]. As RPA can be redeployed elsewhere on short notice, it adds to an organization’s agility and resilience [46], which is also developed through RPA’s reliability and consistency, which the grey literature highlights as a fifth key benefit of RPA.

Reliability and consistency derive from the fact that RPA bots do not lose concentration as their human counterparts would, and they always operate with 100% accuracy and predictability and do not make human errors [45, 53-60]. This not only reduces the number of processes that need to be re-worked but also increases the quality of outcomes [47, 78]. RPA operates within and between multiple systems at once, and it has much higher processing power than its human counterparts. As such, RPA can gather and process vast amounts of data in real-time, automatically feed them into business analytics and reporting, and seamlessly integrate data from multiple IT systems [43, 67, 68, 77]. This allows organizations to access highly accurate management information that supports forecasting and planning, decision making, and resource allocation [46, 71].

Accurate management information further supports the achievement of another key benefit of RPA: increased compliance and governance. All process steps, which RPA completes, are documented transparently and constitute further data that can be analyzed for reporting and monitoring purposes [79]. RPA not only eliminates some of the biggest compliance threats, including human error, data leaks, and criminal intentions but also monitors human transactions for unusual activities. In comparison to traditional outsourcing, organizations that use RPA retain full control over how processes are completed [45, 46]. By providing 100% accuracy in processes, RPA increases organizations’ ability to comply with regulations and governance requirements, which also reduces non-compliance fees and time to remedy [78]. Given that RPA can adapt to changing circumstances, it can implement new regulations quickly and cheaply, thus providing added benefit in industries that face regular changes in regulations [52, 71].

Organizations that comply with regulations provide more accurate service to customers, which means that RPA also increases customer satisfaction and quality of service delivery [52, 78]. RPA can even support organizations in revamping their entire customer experience as bots can not only speed up straight-through processing, but also provide customized solutions that require less effort from customers, for instance, by using bots to offer self-service options [39, 48, 65].

Employees are another stakeholder group, which benefits from RPA as the latter carries out the repetitive, low value, monotonous and boring tasks and thus frees up employees to focus on exception handling and tasks that require emotions, human relationships, intelligence, judgment, and interpretation [53-60]. This releases talent into more interesting and challenging activities (e.g., innovation), which better uses people’s skills, improves working conditions, work-life-balance (particularly during peak times) and increases employee motivation, which in turn positively affects staff engagement, attrition, and employee health [43, 45]. As such, employees can be redeployed rather than laid off, as they can now focus their efforts more on those activities that add value to customers, which supports customer satisfaction [39, 64]. RPA also augments talent as it requires organizations to redesign job roles and allows employees to make use of upskilling opportunities, which – in the long run – enhances their value in the labor market [52, 70].

Overall, the above-mentioned benefits of RPA can produce additional, long-term benefits for organizations: RPA can be seen as one step towards digital transformation and lean management, which can support organizational growth, competitive advantage, and the development of new capabilities that allow organizations to better compete with born-digital start-ups. Organizations that embrace RPA are seen as innovators and high-quality service providers, which has reputational benefits [45, 67, 71, 80].

Despite these significant benefits, RPA is not without its challenges. The grey literature discusses the main challenges, which can be grouped as follows: awareness and perception of RPA; uncertainty about how to prepare for RPA; change management challenges while implementing RPA; and challenges associated with RPA vendors.

Stakeholders' awareness and perception of RPA pose a significant challenge to companies considering RPA implementation. Many organizations report limited awareness of RPA and its benefits and drawbacks, while others report various diverse perceptions; the latter range from the highly negative misconception that RPA will threaten humanity [51], over the traditionalist skeptics who argue in favor of the proven benefits of offshoring as a barrier for RPA [81], to the extremely positive myths that RPA is a panacea that automatically standardizes organizational processes [79]. Although awareness of RPA has increased since 2017 [82], some lack of understanding of the reality of RPA persists, which may lead to distrust, negative attitudes, and active resistance to RPA by those with opposing views, while potentially leading to wrong, unclear, or unmet expectations and poor decision making on the part of those with positive views [45, 47, 61].

Insufficient understanding of RPA also means that many decision-makers lack knowledge of how to prepare for RPA. They may be unsure whether or how RPA could fit in their organization, how to build a business case for implementation, where to begin with RPA deployment, whom to involve, and which processes to automate [62, 77], [53-60]. A key challenge regularly mentioned in the grey literature is for organizations to ensure that RPA is not just considered a project. Instead, it needs to be seen as a strategic move that holistically fits into the overall IT strategy based on an appropriate business case and planned in detail [83, 84]. While preparing for RPA, it is also challenging for organizations to identify which processes can be automated, which RPA solutions to choose, and whom to involve in the process [52]. More recently, a shortage of RPA specialists who can design and implement RPA at scale seems to emerge and add to the challenges organizations may face when seeking to deploy RPA [85].

Once RPA is being implemented, it also carries various challenges, mostly relating to change management, the setting up of bots, and – more recently – concerns around cybersecurity, to which bots are not immune [82, 86, 87]. Change management is a key element of any RPA process as it requires a change in mindset for many stakeholders and will affect workforce management [62, 83]. Re-deployment and upskilling opportunities for employees, whose role will be affected by RPA, need to be developed, while Human Resource processes in terms of recruitment and training need to be amended [44, 46, 79]. Organizations have to communicate clearly and effectively with all stakeholders, and RPA deployment must involve diverse stakeholders as well as top management buy-in [88]. It is challenging to understand that deployment, despite being reasonably quick, requires organizations to make old legacy systems potentially RPA-ready and put in place exception handling systems and time to train the bots [52, 75, 88]. The more recent grey literature regularly refers to the importance of open communication with the IT function in particular as this may not be directly required to deploy the simple bots, but (perceived) lack of involvement of the IT function in the RPA implementation can result in negativity towards RPA [82, 89].

Implementation of RPA is particularly challenging and may become expensive if organizations choose in-house development of RPA [68], but the alternative – that is, to use vendors to support organizations with the choice, implementation [15], and maintenance of RPA – is equally fraught with challenges: The vendor landscape consists of many different vendors, which offer different services, use their own terminology, and may even rely on 'RPA washing' or 'RPA rebranding,' an unethical practice that involves vendors selling RPA-like systems as RPA and selling sub-par RPA systems [51, 52, 74, 90]. Deciding between do-it-yourself (DIY) and do-it-for-me (DIFM) also depends on organizations' current skill set and understanding of the relevant processes as RPA – despite its general simplicity to operate – does require RPA talent to operate and maintain the bots, particularly if errors are identified [64, 91]. Various items of the very recent grey literature [53-60] provided overviews of the different vendors in an attempt to map the RPA industry landscape and to highlight current and potential future industry leaders. Many organizations are drawn

towards the current leaders, although that choice may not be the best, particularly given that the industry contains a spread of niche players and emerging innovative and aggressively expanding challengers who may provide better services or more suitable RPA solutions [53-60] – thus, it is a clear challenge for companies to understand their own requirements, complete research into the various vendors, and eventually choose a suitable vendor [53-60].

5. Implementation guidelines for RPA and future outlook

Many pieces of grey literature are written by vendors that offer RPA solutions or consultancy services that support organizations in their choice of RPA solutions. As such, most pieces contain guidelines for implementing RPA that focus on the type of services the organizations offer. Nevertheless, there are several common guidelines, as well as steps that apply to all organizations wishing to deploy RPA. The key guiding principles to deploying RPA are twofold: A) to plan carefully, and B) to use a phased approach, starting with a small pilot project (e.g., one single process in one single business unit), and to gradually scale up once early, quick wins are reaped, and RPA capacity is being built [45, 47]. More specifically, the grey literature commonly suggests *three main steps of RPA implementation*:

- Step 1: Planning and initiating the RPA journey;
- Step 2: Proof of concept through a pilot project; and
- Step 3: Scaling up and institutionalizing RPA.

To begin the RPA journey, organizations are advised to carry out an audit of their current operations to identify and prioritize the processes that are suitable for RPA [79, 92], to explore use cases [47], and to map suitable processes end-to-end [47]. Recent grey RPA literature, in particular, focuses on this preparatory phase as a key to RPA success: organizations must fully understand and optimize their processes already before RPA as RPA might otherwise perpetuate errors and do so at a much faster speed, more consistently, and without the intuitive knowledge that something is wrong that the human workforce possesses [64, 80, 82, 85]. While auditing and optimizing processes, organizations should also audit their RPA capabilities [40] and technology landscape [79]. This will allow organizations to build the business case [40], decide upon suitable implementation strategies [47], measures, metrics and benchmarks [92], design the RPA solution [78], mobilize appropriate human and financial resources [79] and begin the change management journey by raising awareness amongst their stakeholders [79]. Much recent grey literature focuses particularly on the importance of continuous communications between business and IT functions as RPA is often considered a business project but may be seen as a threat to jobs and responsibilities by IT staff [89, 93].

The second step is the proof of concept [92] or pilot [40] phase, during which key resources are being trained, the bots for a small-scale RPA pilot project are built or sourced and deployed, monitored, and evaluated [40]. If the pilot is successful, organizations start to build a governance framework and operating model and clarify future roles and responsibilities for automation teams [92]. A roadmap for scaling up is developed [79]. Some literature suggests that vendors are explored and selected here [79], while others recommend choosing partners during the planning phase [51].

The third step follows the successful pilot and involves more wide-scale implementation of RPA across the organization by continuing to build expertise [40], by developing a roadmap for further RPA implementation [92], and eventually by fully institutionalizing RPA in the entire organization [40]. This phase also requires the ongoing operation of RPA bots, monitoring, and evaluation [82].

The RPA market has recently been the fastest-growing segment of the enterprise software market, and the grey literature from 2020 suggests this development will continue into the future as the industry consolidates, current vendors continue to make significant investments to improve their RPA offerings, and new RPA providers from adjacent markets (e.g., software or cloud vendors) emerge [53-60].

For RPA itself, the future holds many opportunities as the technology continues to mature. RPA moves further into the direction of being able to automate increasingly cognitive processes: by leveraging elements of AI, machine learning, voice recognition, and sentiment analysis, bots will be able to complete increasingly complex and human tasks, or even make autonomous decisions while requiring less and less human intervention [39, 94, 95]. While RPA has become a

buzzword [96], it is not 100% foolproof [97]. However, the demand for RPA will grow in the future, and notably, the COVID-19 pandemic and resulting negative economic impacts are likely to drive further adoption of RPA [53-60]. The latter is true in the case of traditional RPA-users, such as the banking and insurance industries, but also in industries that have to date not used RPA to a significant extent, e.g., pharmaceutical and healthcare, manufacturing, government, and education [53-60]. The future outlook for people in the context of RPA suggests that the talent pyramid and talent mix will change as new job roles will emerge, and while some high-skilled jobs will be created, some currently existing jobs will be threatened [47, 61, 62, 65, 75].

For organizations moving forward, this means a change in talent recruitment, training and retention strategies and processes [46, 47]. Moreover, RPA will most likely remain a strategic priority, and an increasing number of organizations (including Small and Medium-Sized Enterprises) will implement RPA for increasing numbers of processes, in increasing number of organizational functions [39, 45, 67, 85] and in virtual environments [98]. This will transform not only individual organizations, but entire societies, particularly those currently offering offshoring of repetitive tasks: countries like India will see a reduction in organizations wishing to outsource repetitive tasks, while they are likely going to see an increase in demand for outsourcing of judgment-oriented tasks [42, 46]. More recently, cybersecurity concerns have emerged around the deployment of RPA bots, which suggests that organizations will need to expend resources (including human resources) into security and risk management [86].

The reviewed grey literature clearly shows that the future outlook for RPA in organizations is strong. Although the grey literature does not specify any particular implications for scholarly research in this field, the growing scholarly literature in this area suggests a need for RPA research to continue and intensify, alongside the solid future outlook for RPA in companies. In particular, scholars should conduct large-scale, independent studies of the various short and long-term benefits and challenges of RPA from the perspectives of diverse stakeholders affected by RPA implementation. Furthermore, the identified steps of RPA deployment can be explored by using case studies with primary data collection as a research method. Moreover, scholarly research needs to develop a theoretical understanding of RPA, for instance, by drawing upon the related but theoretically advanced fields of business process automation, digitization, and labor arbitrage, as well as the emerging field of AI.

6. Conclusion

This study is based on a narrative review of six years of organizational grey literature on the emerging topic of robotic process automation. It adds to the scarce academic literature in this evolving field, as it complements the existing RPA literature reviews, the focus of which was exclusively or significantly on peer-reviewed, scholarly literature. As such, this study provides a strong starting point for integrating RPA knowledge stemming from expert organizations into further academic discussions of this field. Due to the paucity of comparative and integrative studies, this study creates a better understanding of RPA, and the exclusive use of organizational grey literature provides strength to the paper's content as organizations are ahead of academic research in this field.

By systematically examining the organizational grey literature, this study has proposed a unified definition of RPA that draws from common themes in existing definitions. The literature categories of RPA were grouped into three predominant types: basic automation, cognitive or intelligent automation, and advanced automation or artificial intelligence. Other distinctions of RPA tools were also identified: unattended/enterprise-level RPA vs attended/desktop RPA; generic vs process-specific RPA tools; and do-it-for-me vs do-it-yourself RPA solutions. Many benefits of RPA were identified, which are grouped into monetary; simplicity; efficiency and productivity; flexibility and scalability; reliability and consistency; compliance and governance; customer satisfaction; employee efficiency; and other long-term organizational benefits. Despite the benefits, RPA adoption has its challenges, most notably: awareness and perception of RPA; uncertainty about how to prepare for RPA; change management challenges while implementing RPA; and challenges associated with RPA vendors. Three main steps of RPA implementation were identified that can guide organizations towards successful RPA deployment. The future for RPA suggests a strong focus on the incorporation of advanced automation, an enhanced implementation for a diverse range of business processes, and a change in talent acquisition practices to cater to RPA skill sets.

This study has manifold implications. First, from a theoretical standpoint, it helps inform researchers by providing a conceptual, bird's eye overview of RPA from an industry perspective. Second, from a practical standpoint, it assists industry practitioners in avoiding or mitigating the identified challenges and adopt a streamlined implementation path.

As with any study, this one also has its limitations. First, the use of grey literature may be questionable as the sole evidence for a scientific claim, but it is justified due to the idiosyncrasies of this particular field: a lack of adequate scholarly RPA literature; the lagging of academic research behind practice; and the role that organizational grey literature plays in providing current contextual information complementary to scholarly literature. Given the rapid developments in this field, it is recommended that further reviews of academic and grey literature be carried out as it emerges over the following years. Second, the evaluation of literature is subject to inherent subjectivity and hence should be treated accordingly. Third, this study was conducted based on specific inclusion criteria (e.g., search for the specific phrase "robotic process automation" omitted literature that may have used alternate terminology). Finally, further research is needed to explore the identified steps of RPA implementation, particularly by using case studies with primary data collection as a research method.

The future outlook for RPA is strong, and this study has provided a conceptual, bird's eye overview of RPA based on organizational grey literature. Research in the RPA field should continue and focus on discovering the many benefits and challenges it can produce in the years ahead.

Acknowledgments

We acknowledge that this study did not receive any specific grant from the public, commercial, or not-for-profit domains.

References

- [1] R. Syed, S. Suriadi, M. Adams, W. Bandara, S.J.J. Leemans, C. Ouyang, A.H.M. ter Hofstede, I. van de Weerd, M. T. Wynn, and H. A.Reijers., "Robotic process automation: contemporary themes and challenges," *Computers in Industry*, vol. 115, pp. 1-15, 2020.
- [2] T. Korhonen. (2016, 22/06/2019). *Robotic process automation*. Available: <https://www.fujitsu.com/fi/Images/Robotic%20Process%20Automization.pdf>
- [3] C. Le Clair. (2017, 22/06/2019). *The RPA market will reach \$2.9 Billion by 2021*. Available: <https://www.forrester.com/report/The+RPA+Market+Will+Reach+29+Billion+By+2021/-/E-RES137229>
- [4] McKinsey Global Institute. (2013, 22/06/2019). *Disruptive technologies: advances that will transform life, business, and the global economy*. Available: https://www.mckinsey.com/~media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Disruptive%20technologies/MGI_Disruptive_technologies_Executive_summary_May2013.ashx
- [5] P. Fettke and P. Loos, "Structuring information systems in the era of robotic process automation," *Preprint*, pp. 1-8, 2018.
- [6] W. M. van der Aalst, M. Bichler, and A. Heinzl, "Robotic process automation," *Business & Information Systems Engineering*, vol. 60, no. 4, pp. 269-272, 2018.
- [7] J. Kiilunen, "Automating project management with RPA," *Turku University of Applied Sciences*, vol. Master's Degree Programme in Project Management thesis, pp. 1-86, 2020.
- [8] J. Kaidalova, K. Sandkuhl, and U. Seigerroth, "How digital transformation affects enterprise architecture management: a case study," *International Journal of Information Systems and Project Management*, vol. 6, no. 3, pp. 5-18, 2018.
- [9] J. Varajão, "The many facets of information systems (+ projects) success," *International Journal of Information Systems and Project Management*, vol. 6, no. 4, pp. 5-13, 2018.
- [10] L. Willcocks, M. Lacity, and A. Craig, "The IT function and robotic process automation," ed: The London School of Economics and Political Science, 2015, pp. 1-39.

- [11] J. Mendling, G. Decker, R. Hull, H. A. Reijers, and I. Weber, "How do machine learning, robotic process automation, and blockchains affect the human factor in business process management?," *Communications of the Association for Information Systems*, vol. 43, no. 19, pp. 297-320, 2018.
- [12] W. M. van der Aalst, "Hybrid Intelligence: to automate or not to automate, that is the question," *International Journal of Information Systems and Project Management*, vol. 9, no. 2, pp. 5-20, 2021.
- [13] Accenture. (2016, 22/06/2019). *Robotic process automation*. Available: https://www.accenture.com/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_24/Accenture-RPA-Video-Transcript.pdf
- [14] NASSCOM. (2015, 22/06/2019). *Seizing the robotic process automation (RPA) opportunity*. Available: <https://www.gita.org.in/Attachments/Reports/8%20NASSCOM-ERI-RPA%20Market%20Opportunity%20%20NASSCOM.pdf>
- [15] Forrester Research. (2017, 22/06/2019). *The Forrester Wave™: robotic process automation, Q1 2017, The 12 providers that matter most and how they stack up*. Available: <https://www.forrester.com/report/The+Forrester+Wave+Robotic+Process+Automation+Q1+2017/-/E-RES131182>
- [16] J. Vom Brocke, W. Maaß, P. Buxmann, A. Maedche, J. M. Leimeister, and G. Pecht, "Future work and enterprise systems," *Business & Information Systems Engineering*, vol. 60, no. 4, pp. 357-366, 2018.
- [17] Institute for Robotic Process Automation. (2018, 15/06/2019). *Definition and benefits*. Available: <https://irpaai.com/definition-and-benefits/>
- [18] Deloitte. (2017, 22/06/2019). *Automate this: The business leader's guide to robotic and intelligent automation*. Available: <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-sdt-process-automation.pdf>
- [19] McKinsey & Company. (2017, 22/06/2019). *A future that works: automation, employment, and productivity*. Available: https://www.mckinsey.com/~media/McKinsey/Global%20Themes/Digital%20Disruption/Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-that-works_Executive-summary.ashx
- [20] D. Fernandez and A. Aman, "Impacts of robotic process automation on global accounting services," *Asian Journal of Accounting and Governance*, vol. 9, pp. 123-131, 2018.
- [21] L. Ivančić, D. S. Vugec, and V. B. Vukšić, "Robotic process automation: systematic literature review," in *International Conference on Business Process Management*, 2019, pp. 280-295: Springer.
- [22] J. G. Enríquez, A. Jiménez-Ramírez, F. Domínguez-Mayo, and J. García-García, "Robotic process automation: a scientific and industrial systematic mapping study," *IEEE Access*, vol. 8, pp. 39113-39129, 2020.
- [23] R. Beetz and Y. Riedl, "Robotic process automation: developing a multi-criteria evaluation model for the selection of automatable business processes," presented at the AMCIS 2019 Proceedings Cancun, Mexico, 15-17 August, 2019.
- [24] F. Santos, R. Pereira, and J. B. Vasconcelos, "Toward robotic process automation implementation: an end-to-end perspective," *Business Process Management Journal*, vol. 26, no. 2, pp. 405-420, 2019.
- [25] D. Farace, "Forward," in *GL '97 Conference Proceedings: Perspectives on the Design and Transfer of Scientific and Technical Information*, Amsterdam, 1998: TransAtlantic.
- [26] D. J. Farace and J. Sch öpfel, "Introduction to grey literature," in *Grey Literature in Library and Information Studies*, D. J. Farace and J. Sch öpfel, Eds. Berlin/New York: Walter de Gruyter GmbH & Co. KG, 2010, pp. 1-7.
- [27] G. White, J. Thomas, P. Weldon, A. Lawrence, H. Galatis, and J. Tyndall, "Grey literature in Australian education," *The Grey Journal (TGJ)*, vol. 9, no. 2, pp. 103-108, 2013.
- [28] R. J. Adams, P. Smart, and A. S. Huff, "Shades of grey: guidelines for working with the grey literature in systematic reviews for management and organizational studies," *International Journal of Management Reviews*, vol. 19, no. 4, pp. 432-454, 2016.
- [29] T. Sharma, M. Choudhury, B. Kaur, B. Naidoo, S. Garner, P. Littlejohns and S. Staniszevska, "Evidence informed decision making: the use of "colloquial evidence" at Nice," *International Journal of Technology Assessment in Health Care*, vol. 31, no. 3, pp. 138-146, 2015.
- [30] K. M. Benzies, S. Premji, K. A. Hayden, and K. Serrett, "State-of-the-evidence reviews: advantages and challenges of including grey literature," *Worldviews on Evidence-Based Nursing*, vol. 3, no. 2, pp. 55-61, 2006.

- [31] P. Cronin, F. Ryan, and M. Coughlan, "Undertaking a literature review: a step-by-step approach," *British Journal of Nursing*, vol. 17, no. 1, pp. 38-43, 2008.
- [32] J. Adams, F. C. Hillier-Brown, H. J. Moore, A. A. Lake, V. Araujo-Soares, M. White, and C. Summerbell, "Searching and synthesising 'grey literature' and 'grey information' in public health: critical reflections on three case studies," *Systematic Reviews*, vol. 5, no. 1, pp. 164-174, 2016.
- [33] J. Tyndall, "How low can you go? Towards a hierarchy of grey literature," presented at the Australian Library and Information Association Biennial Conference, 2-5 September, 2008.
- [34] W. Chung, "Web searching and browsing: A multilingual perspective," *Advances in Computers*, vol. 78, pp. 41-69, 2010.
- [35] J. Hagen-Zanker and R. Mallett, "How to do a rigorous, evidence-focused literature review in international development: a guidance note," Overseas Development Institute 2013, Available: <https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8572.pdf>.
- [36] C. Wagner, M. D. Gebremichael, M. K. Taylor, and M. J. Soltys, "Disappearing act: decay of uniform resource locators in health care management journals," *Journal of the Medical Library Association*, vol. 97, no. 2, pp. 122-130, 2009.
- [37] R. Chugh, S. Macht, and R. Hossain. (2021, 14/10/2021). *Robotic process automation: grey literature from 2015 to 2020. Figshare*. Available: <https://doi.org/10.6084/m9.figshare.13571168>
- [38] E. T. Rother, "Systematic literature review X narrative review," *Acta Paulista de Enfermagem*, vol. 20, no. 2, pp. v-vi, 2007.
- [39] KPMG. (2018, 17/06/2019). *Robotic process automation (RPA): on entering an age of automation of white-collar work through advances in AI and Robotics*. Available: <https://home.kpmg/content/dam/kpmg/jp/pdf/jp-en-rpa-business-improvement.pdf>
- [40] Fujitsu. (2016, 15/06/2019). *If you can teach it, you can automate it: robotic process automation*. Available: <http://www.fujitsu.com/fi/Images/Robotic%20Process%20Automization.pdf>
- [41] Kofax. (2017, 17/06/2019). *Creating a digital workplace: how to eliminate manual tasks with robotic process automation*. Available: https://www.kofax.com/-/media/Files/Infographics/EN/ig_creating-a-digital-workforce_en.pdf
- [42] EY. (2015, 15/06/2019). *Robotic process automation*. Available: [https://www.ey.com/Publication/vwLUAssets/ey-robotic-process-automation-white-paper/\\$FILE/ey-robotic-process-automation.pdf](https://www.ey.com/Publication/vwLUAssets/ey-robotic-process-automation-white-paper/$FILE/ey-robotic-process-automation.pdf)
- [43] Atos. (2016, 22/06/2019). *Robotic process automation for smarter and better working*. Available: <https://atos.net/wp-content/uploads/2017/04/atos-robotic-process-automation-opinion-paper.pdf>
- [44] Protiviti. (2016, 17/06/2019). *Looking deeper into robotic automation*. Available: https://www.protiviti.com/sites/default/files/australia/insights/looking-deeper-into-robotic-automation-protiviti-global-a4_0.pdf
- [45] Capgemini Consulting. (2016, 22/06/2019). *Robotic process automation - robots conquer business processes in back offices*. Available: <https://www.capgemini.com/consulting-de/wp-content/uploads/sites/32/2017/08/robotic-process-automation-study.pdf>
- [46] Capgemini Consulting. (2017, 22/06/2019). *The automation revolution – a plethora of opportunities for organizations and individuals (special edition ed.)*. Available: https://www.capgemini.com/gb-en/wp-content/uploads/sites/3/2017/07/robotic_process_automation_special_edition_summer_2017.pdf
- [47] Everest Group and NASSCOM. (2015, 15/06/2019). *Seizing the robotic process automation (RPA) market opportunity*. Available: <https://www.gita.org.in/Attachments/Reports/8%20NASSCOM-ERI-RPA%20Market%20Opportunity%20-%20NASSCOM.pdf>
- [48] Optimal Corporation. (2017, 17/06/2019). *The case for robotic process automation (RPA)*. Available: http://optimalcorp.com/wp-content/uploads/2017/02/The-Business-Case-for-RPA_Optimal-Corp.pdf
- [49] EY. (2017, 15/06/2019). *Insights on robotic process automation*. Available: <https://www.ey.com/Publication/vwLUAssets/EY-insights-on-robotic-process-automation/%24FILE/EY-insights-on-robotic-process-automation.pdf>

- [50] Infosys. (2016, 15/06/2019). *Robotic process automation (RPA): now is the time to be future ready*. Available: <https://www.infosysbpm.com/offering/functions/robotics-process-automation/Documents/rpa-brochure.pdf>
- [51] Initio. (2017, 17/06/2019). *RPA: The automation of automation*. Available: <https://blgsqr.files.wordpress.com/2017/03/rpa-the-automation-of-automation.pdf>
- [52] KCP. (2017, 17/06/2019). *Robotic process automation: benchmarking the client experience*. Available: <https://static1.squarespace.com/static/58eceda617bffc97d03b69da/t/5b62bdeaf950b7f18d967216/1533197807521/RPA+-+Benchmarking+the+Client+Experience.pdf>
- [53] BDO. (2020, 04/01/2021). *Robotic process automation during COVID-19*. Available: https://www.bdo.com/getattachment/6dc5a0ee-84ad-4fa0-bbed-8b3b1f1d8a99/attachment.aspx?ADV_TBTS_Robotic-Process-Automation_Web.pdf
- [54] Dell Technologies. (2020, 04/01/2021). *Bridging digital transformations through RPA*. Available: https://education.dellemc.com/content/dam/dell-emc/documents/en-us/2020KS_Hashim-Bridging_Digital_Transformations_Through_RPA.pdf
- [55] Gartner. (2020, 04/01/2021). *Magic quadrant for robotic process automation*. Available: <https://www.gartner.com/en/documents/3988021/magic-quadrant-for-robotic-process-automation>
- [56] Infosys. (2020, 04/01/2021). *Effective adoption of robotic process automation in the enterprise*. Available: https://www.infosysconsultinginsights.com/wp-content/uploads/2020/06/adoption-rpa-in-enterprise_pov_infosys-consulting.pdf
- [57] Infosys. (2020, 04/01/2021). *Security considerations in robotic process automation*. Available: <https://www.infosys.com/services/cyber-security/documents/rpa-security.pdf>
- [58] International Group of Controlling. (2020, 04/01/2021). *Robotic process automation in controlling - results of an empirical study*. Available: https://www.igc-controlling.org/fileadmin/downloads/IGC_Study_Report__22Robotic_Process_Automation_in_Controlling_22__2020__in_English_.pdf
- [59] LogiSYM. (2020, 04/01/2021). *Capitalising on supply chain digitisation with robotic process automation*. Available: https://logisym.org/wp-content/uploads/2020/08/Automation-Anywhere_Whitepaper_Capitalising-on-Supply-Chain-Digitisation-with-Robotic-Process-Automation-10-Areas-of-Opportunities.pdf
- [60] Macedon Technologies. (2020, 04/01/2021). *The role of RPA in digital transformation*. Available: <https://macedontechnologies.com/wp-content/uploads/RPA-white-paper.pdf>
- [61] PwC. (2016, 17/06/2019). *People, change... and robots*. Available: <https://www.pwc.com.au/pdf/robotic-process-automation-people-change-and-robots.pdf>
- [62] Deloitte. (2017, 22/06/2019). *The digital workforce is here: understanding and exploring robotic process automation (RPA)*. Available: <https://www2.deloitte.com/content/dam/Deloitte/in/Documents/strategy/in-strategy-innovation-rpa-digital-workforce-noexp.pdf>
- [63] KPMG. (2018, 17/06/2019). *Delivering value in procurement with robotic process automation*. Available: <https://advisory.kpmg.us/content/dam/kpmg-advisory/management-consulting/pdfs/2017/robotic-process-automation-in-procurement.pdf>
- [64] BPM-D. (2019, 04/04/2020). *Value-driven robotic process automation: enabling effective digital transformation*. Available: <https://bpm-d.com/wp-content/uploads/2019/09/RPA-Whitepaper-A4-v2.pdf>
- [65] Contextor. (2017, 22/06/2019). *Robotic process automation: a pragmatic approach to digital transformation*. Available: https://contextor.eu/wp-content/uploads/2017/06/Livre_Blanc_Contextor_EN.pdf
- [66] PwC. (2016, 17/06/2019). *Robotic process automation: creating a digital workforce*. Available: <https://silkstart.s3.amazonaws.com/57e01a64893aaa4bbfba8d18.pdf>
- [67] DXC Technology. (2017, 22/06/2019). *Robotic process automation brings the future to your workplace*. Available: http://assets1.dxc.technology/au/downloads/MD_6241a-18_DXC_RPA_Paper_v2.pdf
- [68] Kofax. (2015, 17/06/2019). *Complete the productivity picture: a guide to robotic process automation*. Available: https://www.kofax.com/-/media/Files/E-books/EN/eb_complete-the-productivity-picture-with-rpa_en.pdf
- [69] T. H. Group. (2016, 15/06/2019). *Understanding robotic process automation: value proposition, deployment model and use cases*. Available: https://cbps.canon.com/assets/pdf/Understanding-Robotic-Process-Automation_White-Paper_Hackett-Group_Canon-Business-Process-Services-2017.pdf

- [70] Avanade & BluePrism. (2017, 22/06/2019). *Robotic process automation: your catalyst for intelligent automation*. Available: <https://www.avanade.com/~media/asset/thinking/blue-prism-pov.pdf>
- [71] Now We Comply. (2017, 17/06/2019). *Robotic process automation: the new engine of business innovation*. Available: <https://www.autologyx.com/sites/default/files/NWC-Whitepaper-Jan2016i-v2.pdf>
- [72] IBM. (2016, 15/06/2019). *Robotic process automation: leading with robotics and automation in a fast-paced, digitally disruptive environment*. Available: https://www-935.ibm.com/services/multimedia/dl_17119_rpa_flyer_04.pdf
- [73] PwC. (2016, 17/06/2019). *Organize your future with robotic process automation*. Available: <https://www.pwc.lu/en/rpa/docs/robotics-process-automation.pdf>
- [74] Kofax. (2018, 17/06/2019). *The ultimate guide to choosing the right robotic process automation solution*. Available: http://www.bernet.net.au/wp-content/uploads/2017/12/wp_guide-to-choosing-robotic-process-automation-solution_en-4.pdf
- [75] Forrester Research. (2015, 15/06/2019). *The state of robotic process automation: a poor man's business process management, or possibly something more*. Available: https://www.nice.com/optimizing-customer-engagements/Lists/WhitePapers/The_State_of_RPA_-_Forrester.pdf
- [76] VNC. (2019, 4/04/2020). *Robotic process automation*. Available: <https://www.vncdigitalservices.com/wp-content/uploads/2019/07/whitepaper-rpa.pdf>
- [77] KPMG. (2016, 17/06/2019). *Rise of the robots*. Available: <https://www.the-digital-insurer.com/wp-content/uploads/2017/07/943-rise-of-the-robots.pdf>
- [78] Brickendon Consulting. (2017, 22/06/2019). *Robotic process automation (RPA)*. Available: <https://www.brickendon.com/wp-content/uploads/2017/10/Brickendon-Consulting-Insight-RPA-Digital-Version-1.pdf>
- [79] KPMG. (2017, 17/06/2019). *Accelerating automation: plan your faster, smoother journey*. Available: <https://home.kpmg/content/dam/kpmg/my/pdf/accelerating-automation-plan-your-faster-smoother-journey.pdf>
- [80] APQC. (2019, 4/04/2020). *Leveraging emerging tools and technologies in finance: robotic process automation (RPA)*. Available: https://www.apqc.org/system/files/K09784_RPA_Leveraging%20Emerging%20Tools%20and%20Tech%20in%20OFM.pdf
- [81] Deloitte. (2015, 22/06/2019). *The robots are coming*. Available: <https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/finance/deloitte-uk-finance-robots-are-coming.pdf>
- [82] Protiviti. (2019, 4/04/2020). *Taking RPA to the next level*. Available: <https://www.protiviti.com/sites/default/files/2019-global-rpa-survey-protiviti.pdf>
- [83] The Hackett Group. (2017, 17/06/2019). *A blueprint for getting started with robotic process automation*. Available: https://www.symphonyhq.com/wp-content/uploads/dlm_uploads/2017/05/Getting_Started_with_Robotic_Process_Automation_October2017.pdf
- [84] Canon. (2018, 4/04/2020). *Key Strategies for Implementing Robotic Process Automation*. Available: https://cbps.canon.com/assets/pdf/Key-Strategies-For-Implementing-Robotic-Process-Automation_Canon-Business-Process-Services.pdf
- [85] A.T. Kearney. (2018, 4/04/2020). *Robotic process automation: the impact of RPA on finance back-office processes*. Available: https://fr.majorel.com/wp-content/uploads/2018/07/Arvato_Whitepaper-Impact-of-RPA-on-finance-back-office-processes.pdf
- [86] EY. (2018, 4/04/2020). *risk and control considerations within robotic process automation implementations*. Available: [https://www.ey.com/Publication/vwLUAssets/ey-robotic-process-automation-implementation/\\$File/ey-robotic-process-automation-implementation.pdf](https://www.ey.com/Publication/vwLUAssets/ey-robotic-process-automation-implementation/$File/ey-robotic-process-automation-implementation.pdf)
- [87] Deloitte. (2019, 4/04/2020). *robotic process automation (RPA) within federal identity management*. Available: <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/public-sector/us-gps-robotic-process-automation.pdf>
- [88] PwC. (2017, 17/06/2019). *Who minds the bots?* Available: <https://www.pwc.com.au/publications/assets/rpa-risk-controls.pdf>

- [89] Deloitte. (2018, 4/04/2020). *Understanding the challenge of implementing your virtual workforce*. Available: <https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/strategy/deloitte-nl-so-understanding-challenge-of-implementing-rpa.pdf>
- [90] Gartner. (2017, 15/06/2019). *Market guide for robotic process automation software*. Available: [http://images.abbyy.com/India/market_guide_for_robotic_pro_319864%20\(002\).pdf](http://images.abbyy.com/India/market_guide_for_robotic_pro_319864%20(002).pdf)
- [91] KPMG. (2018, 4/04/2020). *Robotic process automation: how to move on from the proof of concept phase? a RPA governance framework*. Available: <https://www.compact.nl/pdf/C-2018-1-Doesburg.pdf>
- [92] Chazey Partners. (2017, 22/06/2019). *Robotic process automation: enablement through digital transformation*. Available: <https://chazeypartners.com/wp-content/uploads/2017/08/Chazey-Partners-RPA-Brochure-1.pdf>
- [93] Knowledge Capital Partners. (2018, 4/04/2020). *Keys to RPA success*. Available: <https://static1.squarespace.com/static/58eceda617bffc97d03b69da/t/5bf52dbf2b6a2890e19e83e8/1542794689298/Keys+to+RPA+Success+-+Part+3.pdf>
- [94] FIS. (2019, 4/04/2020). *Robotic process automation enabled back office operations*. Available: <https://www.fisglobal.com/-/media/fisglobal/files/pdf/brochure/robotic-process-automation-enabled-back-office-operations-brochure.pdf>
- [95] Skymind. (2019, 4/04/2020). *Introduction to AI and robotic process automation*. Available: https://skymind.ai/ebook/Skymind_RPA_White_Paper.pdf
- [96] Wipro. (2017). *Robotic process automation: driving efficiency the smarter way*. Available: <http://docplayer.net/storage/60/45036541/1549599983/1Csb09G5h0thPbbihxIxhg/45036541.pdf>
- [97] The Robotic Workforce. (2017, 17/06/2019). *A guide to robotic process automation*. Available: <https://www.theroboticworkforce.com/media/attachments/2017/05/04/the-robotic-workforce---a-guide-to-robotic-process-automation.pdf>
- [98] PwC. (2018, 4/04/2020). *Robotic process automation in a virtual environment*. Available: <https://www.pwc.in/assets/pdfs/publications/2018/robotic-process-automation-in-a-virtual-environment.pdf>

Biographical notes**Ritesh Chugh**

Ritesh Chugh is an associate professor in the School of Engineering and Technology at Central Queensland University, Australia. As an information systems socio-technological expert, his research focuses on the social role of emerging information systems and their influence on humans and organisations in real-world settings. He takes an inter-disciplinary approach in research which includes information systems management, social media, project management, knowledge management, educational systems and technology-enhanced learning. He has received several teaching awards that recognize his teaching excellence, commitment to improved student outcomes and engagement in reflective learning and teaching activities. Ritesh is a senior member of the Institute of Electrical and Electronics Engineers and the Australian Computer Society.

**Stephanie Macht**

Stephanie Macht is a senior lecturer in strategic management at Central Queensland University's School of Business and Law. She teaches in the areas of entrepreneurship, professional development, and research methods, and is an active supervisor of research higher degree students. Stephanie's most recent research interests revolve around sustainability, entrepreneurial finance, and learning and teaching in higher education.

**Rahat Hossain**

Rahat Hossain is a lecturer at Central Queensland University, Australia, with extensive teaching and learning experience across different areas of Information and Communication Technology. He completed his PhD in Computational Intelligence in 2013. Before his current academic position, Rahat acquired more than seven years of learning and teaching experience in the Department of Computer Science and Information Technology at the Islamic University of Technology, Bangladesh. He is currently supervising several Research Higher Degree students. Rahat's research interests are in information systems, machine learning, time-series analysis, and supply chain.



Changes to team autonomy in large-scale software development: a multiple case study of Scaled Agile Framework (SAFe) implementations

Tomas Gustavsson

Karlstad University

Universitetsgatan 2, 651 88 Karlstad, Sweden

tomas.gustavsson@kau.se

Marthe Berntzen

University of Oslo

Gaustadalléen 23 B, 0373 Oslo, Norway

marthenb@ifi.uio.no

Viktoria Stray

University of Oslo, SINTEF

Gaustadalléen 23 B, 0373 Oslo, Norway

stray@ifi.uio.no



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.science sphere.org

T. Gustavsson, M. Berntzen, V. Stray, “Changes to team autonomy in large-scale software development: a multiple case study of Scaled Agile Framework (SAFe) implementations”, *International Journal of Information Systems and Project Management*, vol. 10, no. 1, pp. 29-46, 2022.



Changes to team autonomy in large-scale software development: a multiple case study of Scaled Agile Framework (SAFe) implementations

Tomas Gustavsson

Karlstad University
Universitetsgatan 2, 651 88 Karlstad, Sweden
tomas.gustavsson@kau.se

Marthe Berntzen

University of Oslo
Gaustadalléen 23 B, 0373 Oslo, Norway
marthenb@ifi.uio.no

Viktoria Stray

University of Oslo, SINTEF
Gaustadalléen 23 B, 0373 Oslo, Norway
stray@ifi.uio.no

Abstract:

Large-scale transformations of agile ways of working have received more attention in the industry in recent years. Some organizations have developed their own solutions for scaling, whereas many have chosen trademarked frameworks. In large-scale agile software development, many developers and development teams carry out work simultaneously. When autonomous teams need to coordinate toward a common goal, they must sacrifice some level of autonomy. Development, testing, and integrations need to be coordinated with other teams and aligned with an organization's programs or portfolio. Through the conducting of 28 interviews and 17 on-site visits, this multiple case study explored how team autonomy changed in three agile software development organizations that implemented the Scaled Agile Framework (SAFe). The positive changes to team autonomy that they experienced as a result included getting a better overview, making better long-term decisions, giving and receiving help, and signaling limitations. We found two negative impacts on team autonomy: limited feature choice and enforced refinement. The study extends previous research on large-scale agile software development and improves our understanding of impacts on team autonomy.

Keywords:

agile software development; team autonomy; Scaled Agile Framework; SAFe; large-scale agile.

DOI: 10.12821/ijispm100102

Manuscript received: 23 July 2021

Manuscript accepted: 21 February 2022

1. Introduction

Since agile was introduced more than 20 years ago, it has become highly popular in not only small organizations but also larger organizations [1]. Today, the term “large-scale agile” is used to refer to agile practices and methods used beyond a single development team both at the inter-team and the organizational level [1]. In large-scale agile software development (ASD) settings, where several teams cooperate toward a common goal, new problems arise, such as dealing with dependencies between activities and ensuring shared goals between teams [1]. Typically, a software development team needs to coordinate with other teams regarding the constraints of, for example, requirements, testing, and integration [2]. These dependencies may limit the amount of autonomy and empowerment of the individual team. Therefore, the need to coordinate work processes with the rest of the organization reduces team autonomy [3]. A project is often part of a larger set of development projects, which requires feature delivery to be coordinated across teams. Thus, when self-organizing teams work together in such a setting, some level of autonomy needs to be sacrificed [4].

The balance between the benefits of autonomous, empowered teams and coordinated efforts toward a common goal is an important problem to solve for today’s software industry [5]. Practices for inter-team coordination have been proposed in the agile community to reduce the negative impacts of agile while also maintaining the positive impacts of teamwork stemming from agile ways of working [5]. These practices include, for example, scheduled and unscheduled meetings, as well as the use of shared visualization tools [6]. Moreover, many organizations use large-scale agile frameworks that come with pre-determined coordination practices and tools aimed at improving the inter-team coordination of software development. Many such frameworks are available, and among these, the most commonly adopted framework for large-scale agile today is, by far, the Scaled Agile Framework (SAFe) [7].

SAFe, however, has been criticized for the risk of delimiting autonomy for a single team [8, 9]. Limiting team autonomy could negatively impact teamwork and the team's performance, but these impacts have not been investigated much in large-scale ASD [10]. Based on the importance of team autonomy in large-scale ASD, the purpose of this study was to explore the impacts of scaling up agile ways of working on team autonomy. The research question of this study was formulated as follows:

How does team autonomy change when a large-scale agile framework is implemented?

The remainder of the paper is organized as follows: In Section 2, background information on autonomous agile teams and large-scale agile is presented. In Section 3, the research method is described. Section 4 presents results from the multiple-case study of three large-scale agile software development implementations. These findings are discussed in Section 5. Finally, Section 6 concludes the paper and presents key findings from the study.

2. Agile software development and team autonomy

2.1. Team autonomy in large-scale agile

The term “agile” refers to iterative and incremental practices stemming from a set of values and practices guiding modern approaches to software development. At the core of agile lies the notion of a self-managing team that has the autonomy to decide which practices are used and when to develop a software product [11]. Autonomous teams are defined as teams that have authority over their own work and have responsibility for aspects such as task assignment, planning, and scheduling [12]. In other words, these are teams that have the autonomy to decide which tasks to work on, when, and how.

Studies on team autonomy present several benefits for team members. Research has shown that highly autonomous teams are also more productive, are more creative, and have higher levels of team satisfaction and team commitment [13, 14]. A high level of team autonomy has also been related to higher levels of employee motivation and job satisfaction [15], as well as lower levels of stress [16]. According to the notion of team autonomy in the agile manifesto, self-organizing teams are the source of “the best architectures, requirements, and designs” [17].

However, scaling up agile software development also requires increased coordination needs. A larger software product often has a more complex architecture and code base, and many teams contribute to developing the overall product. This introduces dependencies, which need to be managed [18].

2.2. The Scaled Agile Framework (SAFe)

Many organizations use large-scale development frameworks to manage inter-team development challenges while at the same time ensuring some level of agility in the development process. Among these, SAFe is a popular commercial framework [7]. SAFe is intended to guide enterprises in scaling lean and agile practices by suggesting principles, organizational structure, and workflow patterns promoting alignment and collaboration. The framework describes agile ways of working on different levels, starting from the team level to the program level, portfolio level, and organizational level [19]. In addition, more roles are suggested on different levels. Two of these additional roles on the program level are the system architect, who coordinates architectural decisions, and the *release train engineer* (RTE), who coordinates a cluster of teams working together, known as the *agile release train* [19].

SAFe provides a range of inter-team coordination practices within an agile release train [19]. These inter-team practices include product increment (PI) planning meetings, Scrum of Scrums, and the use of a program board. The PI planning practice consists of a two-day workshop involving all teams and stakeholders who produce a release plan spanning eight to twelve weeks. The Scrum of Scrums practice is a face-to-face coordination meeting between representatives from each team performed several times per week. Finally, the program board visualizes dependencies between teams, both within the agile release train and external dependencies. The program board is produced during PI planning and is often updated in Scrum of Scrums meetings [19].

Recent reviews show that among studies on large-scale agile, SAFe has received the most research attention compared with other large-scale frameworks or studies of large-scale hybrid practices [10, 20, 21].

2.3. Threats to team autonomy in large-scale agile

When several agile teams cooperate toward a common goal, problems arise, such as dealing with dependencies between activities and ensuring shared goals between teams [18]. For example, an ASD team needs to coordinate with other ASD teams when it comes to the constraints of requirements, testing, and integration [2], and it cannot have full authority over all aspects of the work as a single team can [22]. However, coordination across teams has been identified as a major obstacle to large-scale agile's success [1, 20]. Coordination can be defined as the management of dependencies [23] achieved through the use of various mechanisms and practices aimed at resolving these dependencies. Coordination has received much research attention in the agile community [4, 21]. For example, a theory of coordination in co-located ASD teams has been developed, proposing that agile development tools and practices, such as stand-up meetings, backlogs, and team wallboards, contribute to coordination effectiveness within ASD teams [24]. However, in large-scale agile, the need for coordination between teams introduces more and different coordination mechanisms, such as the use of inter-team meetings and roles to ensure a shared overview across teams [25].

Without inter-team coordination, teams might be autonomous but ineffective [26]. For example, Moe et al. [22] describe the case of an ASD team that shielded itself by participating only in activities that it considered to be necessary for the team to take part in. If this prevents a single ASD team from being coordinated with overall plans and goals, it will affect other teams and deliverables. Still, introducing shared goals, activities, and processes is a threat to team autonomy, which is the key to agile ways of working [22].

Along with other teams, decisions from other roles affect a single ASD team. When a large-scale agile framework is implemented, new roles are often introduced, such as those of product managers or architects [27]. The product manager prioritizes the requirements that the teams and architects must develop to clarify the indented technical direction [27]. Dingsøy et al. [28] present in their study that the added roles lead to less autonomy for the team. However, this cooperation with surrounding roles is important for the team. In a study by Hoda and Murugesan [29], they present how a lack of clarity leads to a team's incomplete understanding of requirements, which leads to cascading problems, such as inaccurate estimation and possible rework.

An aspect of role interference related to requirements is goal setting and creating a shared vision. The ability to create a shared vision has been shown in research to be a key to success in software development since the beginning of the 1990s [30]. The importance of a clear, shared vision is also confirmed in recent studies on ASD teams at Spotify [31], and in a study on coordination in large-scale distributed ASD [32]. However, having a shared vision does not always happen as Moe et al. [22] describe in a study on a large-scale ASD transformation, where higher-level managers often defined goals that were not always seen as relevant or successfully communicated to the team. Defined goals were often treated the same as deadlines or deliverables and were not coordinated with other teams or with the rest of the organization.

Another threat to team autonomy is when external stakeholders steal resources [33]. For example, this could occur when customers or managers from various organizational departments approach developers directly with unrelated tasks and disrupt the work that teams are originally assigned to do. In such a situation, team autonomy is reduced [34, 15].

Finally, the large-scale frameworks may in themselves limit autonomy, as the need for structure at the inter-team level may come at the expense of individual team autonomy. For example, in organizations using SAFe, teams may feel limited by not being allowed to choose the sprint length, as well as by the use of pre-planning meetings [21]. However, little knowledge exists regarding the potential negative impacts of limited team autonomy in large-scale agile [10], and more studies are therefore needed.

2.4. Levels of team autonomy

In this study, we relied on the Authority Matrix that Hackman [35] developed as a theoretical approach to guide our analyses of changes to team autonomy in large-scale agile. This model describes four levels of team autonomy ranging from manager-led to self-managing, self-designing, and self-governing teams. As can be seen in Table 1, the amount of autonomy that teams are allowed is based on their responsibility and authority in four areas: (1) how to execute tasks, (2) how to monitor and manage work processes and progress, (3) how to design the team and its context, and (4) deciding on the overall direction [35]. A manager-led team is responsible only for decisions concerning how to execute their tasks. A self-managing (or self-organizing) team also monitors and manages work processes. A self-designing team has the authority to design and modify the team, as well as to make decisions regarding other resources (context). A self-governing team also decides on the team's overall direction. The categories are not distinct types but rather show a continuum reflecting the increasing amounts of authority that teams hold relative to managers [35, 36].

Table 1. Levels of team autonomy [20].

Setting the overall direction				
Designing the team and organizational context				
Monitoring and managing work process and progress				
Executing team task				
	Manager-led unit	Self-managing unit	Self-designed unit	Self-governed unit

According to the Agile Manifesto, agile ASD teams should be allowed to decide *how* to build the product (i.e., executing tasks and managing work processes and progress), whereas the client decides *what* to build, thus contributing to setting the team's overall direction. and management should decide on the team's design and organizational context [17, 29]. In other words, self-organizing ASD teams commit to selecting and accomplishing their own tasks, as well as organizing themselves. Autonomous ASD teams should therefore be responsible for planning and scheduling their work, as allowing team members to participate in these activities will also increase their commitment to the teams' plans [33]. As such, autonomous ASD teams can be considered to be self-managing units. In this study, we are interested in understanding how autonomy changes when a large-scale agile framework is implemented. We will therefore return to autonomy levels in the discussion section.

3. Method

This study was based on an exploratory multiple-case study [37] of three cases called Agency, BizBank, and Vehicle that implemented large-scale agile development frameworks. The three cases of Agency, BizBank, and Vehicle were chosen based on a maximum variation approach [37], which involves selecting organizations that show variety in terms of size, business area, and corporate culture. The cases also had some similarities, which was important for the study and made them interesting to investigate. According to Yin [37], a case study research design is useful when "how" and "why" questions are investigated to achieve a rich and in-depth understanding of a phenomenon. Therefore, a case study approach was deemed appropriate in this study, as the purpose was to understand how autonomy is changing in large-scale agile software development. A multiple-case design was also preferred over a single-case design because the conclusions may offer more possibilities for suggesting generalizations [37].

The overall study investigated how inter-team coordination was performed and tailored over time in three organizations with disparate business logics. The unit of analysis was the 32 to 41 agile teams working in these cases. In all three of the organizations, the studied cases were the first parts of the organization in which SAFe was implemented. Agile ways of working were implemented, but the implementation of SAFe was novel to the organizations. Therefore, the change at each organization was not from a traditional project management approach to SAFe, as the organizations were already mature in agile ways of working. Also, this meant that no previous SAFe experiences existed in the surrounding organizations. Another important factor in the choosing of these organizations was timing. They all began to implement SAFe during the first part of 2017 and could therefore be studied in parallel. This also meant that they had similar external conditions, such as their worldwide economic situation, as they were all studied during the same time span. Therefore, data collected from these three cases were used, and data on the impacts of scaling up agile software development were further analyzed, focusing on the perceived impacts of SAFe on team autonomy.

3.1. Case descriptions

Agency is a pilot project formed by merging teams from two departments at a large government agency into one organization. The pilot project was aimed at discovering best practices for implementing SAFe roles, as well as the practices to be used within the entire organization. The software developed at Agency was web-based services for Swedish citizens. This involved developing backend functionality for administrators, as well as the frontend development of the web interface. The technical environment consisted of both mainframe and modern technical platforms. Teams were responsible for both the development and the operations of the services. Agency consisted of six teams from the start and ended up as nine cooperating teams. Team sizes spanned from four to 12 team members. Although the adoption of agile methods has been slow in the public sector [38], Agency was an early adopter that decided to implement agile ways of working in 2012. After five years of ASD, Agency decided to scale up by implementing the SAFe framework in a pilot project. A core team consisting of department managers and five agile coaches was formed with the purpose of organizing the implementation. The core team decided on all of the roles and oversaw the organizing of teams, which involved re-organizing some teams and team members.

BizBank is a software service development department in one of the largest business banks in Scandinavia. The department developed an in-house software service to manage client fund portfolios for administrators at the bank. This

meant backend functionality and system integration with other financial data services. Integrations with mainframe systems as well as modern technical platforms meant the need for different competencies within the teams. The teams were in charge of both the development and the operations of the developed software. The department grew from six to eight Scrum teams and decided to implement roles and practices based on the SAFe framework. The size of the teams spanned from five to 11 team members. For BizBank, the decision to begin working in an agile way was decided in 2014 when Scrum was implemented in various parts of the organization. In 2017, SAFe was implemented in one department of the bank consisting of five teams.

Vehicle is a department responsible for both the software and hardware development of a significant part of a motor vehicle. The department developed an in-house software platform and services for a motor vehicle. Because the department was also responsible for hardware development, the software platform continuously had to be in sync with changing hardware conditions. Teams were responsible for both the development and the operations of the software, but only for the development of the hardware. The department was first organized into 20 cross-functional teams, and in 2016, it began to implement roles and practices based on the SAFe framework. The 20 teams were organized into three separate units, and team sizes spanned from two to 13 team members. During the SAFe implementation, the department grew organically and ended up having 24 teams during the last visit of data collection. At Vehicle, the organization introduced agile ways of working by forming self-organizing teams in 2013 and decided to implement roles, processes, and practices that SAFe inspired in late 2016. Being a large department of more than 20 teams, it decided to scale up its work processes by forming three units of five to 12 teams each.

3.2. Data collection and analysis

A case study protocol was developed in line with the guidelines for the case study methodology that Yin [37] suggested to prepare for data collection. Semi-structured interviews were the most important source of information and were supplemented with the data collected from participant observations and a survey. Thus, multiple data sources were used for triangulation purposes as shown in Table 1. The general interview guide approach [39], also known as the semi-structured interview, was chosen for two reasons. One reason was to be able to adapt the questions based on the interviewees' roles and individual experiences. The other reason was that it made sure that the relevant topics were explored. The first draft of the interview guide was based on Heikkilä [40], who investigated teamwork in autonomous teams performing release planning. From this first version, the interview guide was constantly updated based on observations and insights from previous interviews. Appendix A shows a subset of questions from the last version of the interview guide (i.e., the questions most relevant to this study). Data collected through observations consisted of photos and field notes during the 17 visits to the case organization's premises. The field notes contained several discussions between employees in their daily work. Sentences from the discussions that were related to team autonomy were used as data.

Table 1. Data collection from case Agency, BizBank, and Vehicle.

Data source	Case Agency	Case BizBank	Case Vehicle
Number of on-site visits	5	6	6
Hours of observation	113	70	196
Interviews	6	8	14
Interview respondent roles	1 Agile Coach, 1 RTE 2 Scrum Masters, 2 Developers	1 Agile Coach, 1 RTE, 1 Product Owner, 1 Scrum Master, 3 Developers, 1 Software Tester	1 Manager, 1 RTE, 1 Product Owner, 3 Scrum Masters, 7 Developers

The on-site visits happened every second or third month and lasted for two to five working days. During these visits, interviews were performed, memoranda from meetings were taken, and a survey was distributed and collected. The survey questionnaire contained four sections of questions regarding teamwork and agile ways of working. Two of the questions used for this study were the following open-ended questions: "What do you consider to be the main benefit of

implementing SAFe in your organization?” and “What do you consider to be the main drawback of working according to SAFe in your organization?” Answers related to team autonomy were used as data in this study.

In total, 28 interviews were performed with key people (such as agile coaches and RTE’s) and team members who gave insights into multiple perspectives of the situation. The duration of the interviews spanned from 45 minutes to one-and-a-half hours. All interviews were recorded based on the participants’ consent, and the first author transcribed them. To ensure the interviewees’ anonymity, the respondents are referred to with role and case names throughout the paper. Data were collected from the beginning of 2017 to the end of 2018.

A thematic analysis method for data analysis was used by following the six steps that Braun and Clarke [41] presented: 1) familiarizing yourself with your data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, and 6) producing the report. Thematic analysis is a method particularly suitable for systematically deriving themes across large amounts of data from different sources [41]. Themes are patterns that are meaningful in relation to the research question. In our case, the themes were related to changes in autonomy in the three organizations. The thematic analyses were conducted following a set of steps [41]. First, the interviews were transcribed and read several times so that we could become familiar with the data. The collected data were imported in NVivo, a tool for qualitative analysis. The next step, to generate initial codes, was performed by identifying patterns of perceived changes to team autonomy in the informants’ answers, observation notes, and answers to open-ended questions in the surveys. To guide our analysis, we used the theoretical lens of change in levels of autonomy [35].

Next, sections were labeled according to these patterns and were clustered into proposed themes. The first author and two other researchers, who also suggested initial themes, performed coding. The proposed themes were then reviewed, compared, and re-organized. The initial themes were then discussed in seminars with other researchers. Finally, we performed a final round of discussions and refining and ended up with six themes: *getting a better overview*, *making better long-term decisions*, *giving and receiving help*, *signaling limitations*, *limited feature choice*, and *enforced refinement*. The themes are presented in the result section.

3.3. Limitations

Inherent to any empirical study, this study has limitations. One such limitation relates to the reliance on interviews as the major data source. For the purpose of improving validity, respondents were chosen based on having enough experience with and knowledge of agile ways of working. Along with a large number of interviews (28), triangulation by observations, meeting memoranda, and a survey helped with reducing the study’s bias. For reliability to be ensured, interviews and observation notes were sent to employees so that they could check for errors or omissions.

4. Results

This section presents the six identified themes that describe perceived changes to team autonomy when SAFe was implemented. The themes are: 1) *getting a better overview*, 2) *making better long-term decisions*, 3) *giving and receiving help*, 4) *signaling limitations*, 5) *limited feature choice*, and 6) *enforced refinement*. We describe different areas, benefits, and drawbacks of these changes to team autonomy in detail in the various subsections. The first section, 4.1, presents the perceived overall view of changes to team autonomy.

4.1. Overall view of changes to team autonomy

Most of the interviewees stated that implementing SAFe had increased team autonomy. At Agency, a respondent stated that the organization was moving in the right direction: “*There are changes in the organization that employees are more actively involved in now. We have started to move towards more autonomy in the teams*” (Agile Coach, Agency). A developer stated, “*Team autonomy has been affected a lot.... We didn’t really have autonomous teams, before but we have a real autonomous way of working now*” (Developer, BizBank). Most respondents at Vehicle also agreed. A Scrum Master expressed, “*I think that we are not as limited as we previously thought.... We’ve got more autonomy, I would say*” (Scrum Master, Vehicle). However, an engineer stated it had not changed: “*I would say that team autonomy is the same today as it was two years ago, before the implementation*” (Release Train Engineer, Vehicle). Several

respondents at BizBank also confirmed this. A Scrum Master said, *“No, I don’t think that [we have less autonomy]. I mean, the teams still decide how they do things.... We break down work and decide [on our own]”* (Scrum Master, BizBank).

At Agency, when the transformation had been going on for several months, the teams’ resistance to the SAFe implementation decreased because the team members were more actively involved. Surprisingly, the removal of agile coaches at Agency one year into the transformation resulted in increased team autonomy. When the agile coaches were not present, employees at Agency experienced more freedom to act independently and to make decisions regarding how to change their way of working without asking the agile coaches for approval. The teams reported perceiving more autonomy after the coaches had left. Several commented that they thought the agile coaches had enforced routines and processes from SAFe by the book without trying to adapt to the environment at Agency. A respondent stated, *“We can work more freely now when we don’t have any ‘method people’ around”* (Release Train Engineer, Agency).

Some respondents in all three cases expressed that team autonomy had not been changed following the SAFe implementation. At Agency, a developer expressed, *“What can I say about team autonomy? We don’t get to decide much now, as I see it, but we didn’t get to do that before, either.... I don’t think it has changed”* (Developer, Agency). A developer at BizBank confirmed the same view by stating the following: *“Nothing special. Think we get to decide most things just like before”* (Developer, BizBank). Finally, a Scrum Master at Vehicle expressed, *“The team has about the same mandate for decision-making now as they had before; no major difference there”* (Scrum Master, Vehicle).

To conclude, most of the respondents cited increased team autonomy in general, whereas a few expressed the status quo following the SAFe implementation.

4.2. Getting a better overview

Several respondents expressed that the benefits of implementing a large-scale agile framework included a better overview. This also meant more transparency in the project as well as an understanding of the bigger picture. This was addressed both in interviews and in 22 answers to the open-ended survey questions in all three cases.

At BizBank, one developer explained how the overall understanding increased due to joint planning and joint reviews. She stated, *“The knowledge of the whole business has definitely increased. You understand why you do things ... that you are part of a larger whole”* (Developer, BizBank). The developers perceived an increase in team autonomy because decisions on the team could now be based on an improved understanding of the overall picture as well as an understanding of what other teams were doing.

At Agency, respondents pointed out that a better overview improved teams’ ability to make better decisions. One informant expressed, *“The more we understand the whole and what the users of the system really need, we make better big picture decisions ourselves”* (Scrum Master, Agency).

As presented above, several respondents at BizBank did not perceive autonomy to be limited when scaling up. Rather, they perceived that team autonomy remained the same or was even improved. However, some team members seemed to have experienced less personal autonomy. According to one respondent, developers felt forced to participate in meetings, thereby limiting their personal autonomy:

“What has been quite tough for many is the change to be less isolated and having to listen to things in meetings that may not be interesting.... Many [developers] have a hard time with always having to share what they do. Getting everyone to understand the value of being transparent and listening to others all the time is something we struggle with” (Scrum Master, BizBank).

In other words, although some perceived participating in meetings as limiting personal autonomy, the impact on team autonomy offers a better overview, as sharing information makes the given work transparent to other teams.

4.3. Making better long-term decisions

Another area in which autonomy was perceived to have been changed was making decisions on a long-term basis. When one is working according to SAFe, an important practice is a joint planning session called PI planning, where plans are made for a number of future sprints. According to many respondents, planning several months ahead led to better long-term decisions. In addition to being addressed in interviews, this was addressed in 14 answers to the open-ended survey questions in all three cases. Understanding long-term plans for software products acted as feedback for the decisions that the team made. An informant stated: “[Planning] has had a feedback effect on us as a team. We have become very good at being foresighted and make better long-term decisions now” (Scrum Master, Vehicle).

A respondent at Agency stated: “It is easier to make our own decisions in the team now that we know where we are heading”(Scrum Master, Agency). In addition, decisions were more thought through due to this, according to a developer: “More thorough and overall better decisions now because we have a longer perspective than we had before” (Developer, Agency).

In another team at Vehicle, the Scrum Master expressed how he was fortunate to have more explicit long-term goals for his team. This made it easier for the team to be more autonomous when it came to making long-term decisions. He stated, “We know where we are going.... We have a clear picture of ‘we will deliver this in a year.’ There is no one else who writes work packages or features for us. So, we can decide much more ourselves” (Scrum Master, Vehicle).

However, teams at Agency also experienced resistance in making long-term decisions based on the organizational culture. An informant stated: “Whenever someone says that this has been decided, someone will right away ask: ‘Who has approved that?’ It is a culture of finding [one specific] person responsible for each decision” (Agile coach, Agency). The agile coach explained that this was a problem not only due to the organizational culture but also due to the rules and regulations within the organization.

4.4. Giving and receiving help

An area of changed autonomy that was perceived in all three cases was the ability to give and receive help more easily than before. This was brought up in interviews and discussions, as well as in 19 answers to the open-ended survey questions. A respondent at Vehicle said: “We have more autonomy when it comes to receiving help or helping others as well” (Developer, Vehicle). According to a respondent at Agency, this change was due to the previously expressed planning benefits of an improved overview and improved transparency: “They find it easier to help each other now. Before, they did not know what each team did, but now, they know it and can say, ‘We did a similar thing last sprint; come to us, and we can show you’” (Release Train Engineer, Agency). A developer at Vehicle confirmed this view, also pointing to an improved overview as a reason for the change, “It is easier to help out across team boundaries. Before, you didn’t really know what the other teams were doing, so you did not know that you could be helpful” (Developer, Vehicle). In a discussion during a PI planning meeting, a respondent even expressed that this change was a main difference related to team autonomy after the implementation of SAFe: “I don’t know if it [team autonomy] has changed really. Although, it’s evident that it is easier to help out between teams now, but nothing besides that” (Release Train Engineer, Agency).

Without pointing out any specific reason for this change, a respondent highlighted the increase in initiatives for helping other teams: “[It is] much easier to help out between teams. I see how often they take the initiative to ask for help and get help from each other during these two [planning] days” (Agile Coach, Agency). In particular, a recently hired employee pointed at this change as being especially important for the newly hired: “All teams are so helpful; it has been great for us who are fairly new. You only have to say that you do not understand something, and people from other teams have helped us” (Scrum Master, Agency). Helping other teams can often be done by presenting previous solutions. As a developer at BizBank expressed: “I notice that many share and help out more than they did before. Shows their own solutions and such” (Developer, BizBank).

4.5. Signaling limitations

Balancing one's capacity and workload is a challenge, and a change that the respondents expressed following the implementation of SAFe was the ability to signal limitations. In addition to being expressed in interviews and discussions, this was expressed in three answers to the open-ended survey questions at Vehicle and BizBank. A respondent at BizBank also highlighted an improvement in the ability to signal limitations to support team decisions regarding not adding work: *"[It has] really been an improvement to get this whole overview and get managers to actually see what we can do and cannot [do]"* (Developer, BizBank).

At Vehicle, a respondent expressed how the joint planning sessions made it easier to show and discuss actual capacity: *"One effect that has also come out that I am quite happy with is that it has become a little clearer; it becomes a little easier for us to actually communicate back what we can and cannot do"* (Manager, Vehicle). A developer at Vehicle who expressed a benefit of implementing SAFe also confirmed this: *"Easy to visualize workload versus resource"* (Developer, Vehicle).

Even when management wanted more from the teams, the transparent plans signaled capacity limitations and made it easy for teams to reject unrealistic demands. As one Scrum Master put it: *"I think that we are not as limited as we previously thought. One of the things that have made us ... that made this planning a little easier was ... that we could signal what limitations we had. We've got more autonomy, I would say"* (Scrum Master, Vehicle).

4.6. Limited feature choice

In all three cases, several respondents felt that implementing SAFe limited their ability to choose which features to implement. In addition to being addressed in respondent interviews, this was addressed in six answers to the open-ended survey questions at Agency and Vehicle. For example, in meetings among Product Owners at Agency, features were divided between teams without involving the Scrum Masters or the developers. The lack of involvement meant that teams did not understand enough about the features before the joint planning sessions took place. As a consequence, both the developers and the Scrum Masters were frustrated, and many of the features decided for the teams at Agency sometimes came as a surprise to the team members. A Scrum Master expressed: *"Features appear in the product backlog without the teams knowing about it. It is a pervasive problem. And it should not be that features pop up without us having a clue what it is"* (Scrum Master, Agency).

The limitation of choosing features was also put forth in two answers to the open-ended questions. The problem of not having the freedom to choose features was also evident at Vehicle. An informant complained that *"[Teams] are getting too detailed requirements.... They are not involved in breaking them down.... [Therefore,] they have a hard time really taking responsibility for [the feature].... They are already so detailed when they get them"* (Release Train Engineer, Vehicle). Another informant confirmed this view at Vehicle: *"Before, it was easier to choose whatever feature you wanted to work with.... We don't get to choose much now. It's much more dedicated [in advance]"* (Developer, Vehicle).

4.7. Enforced refinement

Because SAFe suggests a PI planning horizon of eight to 12 weeks, this means that teams need to understand enough about the upcoming features to be able to plan for such a period. In addition, it means that features need to be refined enough for the teams to understand and estimate them. Several respondents in all three cases explained that this need for understanding forced the teams into a greater amount of refinement than that which was needed before. This was also expressed in six answers to the open-ended survey questions. For example, a respondent at BizBank stated, *"We can decide very much on our own, but then, there is the issue of breaking down [features] a lot before planning"* (Tester, BizBank). A developer stated: *"We are forced into more refinement now than we were before"* (Developer, BizBank). Another respondent expressed that even though more refinement was enforced, it was not a big issue: *"Autonomy? It hasn't changed much. Sure, we are forced to do more refinement than we did before, but I don't see it as a problem"* (Developer, BizBank). A few people perceived the refinements as positive, which a developer at BizBank illustrated:

“We don’t just go to planning unprepared. Instead, we have been given a chance to see and refine features before dividing the job [between teams]” (Developer, BizBank).

However, the number of meetings required to agree on the refinements was seen as a major drawback. A developer stated, “We have so many preparatory meetings. They never seem to be satisfied with how much we refine before PI planning” (Developer, BizBank). The view of too many meetings was also expressed at Agency: “We’ve spent way too much time sitting in refinement meetings” (Scrum Master, Agency). At Vehicle, the impact of too much refinement was seen as stressful: “Very much time is spent on refinements, estimates and planning all the time. I think many people are like me and think that it can be quite stressful at times” (Developer, Vehicle).

5. Discussion

In this section, we discuss the research question *How does team autonomy change when a large-scale agile framework is implemented?* We used the Authority Matrix that Hackman [35] developed to guide our analyses of changes to team autonomy at different levels. The findings improve our understanding of the detailed impacts of implementing SAFe on team autonomy in large-scale ASD. This study also answers calls for future research on autonomous teams in ASD [5, 22]. Table 2 presents an overview of the changes in the levels of team autonomy for all themes.

Table 2. Changes in autonomy (increases or decreases) compared with Hackman’s levels of autonomy [35].

Themes	Areas of decision making			
	Task execution	Process monitoring and management	Designing team and context	Setting overall direction
<i>Getting a better overview</i>		Increased		Increased
<i>Making better long-term decisions</i>		Increased		Increased
<i>Giving and receiving help</i>	Increased		Increased	
<i>Signaling limitations</i>		Increased	Increased	
<i>Limited feature choice</i>			Decreased	Decreased
<i>Enforced refinement</i>	Decreased	Decreased		

A change to team autonomy was that respondents perceived to be *getting a better overview*. This change was identified in all three cases. Having a shared understanding of the organization’s overall goals and visions is an important key to success [30]. Team members expressed how they had obtained an improved overview of their work and of how their parts were important in the larger context, which enabled them to coordinate their decisions with the overall goals and visions. These findings confirm the importance of shared goals and activities in large-scale ASD [37, 32]. Looking at how a team’s level of autonomy changes based on Hackman’s [35] four areas, this theme suggests an increased influence of large-scale ASD on how to monitor and manage work processes and decisions with regard to the overall direction.

Another change to team autonomy that was identified in all three cases was the improved capability of *making better long-term decisions*. Per the investigation of how the level of team autonomy changed based on Hackman’s [35] four areas, this theme suggests an increased influence of large-scale ASD on how to monitor and manage work processes and decisions with regard to the overall direction. The PI planning practice, where several teams perform joint planning for a number of sprints [19], was specifically highlighted as an important practice. With the possibility of longer planning horizons, one could argue that there is a better chance for the team to decide on its own on how to achieve

these goals. This is consonant with Moe et al. [22], who discovered an increased commitment to their plans by letting teams decide more on their long-term plans and schedules.

A Scrum Master at Vehicle expressed that he or she was fortunate to have clear long-term goals, which was not the case for many other teams at Vehicle. The importance of having long-term goals for the team is highlighted in Šmite et al. [31], for example, but this often seems to be lacking on many teams according to previous research [22, 29].

In contrast to making better long-term decisions, an agile coach at Agency explained that some long-term decisions might be hindered due to an organization's in-house culture, where top managers need to approve decisions. This finding confirms previous studies on the importance of the company culture when agile is being scaled [20].

Another theme identified in all three cases was the improved capability of *giving and receiving help*. Team members expressed that the improved overview and the improved transparency due to joint planning with several teams made it easier for them to help other teams. The allocated time for joint planning with several teams made it easier to receive help from other teams as well. Regarding how the team's level of autonomy changed based on Hackman's [35] four areas, this theme suggests an improved influence on how to execute the tasks and context by helping other teams.

With a better overview from joint planning, teams might be able to see potential problems in their own plans and thereby know in advance that they should seek help. Also, by understanding possible problems for other teams, they might be able to help them out in advance. Moe et al. [22] presented a situation in which team members stated that they shielded their team from externalities, filtering out what they considered to be unnecessary for their team to take part in. In these three investigated cases, the teams instead reaped the benefits of not shielding their teams by being able to both help and receive help from one another.

Another theme identified in two of the cases, those of Vehicle and BizBank, was an improved capability of *signaling limitations*. When several teams conduct joint planning together, a high level of transparency of these plans might reveal which teams have too much work planned. The transparent plans therefore allow teams to signal capacity limitations more easily. Being able to signal limitations transparently is important because it might mitigate problems with interfering roles, such as stakeholders stealing resources [33], which is a problem in large-scale ASD [25]. Per the investigation of the level of team autonomy based on Hackman's [35] four areas, this theme suggests an improved influence of large-scale ASD on how to monitor and manage work processes and contexts, as work can be transferred to other teams.

An identified theme expressed in two cases, those of Agency and Vehicle, was *limited feature choice*. Team members expressed a limitation in choosing what to work with within the various teams. Per the investigation of how the level of team autonomy changed based on Hackman's [35] four areas, this suggests a decrease in autonomy, as a team in this situation becomes limited in terms of deciding the team's overall direction and context by not being able to have a say in what other teams should work on.

Dividing work between teams is part of deciding how to best accomplish the work in large-scale ASD [42]. At Vehicle, a respondent explained that some features just turned up in the product backlog and were not understood. This confirms the problems presented in Moe et al. [22] regarding higher-level managers defining goals not successfully communicated to the team. Involving teams in planning and goal setting is important because it increases motivation and a sense of meaningfulness [43].

The final theme, identified in all three cases, was *enforced refinement*. Refinement means that a team is involved in detailing the requirements for a specific feature together with product owners, product managers, or other stakeholders. Some employees felt that always attending refinement meetings was a struggle. They felt forced to comply despite not wanting to, which limited their autonomy. Regarding how the level of autonomy changed based on Hackman's [35] four areas, this suggests that a team becomes limited in terms of how to execute its tasks and how to monitor and manage work processes. This theme has a clear connection with the theme mentioned above concerning the limited possibility of choosing features. By conducting more refinement before each planning session with a specific set of features, a team was considered to be responsible for working with the features due to having gained more insights into

them. At BizBank, however, a respondent did not view the increased refinement as something negative. Rather, it was seen as an improved routine for preplanning, and it did not limit the possibility of choosing features.

5.1 Theoretical contributions

The findings from this study give us more detailed insights into the various levels of team autonomy that are affected when a large-scale agile framework is implemented. Previous research on the impacts on team autonomy in ASD, such as added roles leading to less autonomy [28], has not offered details into the areas of team autonomy that are being affected. An important theoretical contribution of this study is the detailed impacts on changes to team autonomy. This study suggests that all levels of autonomy are affected, and team autonomy is both increased and decreased in different areas of decision-making for agile teams.

The themes of *limited feature choice* and *enforced refinement* show a perceived decrease in team autonomy. However, these limitations in what to work with for the teams also create clarity regarding upcoming work for the teams. As Hoda and Murugesan [29] explain, a lack of clarity is an important problem with potentially cascading negative effects, such as possible rework. Previous research shows the importance of long-term clarity [31, 32], so perhaps these negative impacts on team autonomy are an acceptable price to pay to reap the benefits of a clear, shared plan. The notion that some level of autonomy must be sacrificed [4] makes sense in large-scale ASD because shared goals and visions are needed for effective coordination [30, 31, 32].

5.2 Practical implications

As described in the three themes of *making better long-term decisions*, *giving and receiving help*, and *signaling limitations*, the joint planning practice, PI planning, was viewed as important for these perceived positive changes to team autonomy. Dingsøy et al. [28] found that added roles intended to clarify requirements and technical direction lead to less autonomy on teams, but they are necessary due to the possible impacts of a lack of clarity as found in Hoda and Murugesan [29]. This study suggests that a joint planning practice could mitigate the problem of a lack of clarity. Based on this, added roles might not be as important, or at the very least, they should not have as much of an influence on team decisions.

Along with a lack of clarity, another thing that these findings show is that a joint planning session might mitigate the problems of teams working in silos. Dickert et al. [1] present the problem of teams operating with differing priorities and agendas, and Moe et al. [22] explain how some teams shielded themselves [22]. The findings from this study instead suggest that teams are able to coordinate priorities as well as give and receive help due to joint planning. Strode et al. [24] present the importance of a synchronization strategy and suggest project synchronization once per project, as well as iteration synchronization once per sprint. These findings show the importance of implementing medium-range planning, planning a number of sprints ahead, per the theory of coordination [24] in large-scale ASD. Understanding the great importance and thereby possible benefits of the PI planning practice is an important practical contribution of this study when SAFe is implemented in an organization. For practitioners, we think this paper illustrates the importance of joint planning as well as a shared understanding of goals. The findings also put forth the importance of medium-range planning per the coordination theory in large-scale ASD.

6. Conclusion

This study presents several changes to team autonomy when a large-scale agile framework is implemented. Four identified themes showed changes that were perceived to increase the levels of team autonomy. First, teams experienced the benefits of *getting a better overview*, which suggests an increased influence on how to monitor and manage work processes and decisions with regard to the team's overall direction. Second, teams perceived an improved possibility of *making better long-term decisions*, which also suggests an increased influence on how to monitor and manage work processes and decisions with regard to the team's overall direction. The increased transparency and long-term planning might be reasons for this change. A better overview and increased transparency might also explain why many employees found that *giving and receiving help* was easier. This impact shows an improved influence of large-scale

ASD on how to execute the tasks and context by helping other teams. A practice that was specifically highlighted was the joint planning session, PI planning, which gave teams the capability of *signaling limitations* of capacity more clearly. When several teams planned and shared plans, a high level of transparency revealed which teams had too much work planned for themselves. This might improve the influence on how to monitor and manage work processes and contexts, as work can be transferred to other teams. Two themes were perceived to decrease different levels of team autonomy. One theme, supporting previous studies, was that teams experienced *limited feature choice*. With several teams needing to be coordinated toward a common goal, every team will not be able to choose freely. This suggests a decrease in autonomy because a team becomes limited with regard to deciding the team's overall direction and context. The last identified theme was *enforced refinements*, which suggests that the team becomes limited with regard to how to execute its tasks as well as monitor and manage work processes. The *enforced refinement* might also be a possible reason for the previously mentioned limited choice of features. With a certain team appointed for refining a set of features, the same team was often considered in advance to be responsible for the refined features.

For future work, an area mentioned in the discussion section is the differing views on *enforced refinement*, where some experienced them as a limitation when it came to team autonomy, whereas others expressed the associated benefit of better understanding upcoming features. These diverse experiences call for further research into the impacts of *enforced refinement* on team autonomy. Furthermore, some employees reported that the implementation of SAFe involved an increase in the amount of time spent in meetings. The high number of meetings was perceived as limiting personal autonomy, and the excessive meeting time was viewed as irrelevant for their work. When one is following large-scale frameworks, how to balance the need for coordination and transparency across teams with the need for teams to do focused work is worth investigating.

References

- [1] K. Dikert, M. Paasivaara, and C. Lassenius, "Challenges and success factors for large-scale agile transformations: A systematic literature review," *Journal of Systems and Software*, vol. 119, pp. 87–108, Sep. 2016
- [2] A. Sablis, D. Šmite and N. Moe, "Team-external coordination in large-scale software development projects," *Journal of Software: Evolution and Process*, e2297, 2020.
- [3] J. H. Gundelsby, "Enabling autonomous teams in large-scale agile through architectural principles," *Proceedings of the 19th International Conference on Agile Software Development*, 2018, pp. 1-4.
- [4] J. M. Bass and A. Haxby, "Tailoring product ownership in large-scale agile projects: Managing scale, distance, and governance," *IEEE Software*, vol. 36, no. 2, pp. 58-63, 2019.
- [5] J.M. Bass, "Future trends in agile at scale: a summary of the 7th international workshop on large-scale agile development," In: *Hoda, R. (ed.) XP 2019. LNBP*, vol. 364, 2019, pp. 75–80. Springer, Cham.
- [6] N. B. Moe, T. Dingsøyr and K. Rolland, "To schedule or not to schedule? An investigation of meetings as an inter-team coordination mechanism in large-scale agile software development," *International Journal of Information Systems and Project Management*, vol. 6, no. 3, pp. 45-59, June, 2018.
- [7] Digital.ai, *15th Annual State of Agile Report (2020)*, 2021. [Online]. Available: <https://digital.ai/resource-center/analyst-reports/state-of-agile-report>
- [8] M. Alqudah and R. Razali, "A review of scaling agile methods in large software development," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 6, no. 6, pp. 828-837, 2016.
- [9] I. Stojanov, O. Turetken and J. J. Trienekens, "A maturity model for scaling agile development," *Proceedings of the 41st Euromicro Conference on Software Engineering and Advanced Applications*, 2015, pp. 446-453.
- [10] Ö. Uludağ, P. Philipp, A. Putta, M. Paasivaara, C. Lassenius and F. Matthes, "Revealing the state-of-the-art in large-scale agile development: A systematic mapping Study," *arXiv preprint arXiv:2007.05578*, 2020.

- [11] R. Hoda, J. Noble, and S. Marshall, "Self-Organizing Roles on Agile Software Development Teams," *IEEE Transactions on Software Engineering*, vol. 39, no. 3, pp. 422–444, Mar. 2013.
- [12] R. A. Guzzo, and M. W. Dickson, "Teams in organizations: Recent research on performance and effectiveness," *Annual Review of Psychology*, vol. 47, pp. 307-338, 1996.
- [13] M. Fenton-O'Creevy, "Employee involvement and the middle manager: evidence from a survey of organizations," *Journal of Organizational Behavior*, vol. 19, no. 1, pp. 67-84, January, 1998.
- [14] B. L. Kirkman and B. Rosen, B, "Beyond self-management: Antecedents and consequences of team empowerment," *Academy of Management Journal*, vol. 42, no. 1, pp. 58-74. 1999.
- [15] C. W. Langfred, "The paradox of self-management: Individual and group autonomy in work groups", *Journal of Organizational Behavior*, vol. 21, no. 5, pp. 563-585, August, 2000.
- [16] A. Meier, M. Kropp, C. Anslow and R. Biddle, "Stress in agile software development: practices and outcomes," *Proceedings of the International Conference on Agile Software Development*, 2018, pp. 259-266.
- [17] K. Beck, M. Beedle, A. van Bennekum, A. Cockburn, W. Cunningham, M. Fowler, J. Grenning, J. Highsmith, A. Hunt, R. Jeffries, J. Kern, B. Marick, R. C. Martin, S. Mellor, K. Schwaber, J. Sutherland and D. Thomas. (2015, June 11th). Manifesto for agile software development [Online]. Available: <http://www.agilemanifesto.org>
- [18] D. E. Strode, "A dependency taxonomy for agile software development projects," *Information Systems Frontiers*, vol. 18, no. 1, pp. 23–46, 2016.
- [19] D. Leffingwell, *SAFe 4.5 Reference Guide: Scaled Agile Frame-work for Lean Enterprises*. Addison-Wesley Professional, 2018.
- [20] M. Kalenda, P. Hyna, and B. Rossi, "Scaling agile in large organizations: Practices, challenges, and success factors," *Journal of Software: Evolution and Process*, vol. 30, no. 10, p. e1954, 2018.
- [21] H. Edison, X. Wang, and K. Conboy, "Comparing Methods for Large-Scale Agile Software Development: A Systematic Literature Review," *IEEE Transactions on Software Engineering*, 2021.
- [22] N. B. Moe, B. H. Dahl, V. Stray, L. S. Karlsen, and S. Schjødt-Osmo, "Team autonomy in large-scale agile," *Proceedings of the Annual Hawaii International Conference on System Sciences (HICSS)*, 2019, pp. 6997-7006.
- [23] T. W. Malone and K. Crowston, "The interdisciplinary study of coordination," *ACM Computing Surveys (CSUR)*, vol. 26, no. 1, pp. 87–119, 1994.
- [24] D. E. Strode, S. L. Huff, B. Hope, and S. Link, "Coordination in co-located agile software development projects," *Journal of Systems and Software*, vol. 85, no. 6, pp. 1222–1238, Jun. 2012.
- [25] M. Berntzen, V. Stray, and N. B. Moe, "Coordination Strategies: Managing Inter-team Coordination Challenges in Large-Scale Agile," in *Agile Processes in Software Engineering and Extreme Programming*, Cham, 2021, pp. 140–156.
- [26] A. Salameh and J.M. Bass, "Spotify Tailoring for Promoting Effectiveness in Cross-Functional Autonomous Squads," *Proceedings of the International Conference on Agile Software Development*, 2019, pp. 20-28.
- [27] D. Remta and A. Buchalcevova, "Product Owner's Journey to SAFe - Role Changes in Scaled Agile Framework," *Information*, vol. 12, no. 3, pp. 1-18, 2021.
- [28] T. Dingsøyr, N.B. Moe, T. E. Fægri and E. A. Seim, "Exploring software development at the very large-scale: a revelatory case study and research agenda for agile method adaptation," *Empirical Software Engineering*, vol. 23, no. 1, pp. 490-520, 2018.

- [29] R. Hoda and L.K. Murugesan, "Multi-level agile project management challenges: A self-organizing team perspective," *Journal of Systems and Software*, vol. 117, no. 1, pp. 245- 257, 2016.
- [30] L. Gren, "Understanding work practices of autonomous agile teams: A socialpsychological review," *Proceedings of the International Conference on Agile Software Development*, 2020, pp. 227-235.
- [31] D. Šmite, N.B. Moe, M. Floryan, G. Lavinta and P. Chatzipetrou, "Spotify guilds: When the value increases engagement, engagement increases the value," *Communications of the ACM*, vol. 63, no. 3, pp. 56-61, 2020.
- [32] V. Stray, N. B. Moe, H. Vedal, M. Berntzen, "Using Objectives and Key Results (OKRs) and Slack: A Case Study of Coordination in Large-Scale Distributed Agile," In *Proceedings of the 55th Hawaii International Conference on System Sciences*, 2022.
- [33] N. B. Moe, T. Dingsøy, and T. Dybå, "Overcoming Barriers to Self-Management in Software Teams," *IEEE Software*, vol. 26, no. 6, pp. 20-26, 2009.
- [34] M. Hoegl and P. Parboteeah, "Autonomy and teamwork in innovative projects," *Human resource management*, vol. 45, no. 1, pp. 67, 2006.
- [35] J. R. Hackman, "The psychology of self-management in organizations". In M. S. Pallak & R. O. Perloff (Eds.), *Psychology and work: Productivity, change, and employment*, 1986, pp. 89-136.
- [36] C. C. Manz, "Self-leading work teams: Moving beyond self-management myths," *Human relations*, vol. 45, no. 11, pp. 1119-1140, 1992.
- [37] R. K. Yin, *Case study research and applications: Design and methods*, 6th ed. California, USA: SAGE publications inc, 2017.
- [38] J. Nuottila, K. Aaltonen and J. Kujala, "Challenges of adopting agile methods in a public organization," *International Journal of Information Systems and Project Management*, vol. 4, no. 3, pp. 65-85, April, 2016.
- [39] M. Q. Patton, *Qualitative research and evaluation methods (3rd ed.)*, SAGE Publication, 2002.
- [40] V. T. Heikkilä, *Case studies on release planning in agile development organizations*, Doctoral dissertation, Aalto University, 2015.
- [41] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101, 2006.
- [42] J. Sutherland and K. Schwaber. (2013). *The Scrum guide: The definitive guide to Scrum; The rules of the game* [Online]. Available: <http://www.scrum.org>
- [43] J. R. Hackman, "The design of Work Teams," in *Handbook of organizational behavior*, J. Lorsch, Ed. Englewood Cliffs, N. J., Prentice-Hall, 1987.

Appendix A. Interview protocol questions.

What is your role?

What does your team do?

How long have you been working here?

How long have you been working in an agile way?

Have you received any education/training for agile ways of working? If so, what was it?

How do you experience the introduction of large-scale agile processes in your organization?

- What has been difficult?
- What has been simple (easier than you thought it would be)?
- Has the introduction of large-scale processes had the impact you expected?
- Has it had any negative effects?

Describe how different forms of coordination are performed:

- PI Planning
- Scrum of Scrums
- Usage of the Program Board
- Communities of Practice

Has autonomy in your/each team changed? If so, in what way?

- In what areas do you have more control?
- In what areas do you have less control?

What do you think you could do (change) to increase autonomy for each group while still managing coordination effectively?

Biographical notes**Tomas Gustavsson**

Tomas Gustavsson is an Assistant Professor at Karlstad University. He has a Ph.D. in Information Systems from Karlstad University, an MBA from Stockholm University, and has many years of industry experience as an IT consultant. He is also an author of several prize-winning textbooks on agile development methods. His main research interests are agile ways of working, teamwork, coordination, and leadership in large-scale agile software development.

**Marthe Berntzen**

Marthe Berntzen is a Ph.D. candidate in Software Engineering at the Department of Informatics, University of Oslo. She received the M.Sc. degree from BI Norwegian Business School and has four years of industry experience. Marthe's Ph.D. research centers around inter-team coordination in large-scale agile software development. Her research interests include agile methods and practices, teamwork, leadership, and coordination in distributed settings. Her work has been presented at international conferences within software engineering, information systems and management and she has published research on leadership and coordination in distributed team settings.

**Viktoria Stray**

Viktoria Stray is an Associate Professor at the University of Oslo's Department of Informatics. She also holds a research position at SINTEF Digital. She has a Ph.D. in Software Engineering from the University of Oslo and an M.Sc degree in Computer Science from the Norwegian University of Science and Technology. Her research focuses on agile methods, autonomous teams, coordination, global software engineering, innovation, and large-scale development. She collaborates with large companies and provides research results on current industry-related topics. She has previously worked for Accenture in Norway's largest software development projects.



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijspm.sciencesphere.org

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Frederik Wulf

TU Dresden

Helmholtzstr. 10, 01069, Dresden, Germany

frederik.wulf@mailbox.tu-dresden.de

Markus Westner

OTH Regensburg

Galgenbergstr. 32, 93053 Regensburg, Germany

markus.westner@oth-regensburg.de

Susanne Strahringer

TU Dresden

Helmholtzstr. 10, 01069, Dresden, Germany

susanne.strahringer@tu-dresden.de



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.science sphere.org

F. Wulf, M. Westner, S. Strahringer, “We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?”, *International Journal of Information Systems and Project Management*, vol. 10, no. 1, pp. 49-70, 2022.



We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Frederik Wulf

TU Dresden
Helmholtzstr. 10, 01069, Dresden, Germany
frederik.wulf@mailbox.tu-dresden.de

Markus Westner

OTH Regensburg
Galgenbergstr. 32, 93053 Regensburg, Germany
markus.westner@oth-regensburg.de

Susanne Strahringer

TU Dresden
Helmholtzstr. 10, 01069, Dresden, Germany
susanne.strahringer@tu-dresden.de

Abstract:

When higher-level management of a company has strategically decided to adopt Platform-as-a-Service (PaaS) as a Cloud Computing (CC) delivery model, decision-makers at lower hierarchy levels still need to decide whether they want to post-adopt PaaS for building or running an information system (IS) – a decision that numerous companies are currently facing. This research analyzes the influential factors of this managerial post-adoption decision on the IS-level. A survey of 168 business and Information Technology (IT) professionals investigated the influential factors of this PaaS post-adoption decision. The results show that decision-makers' perceptions of risks inhibit post-adoption. Vendor trust and trialability reduce these perceived risks. While competitive pressure increases perceived benefits, it does not significantly influence PaaS post-adoption. Controversially, security and privacy, cost savings, and top management support do not influence post-adoption, as opposed to findings on company-level adoption. Subsamples constructed by the form of post-adoptive use (migration of IS, enhancement of IS, new IS development) exhibit better goodness-of-fit measures than the full sample. Future research should explore this interrelation of the form of post-adoptive use and the post-adoption influence factors.

Keywords:

Platform-as-a-Service; cloud computing; post-adoption; delivery model.

DOI: 10.12821/ijispm100103

Manuscript received: 13 June 2021

Manuscript accepted: 15 February 2022

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

1. Introduction

“So we [decided to] adopt Platform-as-a-Service (PaaS) [on a company-level]. We spent lots of time to meet technical requirements and established governance structures. After all, nobody used it. We figured that we need to do something to make our employees actually consider using PaaS on information system (IS) level when migrating or enhancing existing IS, or developing new IS.”

This opening vignette narratively describes a current topic identified in a precedent case study [1]. Most companies already adopted Cloud Computing (CC) [2], with the global CC revenue pool rising to USD 266 billion in 2020 [3]. However, innovations need to be extensively used within the value chain to exhibit impact [4]. The company-level adoption of CC, therefore, does not necessarily mean that individuals on lower hierarchy levels decide in favor of actually using CC on IS-level (post-adoption). For long, research considered post-adoption as continuance use or habit formation of IT use [5]. Research increasingly extended this understanding of post-adoption towards exploring how individuals make use of adopted technologies by using available features for current or additional tasks [5]. Now, that most companies adopted CC on a company-level, the question of how decision-makers make use of it in operational sourcing decisions becomes apparent and practically relevant. For the delivery model Platform-as-a-Service (PaaS) specifically, the post-adoptive use raised our interest: PaaS allows to source infrastructure combined with functionalities constituting a new form of sourcing decision, whereas Infrastructure-as-a-Service (IaaS) allows to source infrastructure and Software-as-a-Service (SaaS) software respectively.

All this motivated us to investigate the influential factors of PaaS post-adoption in our research questions (RQs). We focus on large-scale companies because we assume that small- and medium-sized companies involve fewer hierarchy levels, and, therefore, the decision-maker on adoption and post-adoption is likely to be the same individual. For large companies, we expect that PaaS post-adoption decisions occur at lower hierarchy levels than the initial adoption decision and, therefore, could be more decoupled from this initial company-level adoption decision.

RQ1: What influences PaaS post-adoption in large-scale companies?

The context of large-scale companies makes us adopt a multilevel perspective [6]–[9]: The IS-level post-adoption decision corresponds to the micro-perspective, whereas the initial adoption decision corresponds to the macro-perspective. Hence, we evaluate whether adoption and post-adoption are indeed distinct decisions, as argued above. Alternatively, decision-makers on IS-level could also simply mimic the initial adoption decision.

RQ2: Do decision-makers on IS-level decide autonomously on PaaS post-adoption?

Bagayogo et al. [5] differentiate post-adoptive use of information technology (IT) along the dimension of use for current tasks versus use for additional tasks. As this study is – to the authors’ best knowledge – the first to investigate post-adoptive use of PaaS, we explore whether the influential factors of PaaS post-adoption vary for the post-adoptive use forms.

RQ3: Does PaaS post-adoption depend on the post-adoptive use forms?

The contribution of this research is to shift the focus of CC adoption research towards its post-adoptive use. The paper at hand provides managers, aiming to foster PaaS post-adoption in their companies, with an understanding of the factors influencing that decision.

The rest of the paper is structured as follows: Section 2 explains the post-adoptive use of PaaS in organizations, our theoretical grounding in Technological Frames of References (TFR), and the multilevel perspective. Section 3 conceptualizes our research model (representing a revised version of a research-in-progress publication [10]). Section 4 describes the data collection and cleaning process, the dataset, and the approach for our analysis. Section 5 describes our results. Section 6 discusses these results, while section 7 concludes the paper.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

2. Research background

2.1 Platform-as-a-Service (PaaS) and post-adoption

Empirical research shows that organizations adopt CC not primarily for cost advantages but also to leverage CC as a standardized IT platform for innovating and optimizing business processes [11]. For the sake of innovativeness, organizations also aim to develop customer-facing digital solutions using IaaS and PaaS [1]. PaaS assigns the resources hardware, infrastructure, and the platform (software framework and storage) to be managed by the vendor, while the application layer is under the management of the client organization [12]. For PaaS, the vendor provides the application development stack (including run-time optimization) and the infrastructure [13]. PaaS allows client organizations to use all features provided by the vendor for software development, leaving more resources to focus on innovating the software on the application layer. Therefore, this study aims to investigate the post-adoption of PaaS because it enables the acquiring organization to leverage provided infrastructure and features while managing the applications to bring on this platform.

A pilot case-study conceptualized the transition from adoption to post-adoption of CC, exhibited in Fig. 1 [1]. First, companies decide to adopt CC, enter framework contract agreements with one or multiple vendors, and enable its usage (e.g., establishment of governance elements). Second, companies decide on IS-level upon post-adoption. In the previously mentioned pilot case study, we conceptualized this transition from adoption to post-adoption and integrate the notion of post-adoptive use forms [5] based on the task at hand: Migration of existing ISs to CC relates to using the technology for current tasks, developing new IS development relates to using CC for additional tasks, whereas the enhancement of existing IS using CC either enlarges the scope of the task or performs the same task at higher quality or performance.

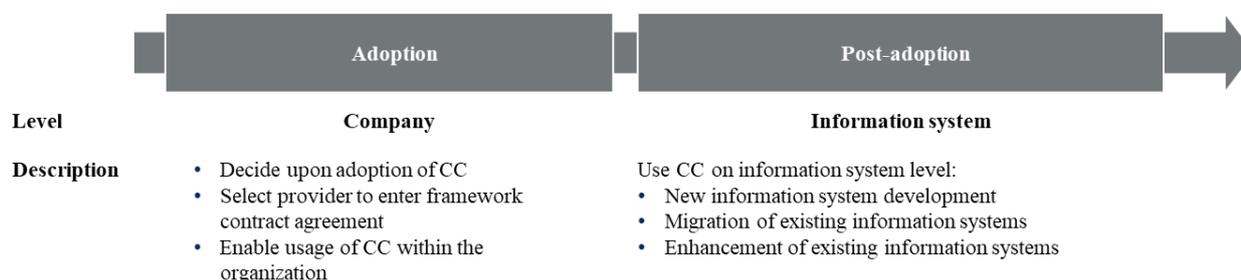


Fig. 1. Conceptualization of CC adoption and post-adoption

2.2 Technological Frames of References (TFR)

Prior research applied various theories to the context of CC adoption, depending on the focus of the investigation. One stream of research employed the technology acceptance model (TAM) [14] to CC in various studies [e.g., 15–17] or its extension, the Unified Theory of Acceptance and Use of Technology (UTAUT) [18]. Studies relying on TAM and UTAUT focus on the individual choice level without involving organizational behavior and managerial decision processes [19]. Additionally, UTAUT proved not always useful in empirically confirming anticipated relationships [18].

Another stream of research employs the Technology – Organization – Environment (TOE) model with the diffusion of innovation theory [e.g., 20–22], focusing on the organizational and environmental level [21]. TOE emphasizes, besides the technological characteristics, the influence of the organization and its environment on technology adoption [23]. However, TOE does not address the individual’s perspective [24]. This observation motivated the authors to base the research approach in this paper on a theory that aims to integrate the individual’s perception of technology while simultaneously acknowledging the importance of the organizational and the environmental level.

This paper is, therefore, grounded in the TFR theory, which has its roots in social cognitive research [25]. Technological frames are shared beliefs (interpretations of technological artifacts [25]) by members of a group regarding technology that “concern the assumptions, expectations, and knowledge they use to understand technology in organizations” [25, p. 179]. Prior research defined a technological frame as “a built-up repertoire of tacit knowledge that is used to impose structure upon, and impart meaning to, otherwise ambiguous social and situational information to facilitate understanding” [26, p. 56]. Hence, an individual’s technological frame reflects the individual’s perception of a technology’s advantageousness. Additionally, the organizational and environmental triggers influence this perception in a systematic approach to social-cognitive research on IT [25]. Therefore, TFR theory enables an analysis of the decision-maker’s perception of PaaS and acknowledges the influence of the organization and the environment, which offsets the shortcomings of TAM, UTAUT, and TOE.

The expectations, assumptions, or knowledge about key aspects of the technology may be different between individuals or groups, defined as incongruence [25]. This incongruence explains difficulties in technology implementation [25]. The process to reach congruence (i.e., consensus) on the respective technological frame is referred to as stabilization and closure [27], [28]. Stabilization occurs within a “relevant social group if members begin to talk and think about the technology increasingly uniformly” [28, p.32]. Closure implies that the interpretive flexibility regarding the technology diminished, and dominant meaning emerges [27], [28]. An individual’s technological frame may change by a trigger, which can be either organizational or environmental [28]. Hence, this paper takes on a TFR perspective to examine whether congruence between the technological frame of the decision-makers, the organizational actors, and influencing actors from the environment exists when it comes to PaaS post-adoption in large-scale organizations. Congruence, with a positive perception of PaaS’s associated benefits and risks, implies the post-adoption of PaaS. Incongruence between the actors, or a decision-maker’s negative perception of benefits and risks would result in decision-makers choosing other sourcing options over PaaS. The proposed model investigates technological frames of potential applications of PaaS, which we classify into the domain of “frames related to the potential organizational applicability of IT” [28, p. 27]. Various other papers undertook research based on TFR in this domain [25], [28]–[30], however – to the best of our knowledge – none in the context of CC adoption.

2.3 A multilevel research perspective

Research in Information Systems (IS) can regard multiple levels of analysis, which stems from the notion that organizations are multilevel by nature [8]. Fundamentally, this paper differentiates research between the lenses of micro- or a macro-perspective [6]–[9]. The idea of multilevel research is to bridge the divide between micro and macro by integrating the perspectives of individuals, organizations, and the environment [31]. The micro-perspective focuses on individuals or groups, whereas the macro-perspective focuses on organizations, environments, or strategies [6], [7], [32], [33].

The requirement to integrate various levels of analysis also applies to the phenomenon of CC, precisely because researchers investigated multiple units of analysis in the past. Most of the previous research on CC analyzed the organizational level perspective of CC adoption obtaining a macro-perspective [e.g., 21, 34, 35] to which the paper at hand refers as company-level adoption. Fewer contributions analyzed the individual level, e.g., decision-makers’ characteristics [36], [37] or the decisions related to a specific IS [20], [38], [39], obtaining a micro-perspective. Therefore, these analyses provide fragmented perspectives on the same phenomenon without bridging the micro and the macro-perspective.

Considering PaaS adoption specifically, requires a bridge between the micro and the macro-perspective: Senior (IT) managers decide on the number and vendors that are made available within the organization (adoption) [1]. The availability of frame contracts with vendors is a pre-condition for the usage within software development if organizations roll-out rogue adoption through business-managed IT [40].

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

The operational sourcing decisions are then made on IS-level (post-adoption). This actual migration towards the cloud is not sufficiently considered by prior research, which mainly focused on the company-level adoption phase [11]. TFR, in contrast to theories applied in previous research, provides such an integrative bridge between the levels, arguing that multiple actors are involved in the organizational employment of technology [25].

Various studies investigate not only the organizational factor for CC adoption but incorporate environmental factors as well [e.g., 20, 21, 41]. The environmental factors are also considered as essential for PaaS post-adoption because they can evoke a trigger to the decision maker’s technological frame. Furthermore, various studies include technological factors in adoption models on an organizational level.

3. Research model

TFR theory suggests that technology will be adopted if a congruent view of its advantageousness persists. Post-adoption of PaaS occurs if the perceived benefits outweigh the perceived risks in a specific sourcing decision from the decision maker’s perspective, which is influenced by organizational and environmental actors. Hence, the interactions within the organizations by knowledge transfer from colleagues, support of senior managers, and the interactions outside the organization with, e.g., trading partners, vendors, competitors trigger a shift in the technological frame of the decision-maker’s initial perspective. Also, her own experience with CC may trigger this shift, e.g., trialability of PaaS.

Hence, we hypothesize that the decision-maker’s ability to try PaaS, tacit knowledge sharing, top management support, trading partner pressure, vendor trust, and competitive pressure are the factors influencing perceived benefits and risks. Furthermore, we assume a moderating effect of the decision maker’s voluntariness to post-adopt PaaS. Although we expect no influence on PaaS post-adoption, we control for security and privacy, cost savings, IT organization structure and size, and the year of the decision. Fig. 2 exhibits the research model.

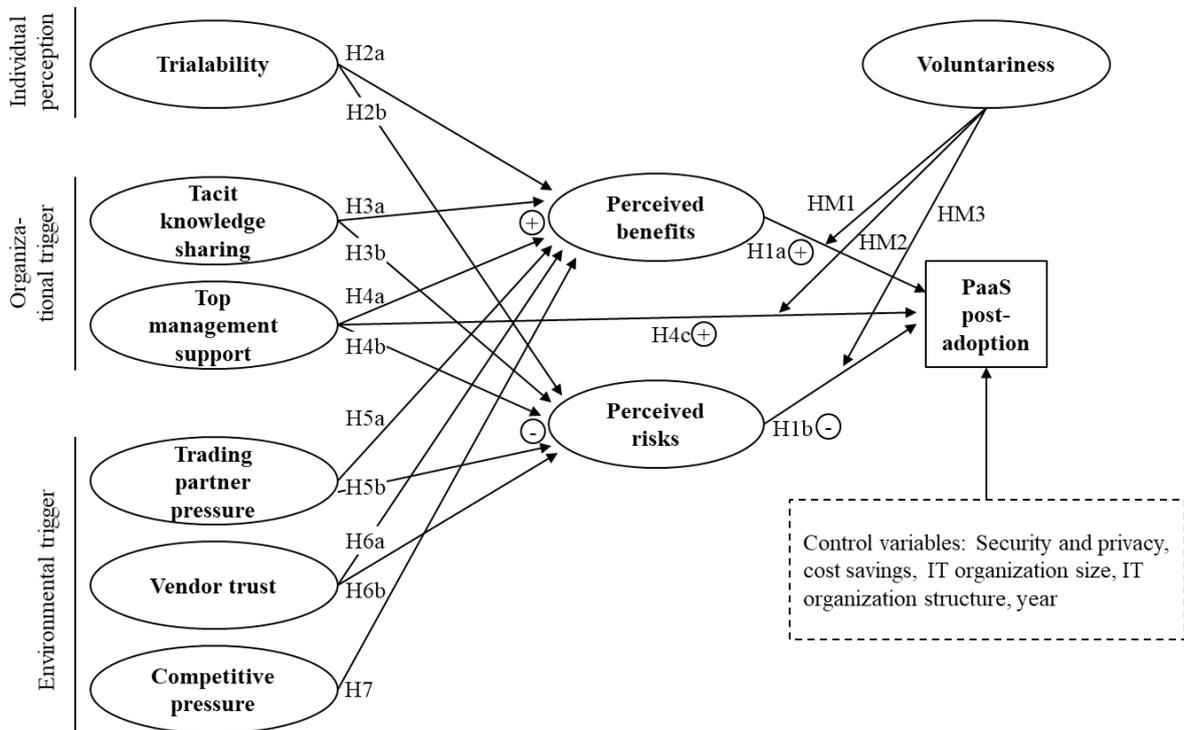


Fig. 2. Research model on PaaS post-adoption

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

The focus on PaaS post-adoption specifically, the integration of individual perception and organizational/environmental triggers, and the multilevel perspective are the differentiating factors of the model in terms of originality in comparison with prior research efforts.

3.1 Individual perception

The TFR defines the categories and content in which technology is perceived [25]. The most important success measures for decision-making are the positive and negative impacts of CC adoption [38]. The expected benefits and risks are the key factors for switching towards CC [42]. With this, risks infer the potential negative consequences of the sourcing decision (contrary to some definitions of risk implying uncertain positive or negative consequences). According to TFR, this analysis depends on the technological frame on PaaS, i.e., its perceived benefits and perceived risks.

H1a: *Perceived benefits* influence *PaaS post-adoption* positively.

H1b: *Perceived risks* influence *PaaS post-adoption* negatively.

Technological frames are defined as “tacit knowledge that is used to impose structure upon, and impart meaning to, otherwise ambiguous social and situational information to facilitate understanding” [26, p. 56]. Therefore, the formation of a technological frame is a dynamic interpretative process [28] in which tacit knowledge is built-up. Tacit knowledge is rooted in actions and experiences in a specific context [43]. Hence, technological frames emerge from work experiences [25] in the CC context. Additionally, empirical evidence suggests that individuals who try CC [22], or where pilot applications are present [39] are more likely to adopt CC: The innovativeness of CC becomes apparent when trying and using CC [1]. Therefore, decision-makers, who tried PaaS, gained experience with the technology. We argue that the gain of tacit knowledge through trying increases the decision-makers’ perception of benefits and decreases the perception of associated risks.

H2a: *Trialability* influences *perceived benefits* positively.

H2b: *Trialability* influences *perceived risks* negatively.

3.2 Organizational triggers

The lack of (tacit) knowledge on CC hinders the adoption of CC [44]. The knowledge management process by which an individual’s knowledge increases by involvement is knowledge transfer [43]. Therefore, we hypothesize that tacit knowledge sharing, as the involvement of an individual in someone else’s experiences, promotes PaaS post-adoption, analogously to trying PaaS oneself.

H3a: *Tacit knowledge sharing* influences *perceived benefits* positively.

H3b: *Tacit knowledge sharing* influences *perceived risks* negatively.

Based on the multilevel perspective, we argue that decision-makers regard the decision to adopt PaaS on company-level by top management (macro-perspective) when deciding in software development projects (micro perspective). Top management support increases the adoption of technology, specifically by the perception of CC benefits [42], [45].

H4a: *Top management support* influences *perceived benefits* positively.

H4b: *Top management support* influences *perceived risks* negatively.

3.3 Environmental triggers

Besides organizational triggers, environmental triggers may also result in interpretative shifts within an organization [28]. We include environmental triggers identified as relevant in prior research on CC adoption in the research model.

Organizations consider the experiences of trading partners when they decide on CC adoption [46]. Negative technological frames on CC by trading partners result in artifacts such as prohibiting contract clauses hindering

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

adoption [1]. Positive technological frames on CC by trading partners positively influence the post-adoption decision because PaaS allows integration with the environment [1]. Therefore, the decision-maker's technological frame on PaaS is influenced by the pressure of the trading partners as a result of the trading partners' technological frame on PaaS.

H5a: *Trading partners' pressure influences perceived benefits positively.*

H5b: *Trading partners' pressure influences perceived risks negatively.*

The way the vendor markets the technology may affect the decision-maker's technological frame [25]. In the context of PaaS, organizations require a completely different mindset to rely on a vendor for IT services [21]. Trust is a fundamental factor for the acquiring organization to inform itself [47]. Further on, the presence of uncertainty related to CC requires trust to overcome these concerns (i.e., perceived risks) and adopt CC [35], [48].

H6a: *Vendor trust influences perceived benefits positively.*

H6b: *Vendor trust influences perceived risks negatively.*

Competitive pressure urges organizations to adopt technology to create a competitive advantage through innovation [41]. Competitive pressure is a strong driver of the adoption decision in the context of CC [49]. In the context of PaaS post-adoption, specifically, where the prospect of sourcing is the creation of new business models, competitive pressure will positively influence the perception of benefits.

H7: *Competitive pressure influences perceived benefits positively.*

3.4 Moderation and controls

The premise of the model, so far, is that the decision-making context is in an enabling control setting [50]. One might bring up that in some organizations or some circumstances, the decision-maker might not have the autonomy to decide by herself. In these cases, the decision-maker would need to follow the top management's adoption decision on a company level.

HM1: *Voluntariness moderates the influence of perceived benefits on PaaS post-adoption.*

HM2: *Voluntariness moderates the influence of perceived risks on PaaS post-adoption.*

H4c: *Top management support influences PaaS post-adoption positively.*

HM3: *Voluntariness moderates the influence of top management support on PaaS post-adoption.*

Furthermore, TFR does not lead us to derive hypotheses on the influence of security and privacy or cost savings, factors extensively considered in the company-level adoption decision [51]. Additionally, we control for potential technological factors' influence of the IT organization size and structure, as well as the year in which the decision took place, as PaaS is a rapidly developing technology.

C1: *Security and privacy do not influence PaaS post-adoption.*

C2: *Cost savings do not influence PaaS post-adoption.*

C3: *IT organization size does not influence PaaS post-adoption.*

C4: *IT organization structure does not influence PaaS post-adoption.*

C5: *Year does not influence PaaS post-adoption.*

An implicit assumption of the research model is that there are – apart from top management support – no direct effects of the antecedents of perceived benefits and risks on PaaS post-adoption. Thus, we claim full mediation of these factors via perceived benefits and risks.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

4. Methods

4.1 Data collection

We operationalized the latent endogenous constructs based on measurement models previously applied in the context of CC adoption and the broader IT adoption information systems literature. We measure the indicators on 5 point (pt) and 7pt Likert scales. We chose to retain the scales used by other researchers and standardized the scores during the measurement model assessment. We operationalized PaaS post-adoption, and the controls for cost savings, year, IT organization size and structure as single items. Table A1 in the Appendix provides an overview of the measurement instruments.

We approached individuals employed at companies with more than one billion Euro revenue on the professional social network LinkedIn to find suitable candidates for the survey. We restricted the search to companies headquartered in Germany. We searched for the terms “cloud”, “PaaS”, “infrastructure”, “digital”, “project manager”, “technology”, “product owner”, and combinations thereof. We presented participants a differentiation between the CC delivery models IaaS, PaaS, and SaaS to ensure that they can assess whether they have experience with the PaaS delivery model. We filtered the participants for PaaS experience and filtered-out participants employed at a company that did not yet adopt PaaS on the company-level or were not involved in decision-making on PaaS post-adoption on IS-level. The people participating in the survey answered it between March 2020 and early June 2020. We sent out around 3,000 invitations to users from German large-scale organizations. However, we additionally encouraged the individuals to share the link among colleagues within the company to extend our reach beyond the social network LinkedIn. This approach, however, inhibits us from reporting exact turnout statistics, as the survey was anonymous.

The approach ensured that all individuals answering the questionnaire are subject to the same legal regulation and reside in a developed economy. Moreover, the approach targeted IT and business profiles, as both are potentially involved in the decision to post-adopt PaaS. We acknowledge that we relied on the validity and correctness of the information provided in their profiles.

While the approach targets individuals that are potentially involved in PaaS post-adoption decisions, we needed to control for the factual ability to answer the questions reliably. In total, the survey link received 738 clicks. 47 participants answered that PaaS is not available at their company and were, therefore, filtered out. We filtered-out an additional 182 individuals that stated not to be involved in one or more PaaS post-adoption decision. 192 individuals stopped the survey before answering the first question, and 98 individuals broke off in between. Hence, we received 219 completed questionnaires as the starting point for the data preparation.

4.2 Data cleaning and preparation

We prepared the data for analysis based on the procedure described in Hair et al. [52]. We screened the commentary fields for input, alluding that the individual did not answer the survey in a context different from the intended context. By this, we deleted 14 responses that regarded providing IT-services as a vendor, where the individual answered from an external consultant’s perspective, or the individual did not focus on a single sourcing decision.

We followed Hair et al. [51] for the procedures of missing data for the remaining responses, deleting four responses exhibiting more than 15 percent missing values (4 responses). We deleted the indicator “CMPR3” that exhibited more than 15 percent missing values, likewise. For indicators missing less than five percent of data, we replaced the missing values with the mean of the responses with non-missing data (VNDR2, TPRR1, TPRR2).

For VNDR1, VNDR3, TPRR3, TPRR4, CMPR1, and CMPR2 exhibited less than 15 but more than five percent of missing values. For such indicators, missing values should be replaced based on demographic-corrected means [52]. Hence, we replaced the values based on the subgroup mean of the individual’s professional experience, as this represents the sole demographic information collected from the participants.

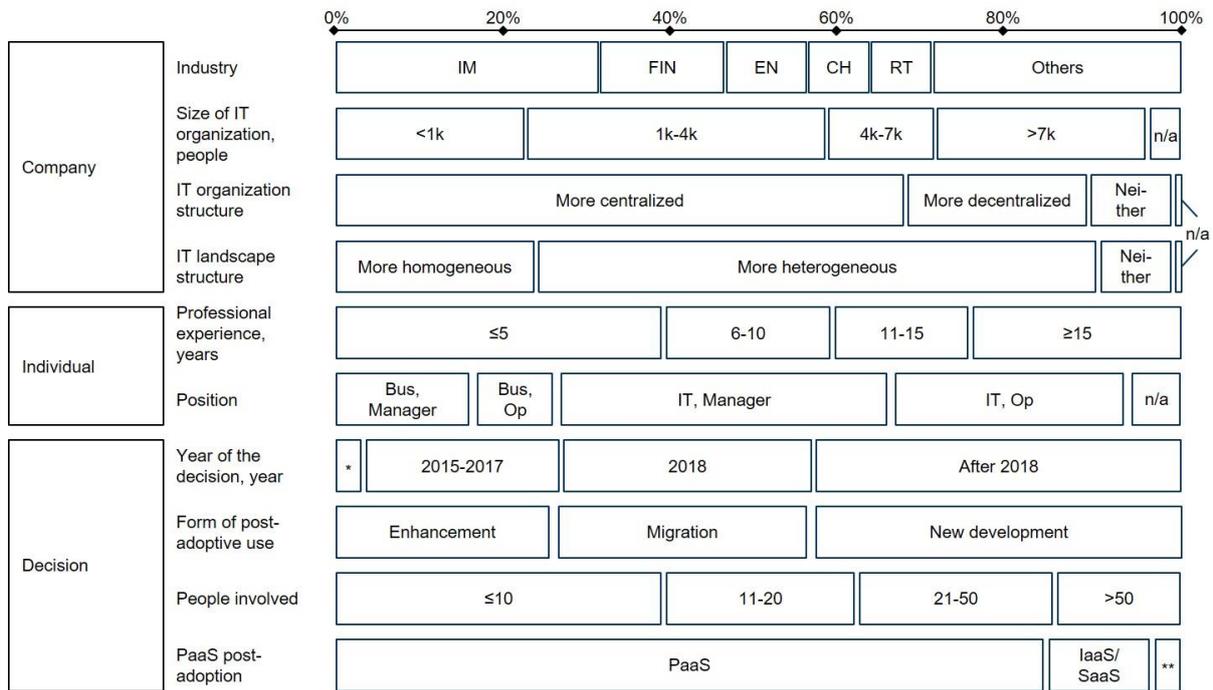
We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Additionally, we screened the responses for patterns and consistency [52]. Analyzing the responses for extreme values indicated that two responses selected the middle value of the scale in more than 50 percent of the answers. We analyzed the variance of the responses separately for 5pt- and 7pt-Likert-scale indicators without identifying further critical observations. Two respondents selected the highest value of the scale of more than 50 percent of the time, which we deleted. The maximum percentage of selecting the lowest value of the scale was 18 percent.

Additionally, we analyzed the difference between the item VLTN3 and the reverse coded item VLTN1 with similar content. We identified 29 respondents whose answers diverged by more than three on a 7pt-Likert-scale, which we consider as inconsistent. Hence, we excluded these 33 questionnaires from analysis, leading to 168 analyzable questionnaires.

4.3 Sample description

Fig. 3 describes the dataset of 168 analyzable responses. The most numerous industries in the dataset are industrial manufacturing and financial services, corresponding to the overall industry landscape in Germany. Most IT organizations have between 1,000 and 4,000 employees, exhibit a more centralized than decentralized structure, and a more heterogeneous than homogeneous IT landscape. The individuals mostly work on managerial, followed by an operational level in IT, and 60% have more than five years of professional experience. The decision on which the participants based their answers took predominantly place between 2018 and 2020. The sample includes post-adoptive use forms of migrations (50 responses), enhancements of existing IS (43 responses), and new IS developments (75 responses).



Legend: Industrial manufacturing (IM), Financial Services (FIN), Energy, Utility, Resources (EN), Chemicals (CH), Retail (RT), Before 2015 (*), Business (Bus), Information Technology (IT), Operational (Op), Other technology (**)

Fig. 3. Sample description

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

The majority of decisions involved 20 people or less. Most decisions in the sample post-adopted PaaS, which we coded with the value 1. Interestingly, responses that did not post-adopt PaaS for a specific IS, mostly chose either IaaS or SaaS (20 responses), rather than other technologies (five responses), both coded as 0. The finding that companies in parts decided more often for IaaS and SaaS rather than other technologies suggests that companies partially consider both IaaS and SaaS, in some cases, as substitutes of PaaS. Interviews of a consecutive study with survey participants revealed insight into this: One interviewee reported on the decision of a new human resource IS. The company considered whether this system is a differentiator from the competition (suggesting PaaS to develop the IS), or else source an SaaS. Another interviewee elaborated on an analytics implementation for product comparison. In this case, the company evaluated whether to build algorithms itself on IaaS, or whether the available off-the-shelf algorithms in PaaS are sufficient.

4.4 Data analysis

To test the hypothesis outlined in section 3, we combine partial least squares structural equation modeling (PLS-SEM) and logistic regression. PLS-SEM should be used for complex models aiming to identify main drivers and enables calculation of latent variable scores to be used in further analysis [52]. However, PLS-SEM is not recommended for the analysis of binary dependent variables [52], which is the case for PaaS post-adoption. Applying PLS-SEM for the hypotheses on PaaS post-adoption would change the interpretation of a linear probability model. Logistic regression models are a common choice to analyze binary dependent variables [53], as it does not minimize squared deviations but maximize the likelihood of (post-)adopting IS innovations [54].

Bodoff and Ho [55] provide a procedure on how to combine PLS-SEM with logistic regression: Step 1, assess and fit the measurement model of all latent variables. Step 2, estimate the structural model on non-binary endogenous dependent variables and retain the latent variable scores. Step 3, perform logistic regression on the binary dependent variable. In addition to this suggested approach, we, in step 2, control for the absence of direct effects of the antecedent constructs in a linear probability model. Thus, we split the analysis into these steps and adding a subsample analysis as step 4. We conduct steps 1 and 2 in SmartPLS 3 [56], and steps 3 and 4 in Stata 16. We organize the results section accordingly, along with these steps.

5. Results

5.1 Step 1: measurement model assessment

Indicator loadings. We drop indicators that exhibit outer loadings (all measurement models are reflective) below 0.4. We, therefore, drop TKLS1, TKLS3, TMGS3, and VLTN2 before re-running the PLS-SEM algorithm. For loadings between 0.4 and 0.707, we regard whether the average variance extracted (AVE) is below the cutoff value 0.5. Trading partner pressure exhibited an AVE < 0.5. Hence, we drop TPPR4 as an indicator with the lowest loading, resulting in an AVE above the threshold.

Table 1 exhibits the composite reliability and Cronbach's Alpha to test the internal consistency reliability of the measurement models. For composite reliability, all constructs exhibit values above the 0.7 cutoff value [52]. For competitive pressure, the more conservative Cronbach's Alpha is below 0.6, indicating a potential lack of internal reliability that is a limitation of this construct. To assess convergent validity, we report the AVE in Table 1 as well. We find convergent validity above the 0.5 cutoff value [52] for all constructs.

Discriminant validity and collinearity. We assess discriminant validity by the heterotrait-monotrait (HTMT) ratio, which should be below 1, which means the construct should better explain the variance of its indicators than other constructs' variance [52]. The maximum heterotrait-monotrait ratio in the sample is 0.45, and therefore far below the critical values of 0.9 [57].

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Table 1. Internal consistency reliability and convergent validity measures

Construct	Composite reliability	Cronbach's Alpha	Average variance extracted (AVE)
<i>Perceived benefits</i>	0.848	0.792	0.528
<i>Perceived risks</i>	0.832	0.703	0.624
<i>Trialability</i>	0.858	0.760	0.671
<i>Tacit knowledge sharing</i>	0.882	0.877	0.603
<i>Top management support</i>	0.861	0.765	0.759
<i>Trading partner pressure</i>	0.742	0.611	0.505
<i>Vendor trust</i>	0.792	0.651	0.562
<i>Competitive pressure</i>	0.762	0.552	0.517
<i>Voluntariness</i>	0.739	0.718	0.516
<i>Security and privacy</i>	0.864	0.773	0.683

5.2 Step 2: antecedent assessment and absence of direct effects

We carry out the PLS-SEM algorithm and bootstrapping with 5,000 subsamples to assess the hypotheses on perceived benefits and perceived risks as antecedents of PaaS post-adoption. Table 2 reports the results of the hypotheses on perceived benefits and risks. For both dependent variables, the R^2 values are low, but Stone-Geisser Q^2 values exceed zero. We find support in Hypothesis H2b, H6a, H6b, and H7, but not for H2a, H3a and b, H4a and b, and H5a and b.

Collinearity, indicated by variance inflation factors above 5 [52], is not present in the sample (maximum value is 2.656). Blind-folding to calculate Stone-Geisser Q^2 values should select an omission distance between five and ten [52], so we selected 9.

Table 2. PLS-SEM results for hypotheses on perceived benefits and risks

Construct/statistic	Antecedent assessment model		Direct effect control model		<i>PaaS post-adoption</i>	Hypothesis testing
	<i>Perceived benefits</i>	<i>Perceived risks</i>	<i>Perceived benefits</i>	<i>Perceived risks</i>		
R^2	0.124	0.125	0.117	0.115	0.136	
Q^2	0.023	0.034	0.023	0.016	-0.121	
<i>Trialability</i>	0.130	-0.162*	0.146	-0.179*	-0.092	H2a: Not supported H2b: Supported
<i>Tacit knowledge sharing</i>	0.054	-0.037	0.004	-0.004	0.081	H3a: Not supported H3b: Not supported
<i>Top management support</i>	-0.150	-0.093	-0.146	-0.106	-0.021	H4a: Not supported H4b: Not supported
<i>Trading partner pressure</i>	-0.042	0.184*	-0.064	0.161	-0.059	H5a: Not supported H5b: Not supported

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Construct/statistic	Antecedent assessment model		Direct effect control model		PaaS post-adoption	Hypothesis testing
	Perceived benefits	Perceived risks	Perceived benefits	Perceived risks		
Vendor trust	0.170*	-0.155*	0.160	-0.143*	0.044	H6a: Not supported H6b: Supported
Competitive pressure	0.29**		0.287**		0.147	H7: Supported

*** p<0.001; ** p<0.01; * p<0.05; (one-tailed)

We run an auxiliary PLS-SEM on PaaS post-adoption to test the controls and to test that the antecedent constructs for perceived benefits and risks do not exhibit a direct effect on PaaS post-adoption. We do not evaluate our hypotheses on PaaS post-adoption, because the interpretation as a linear probability model challenges the evaluation of goodness-of-fit. In this auxiliary PLS-SEM, we find that most of the antecedent constructs exhibit no significant influence on PaaS post-adoption while controlling for indirect effects via perceived benefits and risks. The positive influence of competitive pressure on perceived benefits and the negative influence of trialability and vendor trust on perceived risks remains significant, supporting H2b, H6b, and H7. Solely the influence of vendor trust on perceived benefits turns non-significant, leading us to find no support for H6a. Stone-Geisser Q^2 of PaaS post-adoption is below zero, indicating that the linear probability model does not have predictive power. Hence, we find support for the approach to analyze the hypotheses on PaaS post-adoption via logistic regression, and therefore retain the latent variable scores of the antecedent model.

5.3 Step 3: full sample assessment of PaaS post-adoption

We report the results of the logistic regression to evaluate hypotheses on PaaS post-adoption in Table 3. We find that PaaS post-adoption is significantly negatively influenced by perceived risks (H1b), but not perceived benefits (H1a) and top management support (H4c). The influence of top management support and the moderating effects of voluntariness are also not significant. Thus, we find no support in H4c, HM1, HM2, and HM3. The non-significant Wald χ^2 statistics for the control variables support the controls C1 to C6, signifying that the post-adoption decision does not exhibit the same influence factors as adoption on the company-level.

The R^2 to test the goodness-of-fit does not exist in logistic regressions. The Hosmer-Lemeshow test analyzes the differences between the fitted values and the actual values [58]. The non-significant p-values indicate no significant difference between the model and a perfect model [53]. Nagelkerke's R^2 provides a statistical measure for the model's ability to explain the data [53], exhibiting low explanatory power. However, the practical relevance of logistic models depends on the model's ability to correctly classify observations [53]. We, therefore, assess the practical significance of the model results using a classification matrix. The common standards of comparisons of the classification accuracy when group sizes are unequal are the proportionate chance criterium and the very conservative maximum chance criterium [53].

Despite the low Nagelkerke's R^2 , indicating low explanatory power, the model has practical relevance to classify observations correctly, displayed in Table 4. The classification accuracy exceeds the conservative maximum chance criterium, which classifies all observations as post-adopters, and therefore exhibits an accuracy of 85.1% (143 out of 168). The proportionate chance criterium is 74.7%, assuming unequal group sizes with the proportions of the sample distribution of PaaS post-adoption. A statistical test for the discriminatory power of the model is Press' Q, testing whether the model significantly outperforms the chance model [53], which is significant at the p=0.001 level of significance. The model correctly classifies all post-adopters but identifies only one non-post-adopter. This outcome, the overall low Nagelkerke's R^2 , and the significant influence of perceived risks may be caused by an underlying structure creating noise. I.e., the model's parameters are different for subsamples constructed by the form of post-adoptive use which we explore in the subsequent section.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Table 3. Logistic regression results of hypotheses on PaaS post-adoption

Coefficients					
Independent variables	β	Std. Err.	Wald χ^2	Pr > χ^2	Hypothesis/control
<i>Perceived benefits</i>	0.183	0.218	0.70	0.4034	H1a: Not supported
<i>Perceived risks</i>	-0.585*	0.248	5.58	0.0182	H1b: Supported
<i>Top management support</i>	0.068	0.228	0.09	0.7673	H4c: Not supported
<i>Mod. perceived benefits</i>	-0.010	0.219	0.00	0.9619	HM1: Not supported
<i>Mod. perceived risks</i>	-0.060	0.235	0.07	0.7981	HM2: Not supported
<i>Mod. top mgmt. supp.</i>	-0.071	0.222	0.10	0.7513	HM3: Not supported
<i>Security and privacy</i>	0.032	0.236	0.02	0.8912	C1: Supported
<i>Cost savings</i>	0.058	0.250	0.05	0.8155	C2: Supported
<i>IT organization size</i>	-0.229	0.162	2.00	0.1578	C3: Supported
<i>IT organization structure</i>	-0.375	0.222	2.84	0.0917	C4: Supported
<i>Year</i>	-0.482	0.315	2.34	0.1259	C5: Supported
Constant	4.191***	1.154	13.2	0.0003	
Goodness-of-fit measures					
-2LL	-63.02	Nagelkerke R ²	0.15		
Hosmer-Lemeshow	174.1**	Press Q	85.7***		

Table 4. Classification matrix (full sample)

		Predicted		
		Post-adopters	Non-post-adopters	Accuracy
Observed	Post-adopters	143	24	100%
	Non-post-adopters	0	1	4%
Overall percentage				86%

5.4 Step 4: sub-sample analysis by forms of post-adoptive use

We run the sample model of step 3 separately for the subsamples of the form of post-adoptive use (1) Migration of existing system, (2) Enhancement of existing system, and (3) New IS development.

Table 5 exhibits the results of the sub-sample assessment. Assessing the goodness-of-fit for the post-adoptive use specific models yield increases of Nagelkerke’s R² for all subsamples (0.283, 0.502, 0.294). Hosmer-Lemeshow tests still indicate no significant difference in the model compared to the perfect model for sub-samples (2) and (3), but not for subsample (1). The classification accuracy (reported in

Table 6) improves to 89%, identifying further eight non-post-adopters correctly, at the expense of misclassifying two post-adopters, leading to an increase in Q Press’ test statistic compared to the full sample assessment. We, therefore, conclude that the post-adoptive-use-specific models fit the data better than the full sample assessment.

Analyzing subsamples comes at the expense of reduced statistical power. A reduced statistical power means that non-significant results for the coefficients not necessarily imply that the effect is not significant in the population. We find

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

differences in the coefficient values worth noting, despite that they are mostly non-significant. Perceived benefits exhibit a large, positive, but insignificant coefficient for subsample (1), but is close to zero for subsamples (2) and (3). The perceived risk coefficient is negative for all subsamples, but much smaller for subsample (2) and significantly different from zero, despite the small sample size. The size of the IT organization exhibits a significant, negative influence on PaaS post-adoption in subsample (1). For all other variables than security and privacy, the results show changes in arithmetic signs or large differences in coefficient size across subsamples.

Table 5. Logistic regression results of subsamples constructed by the form of post-adoptive use

Independent variables	(1) β	(2) β	(3) β
<i>Perceived benefits</i>	0.750	-0.111	0.043
<i>Perceived risks</i>	-0.325	-1.969*	-0.772
<i>Top management support</i>	0.163	0.173	-0.095
<i>Mod. perceived benefits</i>	0.073	0.066	-0.288
<i>Mod. perceived risks</i>	0.215	-1.646	0.356
<i>Mod. top mgmt. supp.</i>	-0.496	-0.905	0.481
<i>Security and privacy</i>	-0.174	-0.289	-0.240
<i>Cost savings</i>	-0.328	0.245	0.194
<i>IT organization size</i>	-0.755*	-0.215	0.058
<i>IT organization structure</i>	-0.253	-0.806	-0.521
<i>Year</i>	0.065	-0.273	-1.667
Constant	5.682*	6.750*	4.320
Goodness-of-fit measures			
-2LL	-18.82	-11.56	-21.30
Hosmer-Lemeshow	73.62	33.59**	55.41**
Nagelkerke R ²	0.283	0.502	0.294
Press Q	103.7142857***		

(1) Migration of existing system; (2) enhancement of existing system; (3) new IS development
 * Coefficient's Wald test significant at 0.05 level of significance
 ** Test is non-significant at the 0.05 level of significance (p=0.3427/0.7406)
 *** Test is significant at the 0.001 level of significance

Table 6. Classification matrix (sub-samples)

		Predicted		
		Post-adopters	Non-post-adopters	Accuracy
Observed	Post-adopters	141	16	99%
	Non-post-adopters	2	9	36%
Overall percentage				89%

6. Discussion and limitations

Contrary to research on CC adoption [51], cost savings, top management support, and security and privacy risks, do not influence the PaaS post-adoption decision. Stieninger et al. [59] also found that relative advantage (a construct similar to perceived benefits) and security and trust do not influence actual usage but have a weak influence on the attitude towards CC. Al-Sharafi et al. [46] identified cost savings, top management support, and relative advantage being the most influential factors for continuant use of CC. The only other study in the field of PaaS post-adoption to compare our results investigated the cases of an integrating and an application PaaS retrospectively [11]. The study found as well that cost savings did not motivate post-adoption. While the study identified technological characteristics as flexibility, time-to-market, enabling innovation, and reducing IT complexity as motivations, we showed that these perceived benefits do not differentiate between post-adopters and non-post-adopters. Considering that our dataset involved mainly non-post-adopters that decided for other CC delivery models, we conclude that these perceived benefits apply across delivery models, as shown previously in a multiple case study [60].

Assessing a model's goodness-of-fit requires comparison to similar studies in the same field [52], for which we compare our results to logistic regressions on CC adoption. Lynn et al. [33] report a Nagelkerke R^2 of 0.34 and classification accuracy of 74.4%. Loukis et al. [61] report a Nagelkerke R^2 of 0.18, and Senyo et al. [40] a Nagelkerke R^2 of 0.13. Hence, we conclude that our full sample results yielded comparable results with a Nagelkerke R^2 of 0.15 and classification accuracy of 86%. The subsample results exceed these comparison studies with Nagelkerke R^2 values of 0.28, 0.50, and 0.29, and classification accuracy of 89%.

By design, the results obtained in this paper consider large-scale companies only. The data collection focus on Germany makes the results applicable to developed countries but did not allow for comparisons across countries, which could be subject to legal differences regarding the usage of PaaS. Statistically, we acknowledge that the results are limited by the internal consistency reliability of competitive pressure, vendor trust, trading partner pressure, and perceived risk if one applies Cronbach's Alpha as the standard of comparison, but not if the composite reliability is applied. The analysis of post-adoptive use subsamples reduces the statistical power of the analysis given the small subsample size. Hence, we did not reliably identify all effects in the real population but can provide indications which factors are more important for the specific form of post-adoptive use.

7. Conclusion

Regarding the influence factors of PaaS post-adoption (RQ1), we find that the factors most frequently discussed in the context of company-level CC adoption (cost savings, security and privacy, and top management support) do not influence the post-adoption decision on IS-level. However, we find that the decision-maker's perceived risks negatively influence PaaS post-adoption. In summary, decision-makers on IS-level aim to avoid mistakes (i.e., decide risk-averse), rather than considering the security and privacy implications of an adopted technology in detail, the benefits such as cost savings, or top management's support. As antecedents, trialability and the trust in the vendor significantly lower the perceived risks. Practitioners aiming to foster PaaS post-adoption in their company should establish trial possibilities for the decision-makers as training, demos, and the distribution of trial versions. Moreover, practitioners aiming to promote PaaS post-adoption should regard the vendor relationship to enhance trust. This includes selecting a trustworthy vendor in the first place, but also establishing a trustful relationship after that.

RQ2 suggests that the decision-making process upon PaaS post-adoption could be pre-empted by the macro decision to adopt PaaS on the company-level. The conducted analysis revealed non-significant coefficients for the top management support, and the moderating effects of voluntariness on top management support, perceived benefits, and perceived risks. Our interpretation of these results is that decision-makers decide on PaaS post-adoption based on their perceived risks and do not "have" to decide on it based on the adoption decision on the company-level. Hence, the post-adoption of PaaS is a company-wide endeavor that requires support from the decision-makers on IS-level.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Investigating the dependency of the form of post-adoptive use (RQ3), we find that the subsample analysis better fits the data. This lets us conclude that the coefficients of the variables in the model differ in the form of post-adoptive use. We see that perceived risks have the strongest (negative) impact on PaaS post-adoption for enhancements of existing IS, and the IT organization's size negatively affects migrations of existing ISs. The practical implication of the above finding is that the decision on IS enhancements is, to the largest extent, driven by the decision-maker's perception of risks. The latter finding signifies that larger IT organizations tend to develop functionalities themselves on IaaS, rather than sourcing functionalities via PaaS.

While the conducted analysis yielded an overall practical significance in classifying post-adopters and non-post-adopters, we explored that models' coefficients varied across the form of post-adoptive use. This observation prompts us to call for further research on PaaS-post-adoption that investigates the differences across forms of post-adoptive use in more depth. Especially, the question of what influences post-adoption decisions that regard new IS development requires further exploration.

References

- [1] F. Wulf, M. Westner, M. Schön, S. Strahringer, and C. Loebbecke, "Preparing for a Digital Future: Cloud Strategy at Continental AG," in *Proceedings of the 40th International Conference on Information Systems (ICIS)*, 2019.
- [2] A. Pols and M. Vogel, "Cloud-Monitor 2019," *Bitkom*, 2019. [Online] Available: https://www.bitkom.org/sites/default/files/2019-06/bitkom_kpmg_pk_charts_cloud_monitor_18_06_2019.pdf
- [3] K. Costello and M. Rimol (2019, Nov 13), *Gartner Forecasts Worldwide Public Cloud Revenue to Grow 17% in 2020* [Online]. Available: <https://www.gartner.com/en/newsroom/press-releases/2019-11-13-gartner-forecasts-worldwide-public-cloud-revenue-to-grow-17-percent-in-2020>
- [4] K. Zhu, S. Dong, S. X. Xu, and K. L. Kraemer, "Innovation diffusion in global contexts: determinants of post-adoption digital transformation of European companies," *European Journal of Information Systems*, vol. 15, no. 6, pp. 601–616, 2006.
- [5] F. Bagayogo, L. Lapointe, and G. Bassellier, "Enhanced Use of IT: A new perspective on post-adoption," *Journal of the Association for Information Systems*, vol. 15, no. 7, pp. 361–387, 2014.
- [6] F. Bélanger, M. Cefaratti, T. Carte, and S. Markham, "Multilevel Research in Information Systems: Concepts, Strategies, Problems, and Pitfalls," *Journal of the Association for Information Systems*, vol. 15, no. 9, pp. 614–650, 2014.
- [7] K. Klein and S. W. J. Kozlowski, "From Micro to Meso: Critical Steps in Conceptualizing and Conducting Multilevel Research," *Organizational Research Methods*, vol. 3, no. 3, pp. 211–236, 2000.
- [8] K. J. Klein, F. Dansereau, and R. Hall, "Levels Issues in Theory Development, Data Collection, and Analysis," *Academy of Management Review*, vol. 19, no. 2, pp. 195–229, 1994.
- [9] F. Morgeson and D. Hofman, "The structure and function of collective constructs: Implications for multilevel research and theory development," *Academy of Management Review*, vol. 24, no. 2, pp. 249–265, 1999.
- [10] F. Wulf, "Platform-As-A-Service Post-Adoption by Large-Scale Organizations: A Research Model Design," in *ECIS 2020 Research-in-Progress Papers*, 2020.
- [11] T. Boillat and C. Legner, "Why Do Companies Migrate Towards Cloud Enterprise Systems? A Post-Implementation Perspective," in *2014 IEEE 16th Conference on Business Informatics*, Geneva, Switzerland, 2014, pp. 102–109.
- [12] Q. Zhang, L. Cheng, and R. Boutaba, "Cloud Computing: State-of-the-Art and Research Challenges," *Journal of Internet Services and Applications*, vol. 1, no. 1, pp. 7–18, 2010.
- [13] A. Rashid and A. Chaturvedi, "Cloud Computing Characteristics and Services A Brief Review," *International Journal of Computer Sciences and Engineering*, vol. 7, no. 2, pp. 421–426, 2019.
- [14] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly*, vol. 13, no. 3, pp. 319–340, 1989.
- [15] N. Haile and J. Altmann, "Risk-Benefit-Mediated Impact of Determinants on the Adoption of Cloud Federation," in *Pacific Asia Conference on Information Systems*, Singapore, Singapore, 2015.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

- [16] D. Kumar, H. V. Samalia, and P. Verma, “Factors Influencing Cloud Computing Adoption by Small and Medium-Sized Enterprises (SMEs) In India,” *Pacific Asia Journal of the Association for Information Systems*, vol. 9, no. 3, pp. 25–48, 2017.
- [17] M. Velázquez and S. M. Ho, “Do You Trust the Cloud? Modeling Cloud Technology Adoption in Organizations,” in *Americas Conference on Information Systems*, Puerto Rico, 2015.
- [18] S. Alharbi, “An Empirical Investigation on the Impact of Trust Mediated Determinants and Moderating Factors on the Adoption of Cloud Computing,” *International Journal of Information Technology and Computer Science*, vol. 9, no. 11, pp. 12–22, 2017.
- [19] N. Khanal, G. Parsons, T. Mantz, and R. Mendelson, “Critical Factors Influencing the Adoption of Cloud Computing,” *European Journal of Business Research*, vol. 16, no. 1, pp. 73–96, 2016.
- [20] X. Cheng, “Cloud Computing and Decision-Making: Determinants, Modelling and Impacts,” Ph.D. dissertation, Université Paris-Saclay, Paris, France, 2017.
- [21] C.-L. Hsu and J. C.-C. Lin, “Factors Affecting the Adoption of Cloud Services in Enterprises,” *Information Systems and e-Business Management*, vol. 14, no. 4, pp. 791–822, 2016.
- [22] S. Karunakaran, S. Mathew, and F. Lehner, “Differential Adoption of Cloud Technology: A Multiple Case Study of Large Firms and SMEs,” in *International Conference on Information Systems*, Dublin, Ireland, 2016.
- [23] L. G. Tornatzky and M. Fleischer, *The Processes of Technological Innovation*. Lexington, MA: Lexington Books, 1990.
- [24] T. Oliveira, M. Thomas, and M. Espadanal, “Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors,” *Information & Management*, vol. 51, no. 5, pp. 497–510, 2014.
- [25] W. J. Orlikowski and D. C. Gash, “Technological frames: making sense of information technology in organizations,” *ACM Transactions on Information Systems*, vol. 12, no. 2, pp. 174–207, 1994.
- [26] D. A. Goia, “Symbols, scripts, and sensemaking: Creating meaning in the organizational experience.,” *The thinking organization*, vol. 49, pp. 49–74, 1986.
- [27] W. Bijker, *Of bicycles, bakelites and bulbs: Toward a theory of sociotechnical change*. Cambridge, MA; London, UK: MIT Press, 1995.
- [28] E. Davidson, “A Technological Frames Perspective on Information Technology and Organizational Change,” *The Journal of Applied Behavioral Science*, vol. 42, no. 1, pp. 23–39, 2006.
- [29] T. McGovern and C. Hicks, “How political processes shaped the IT adopted by a small make-to-order company: a case study in the insulated wire and cable industry,” *Information & Management*, vol. 42, no. 1, pp. 243–257, 2004.
- [30] N. Shaw, L.-P. Eng, and J. Ang, “Understanding End-User Computing Through Technological Frames,” in *International Conference on Information Systems*, 1997, pp. 453–459.
- [31] K. J. Klein, H. Tosi, and A. A. Cannella Jr, “Multilevel Theory Building: Benefits, Barriers, and new Developments,” *Academy of Management Review*, vol. 24, no. 2, pp. 243–248, 1999.
- [32] R. Agarwal and H. Lucas, “The Information Systems Identity Crisis: Focusing on High-Visibility and High-Impact Research,” *MIS Quarterly*, vol. 29, no. 3, pp. 381–398, 2005.
- [33] R. P. DeShon, S. W. J. Kozlowski, A. M. Schmidt, K. R. Milner, and D. Wiechmann, “A Multiple-Goal, Multilevel Model of Feedback Effects on the Regulation of Individual and Team Performance.,” *Journal of Applied Psychology*, vol. 89, no. 6, pp. 1035–1056, 2004.
- [34] T. Lynn, J. P. Morrison, X. Liang, G. Fox, A. Gourinovitch, and P. Rosati, “Understanding the Determinants of Cloud Computing Adoption for High Performance Computing,” in *Hawaii International Conference on System Sciences*, 2018, pp. 3894–3903.
- [35] P. Priyadarshinee, R. D. Raut, M. K. Jha, and B. B. Gardas, “Understanding and Predicting the Determinants of Cloud Computing Adoption: A Two Staged Hybrid SEM - Neural Networks Approach,” *Computers in Human Behavior*, vol. 76, pp. 341–362, 2017.
- [36] S.-L. Chen, J.-H. Chen, and S. C. Chang, “Understanding the Antecedents of Individuals Intention of Using Cloud Services,” *Journal of Economics and Management*, vol. 13, no. 2, pp. 139–166, 2017.

- [37] V. Ratten, “Factors Influencing Consumer Purchase Intention of Cloud Computing in the United States and Turkey: The Role of Performance Expectancy, Ethical Awareness and Consumer Innovation,” *EuroMed Journal of Business*, vol. 10, no. 1, pp. 80–97, 2015.
- [38] E. Donovan, I. R. Guzman, M. Adya, and W. Wang, “A Cloud Update of the Delone and McLean Model of Information Systems Success,” *Journal of Information Technology Management*, vol. 29, no. 3, pp. 23–34, 2018.
- [39] M. Holloway, M. Dickhaus, R. Hans, B. Emondts, A. Rizk, and R. Steinmetz, “Cloud Adoption in the Spotlight - Empirical Insights from German IT Experts,” in *Americas Conference on Information Systems*, Boston, MA, USA, 2017.
- [40] A. Kopper *et al.*, “Shadow IT and Business-Managed IT: A Conceptual Framework and Empirical Illustration,” *International Journal of IT/Business Alignment and Governance*, vol. 9, no. 2, pp. 53–71, 2018.
- [41] P. K. Senyo, J. Effah, and E. Addae, “Preliminary Insight into Cloud Computing Adoption in a Developing Country,” *Journal of Enterprise Information Management*, vol. 29, no. 4, pp. 505–524, 2016.
- [42] Z. S. Hachicha and K. Mezghani, “Understanding Intentions to Switch Toward Cloud Computing at Firms’ Level: A Multiple Case Study in Tunisia,” *Journal of Global Information Management*, vol. 26, no. 1, pp. 136–165, 2018.
- [43] M. Alavi and D. E. Leidner, “Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues,” *MIS Quarterly*, vol. 25, no. 1, pp. 107–136, 2001.
- [44] E. O. Güner and E. Sneider, “Cloud Computing Adoption Factors in Turkish Large Scale Enterprises,” in *Pacific Asia Conference on Information Systems*, Chengdu, China, 2014.
- [45] H. Gangwar, H. Date, and R. Ramaswamy, “Understanding determinants of cloud computing adoption using an integrated TAM-TOE model,” *Journal of Enterprise Information Management*, vol. 28, no. 1, pp. 107–130, 2015.
- [46] M. A. Al-Sharafi, R. A. Arshah, and E. A. Abu-Shanab, “Factors Affecting the Continuous Use of Cloud Computing Services from Expert’s Perspective,” in *TENCON 2017 - 2017 IEEE Region 10 Conference*, Penang, Malaysia, 2017, pp. 986–991.
- [47] J. K. Adjei, “Explaining the Role of Trust in Cloud Computing Services,” *info*, vol. 17, no. 1, pp. 54–67, 2015.
- [48] A. Dimoka, “What Does the Brain Tell Us About Trust and Distrust? Evidence from a Functional Neuroimaging Study,” *MIS Quarterly*, vol. 34, no. 2, pp. 373–396, 2010.
- [49] A. Gutierrez and R. Lumsden, “Key Management Determinants For Cloud Computing Adoption,” in *UK Academy for Information Systems Conference*, Oxford, United Kingdom, 2014.
- [50] R. F. Speklé and S. K. Widener, “Challenging Issues in Survey Research: Discussion and Suggestions,” *Journal of Management Accounting Research*, vol. 30, no. 2, pp. 3–21, 2018.
- [51] S. Schneider and A. Sunyaev, “Determinant Factors of Cloud-Sourcing Decisions: Reflecting on the IT Outsourcing Literature in the Era of Cloud Computing,” *Journal of Information Technology*, vol. 31, no. 1, pp. 1–31, 2016.
- [52] J. F. Hair, G. T. M. Hult, C. Ringle, and M. Sarstedt, *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage, 2016.
- [53] J. F. Jr. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, *Multivariate Data Analysis*, 7th ed. Prentice hall, NY, USA: Upper Saddle River, 2009.
- [54] G. Premkumar, “A Meta-Analysis of Research on Information Technology Implementation in Small Business,” *Journal of Organizational Computing and Electronic Commerce*, vol. 13, no. 2, pp. 91–121, 2003.
- [55] D. Bodoff and S. Y. Ho, “Partial Least Squares Structural Equation Modeling Approach for Analyzing a Model with a Binary Indicator as an Endogenous Variable,” *Communications of the Association for Information Systems*, vol. 38, pp. 400–419, 2016.
- [56] C. M. Ringle, S. Wende, and J.-M. Becker (2015), *SmartPLS 3*. [Online]. Available: <http://www.smartpls.com>
- [57] J. Henseler, C. M. Ringle, and M. Sarstedt, “A new criterion for assessing discriminant validity in variance-based structural equation modeling,” *Journal of the Academy of Marketing Science*, vol. 43, no. 1, pp. 115–135, 2015.
- [58] D. W. Jr. Hosmer, S. Lemeshow, and R. X. Sturdivant, “Applied Logistic Regression.” John Wiley & Sons, 2013.
- [59] M. Stieninger, D. Nedbal, W. Wetzlinger, G. Wagner, and M. A. Erskine, “Factors influencing the organizational adoption of cloud computing: a survey among cloud workers,” *International Journal of Information Systems and Project Management*, vol. 6, no. 1, pp. 5–23, 2018.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

- [60] F. Wulf, T. Lindner, M. Westner, and S. Strahringer, “IaaS, PaaS, or SaaS? The Why of Cloud Computing Delivery Model Selection – Vignettes on the Post-Adoption of Cloud Computing,” in *Hawaii International Conference on System Sciences*, 2021.
- [61] E. Loukis, S. Arvanitis, and N. Kyriakou, “An Empirical Investigation of the Effects of Firm Characteristics on the Propensity to Adopt Cloud Computing,” *Information Systems and e-Business Management*, vol. 15, no. 4, pp. 963–988, 2017.
- [62] G. C. Moore and I. Benbasat, “Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation,” *Information Systems Research*, vol. 2, no. 3, pp. 192–222, 1991.
- [63] J. S. Holste and D. Fields, “Trust and Tacit Knowledge Sharing and Use,” *Journal of Knowledge Management*, vol. 14, no. 1, pp. 128–140, 2010.
- [64] C.-P. Lin, “To Share or Not to Share: Modeling Tacit Knowledge Sharing, Its Mediators and Antecedents,” *Journal of Business Ethics*, vol. 70, no. 4, pp. 411–428, 2007.
- [65] Z. Wang and N. Wang, “Knowledge Sharing, Innovation and Firm Performance,” *Expert Systems with Applications*, vol. 39, no. 10, pp. 8899–8908, 2012.
- [66] Z. Wang, N. Wang, and H. Liang, “Knowledge Sharing, Intellectual Capital and Firm Performance,” *Management Decision*, vol. 52, no. 2, pp. 230–258, 2014.
- [67] S. S. Alam, Md. Y. Ali, and Mohd. F. Mohd. Jani, “An Empirical Study of Factors Affecting Electronic Commerce Adoption Among Smes in Malaysia,” *Journal of Business Economics and Management*, vol. 12, no. 2, pp. 375–399, 2011.
- [68] P. Chwelos, I. Benbasat, and A. S. Dexter, “Research Report: Empirical Test of an EDI Adoption Model,” *Information Systems Research*, vol. 12, no. 3, pp. 304–321, 2001.
- [69] Y. Zhu, Y. Li, W. Wang, and J. Chen, “What Leads to Post-Implementation Success of ERP? An Empirical Study of the Chinese Retail Industry,” *International Journal of Information Management*, vol. 30, no. 3, pp. 265–276, 2010.
- [70] S. Chakrabarty, D. Whitten, and K. Green, “Understanding Service Quality and Relationship Quality in is Outsourcing: Client Orientation & Promotion, Project Management Effectiveness, and the Task-Technology-Structure Fit,” *Journal of Computer Information Systems*, vol. 48, no. 2, pp. 1–15, 2016.
- [71] A. Gutierrez, E. Boukrami, and R. Lumsden, “Technological, Organisational and Environmental Factors influencing Managers’ Decision to Adopt Cloud Computing in the UK,” *Journal of Enterprise Information Management*, vol. 28, no. 6, pp. 788–807, 2015.
- [72] P.-F. Hsu, S. Ray, and Y.-Y. Li-Hsieh, “Examining Cloud Computing Adoption Intention, Pricing Mechanism, and Deployment Model,” *International Journal of Information Management*, vol. 34, no. 4, pp. 474–488, 2014.
- [73] C. Low, Y. Chen, and M. Wu, “Understanding the Determinants of Cloud Adoption,” *Industrial Management & Data Systems*, vol. 111, no. 7, pp. 1006–1023, 2011.
- [74] T. Oliveira and M. F. Martins, “Literature Review of Information Technology Adoption Models at Firm Level,” *The Electronic Journal Information Systems Evaluation*, vol. 14, no. 1, pp. 110–121, 2011.
- [75] P. Ifinedo, “An Empirical Analysis of Factors Influencing Internet/E-business Technologies Adoption by SMEs in Canada,” *International Journal of Information Technology & Decision Making*, vol. 10, no. 4, pp. 731–766, 2011.
- [76] T. Oliveira and M. F. Martins, “Understanding E-business Adoption Across Industries in European Countries,” *Industrial Management & Data Systems*, vol. 110, no. 9, pp. 1337–1354, 2010.
- [77] T. Oliveira and M. F. Martins, “Firms Patterns of E-business Adoption: Evidence for the European Union-27,” *Electronic Journal of Information Systems Evaluation*, vol. 13, no. 1, pp. 47–56, 2010.
- [78] M. Ghobakhloo, D. Arias-Aranda, and J. Benitez-Amado, “Adoption of e-commerce applications in SMEs,” *Industrial Management & Data Systems*, vol. 111, no. 8, pp. 1238–1269, 2011.
- [79] A. Benlian and T. Hess, “Opportunities and Risks of Software-as-a-Service: Findings from a Survey of IT Executives,” *Decision Support Systems*, vol. 52, no. 1, pp. 232–246, 2011.
- [80] M. S. Featherman and P. A. Pavlou, “Predicting E-services Adoption: A Perceived Risk Facets Perspective,” *International Journal of Human-Computer Studies*, vol. 59, no. 4, pp. 451–474, 2003.

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Appendix A. Measurement instruments

Table A1. Measurement instruments

	Index	Indicator	Scale/ options	Origin
Trialability	TRIA1	I had a great deal of opportunity to try various PaaS services.	5pt Likert	[21], [62]
	TRIA2	Before deciding whether to use PaaS, I was able to properly try it out.		
	TRIA3	I was permitted to use PaaS on a trial basis long enough to see what it could do.		
Tacit knowledge sharing	TKLS1	Employees in my company frequently shared knowledge based on their experience.	7pt Likert	[63]–[66]
	TKLS2	Employees in my company frequently collected knowledge from others based on their experience.		
	TKLS3	Employees in my company frequently shared knowledge of know-where or know-whom with others.		
	TKLS4	Employees in my company frequently collected knowledge of know-where or know-whom with others.		
	TKLS5	Employees in my company frequently shared knowledge based on their expertise.		
	TKLS6	Employees in my company frequently collected knowledge from others based on their expertise.		
	TKLS7	Employees in my company shared lessons learned from past failures when they felt that it was necessary.		
Top management support	TMGS1	The company's top management supported the implementation of PaaS.	5pt Likert	[24], [67]–[69]
	TMGS2	The company's top management provided strong leadership and engaged in the process when it comes to information systems.		
	TMGS3	The company's top management was willing to take risks (financial and organizational) involved in the adoption of PaaS.		
Voluntariness	VLTN1	My superiors expected me to decide to use PaaS.	7pt Likert	[62]
	VLTN2	My decision whether to use PaaS was voluntary.		
	VLTN3	My boss did not require me to decide in favor for PaaS.		
	VLTN4	Although it might be helpful, deciding to use PaaS was certainly not mandatory.		
Vendor trust	VNDT1	In our relationship, the PaaS service provider made decisions beneficial to us.	7pt Likert	[70]
	VNDT2	In our relationship, the PaaS service provider was willing to provide assistance to us.		
	VNDT3	In our relationship the PaaS service provider was honest.		
Trading partner pressure	TPPR1	Adoption of PaaS required support from our business partners.	5pt Likert	TPPR1,3,4: [71]–[74] TPPR2: own
	TPPR2	Adoption of PaaS was demanded by our business partners.		
	TPPR3	Adoption of PaaS was influenced by the marketing activities of our business partners.		

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

	Index	Indicator	Scale/ options	Origin
	TPPR4	Adoption of PaaS was influenced by our business partners' level of support.		
Competitive pressure	CMPR1	Top management thought that PaaS has an influence on competition in their industry.	7pt Likert	[24], [75]–[77]
	CMPR2	Our company was under pressure from competitors to adopt PaaS.		
	CMPR3	Some of our competitors already started using PaaS.		
Perceived benefits	PBEN1	PaaS allows to manage operations in an efficient way.	5pt Likert	[24], [62], [75], [78]
	PBEN2	The use of PaaS improves the quality of operations.		
	PBEN3	Using PaaS allows to perform specific tasks more quickly.		
	PBEN4	The use of PaaS offers new opportunities.		
	PBEN5	Using PaaS allows to increase business productivity.		
Perceived risks	PCRK1	Adopting PaaS is associated with a high level of risk.	5pt Likert	[79], [80]
	PCRK2	There is a high level of risk that the expected benefits of adopting PaaS will not come true.		
	PCRK3	Overall, I consider the adoption of PaaS to be risky.		
PaaS post-adoption	PPAD	Did the company decide in favor of PaaS in this decision?	Yes=1, No=0	Own
Security and privacy	SCNP1	The security systems built into PaaS are strong enough to secure our data.	5pt Likert	[16], [24]
	SCNP2	The confidentiality of business data is guaranteed when using PaaS.		
	SCNP3	I am confident that the PaaS provider will not use my company's data for their own commercial benefits.		
Cost savings	COST	Using PaaS reduces costs (e.g., customer service, procurement, human resources, IT training, investment and administration management).	5pt Likert	[21], [62]
IT organization size	SIZE	How many employees work in IT-roles in your company?	6pt scale (below 500 to above 10,000)	Own
IT organization structure	STRT	How would you describe the structure of the IT-organization in your company?	5pt Likert	Own
Form of post-adoptive use		What was the context of the decision on whether to use PaaS?	Migration, Enhancement, New development	Own

We have a platform, but nobody builds on it – what influences Platform-as-a-Service post-adoption?

Biographical notes



Frederik Wulf

is a PhD graduate at the Chair of Business Informatics, especially IS in Trade and Industry at the TU Dresden. His professional background comprises multiple years of experience in management consulting focusing on digitalization and cyber security. Before that, he obtained diplomas in Financial Management and Business Administration and Economics at the Universities of Hohenheim and Liège. His current research interests are cloud computing adoption and cloud security, with a focus on large-scale organizations. Specifically, his research focuses on the post-adoptive use of cloud computing in such large-scale organizations.



Markus Westner

is a professor for Business Informatics at OTH Regensburg, a Technical University for Applied Sciences. Before joining OTH, he worked as a management consultant for Bain & Company. He graduated from Unitec Institute of Technology and the European Business School where he also earned his PhD. He has published in Information & Management, Journal of Information Technology Theory and Applications, Information Systems Management, Journal of Systems and Information Technology, and others. His research interests focus on IS management and IS sourcing.



Susanne Strahringer

is a professor for Business Informatics, esp. IS in Trade and Industry at TU Dresden, Germany. Before joining TU Dresden, she held positions at the University of Augsburg and the European Business School. She graduated from the Darmstadt University of Technology where she also obtained her Ph.D. and completed her habilitation thesis. She has published in Information & Management, Journal of Information Technology Theory and Application, Information Systems Management, and Information Systems and e-Business Management, among others. Her research interests focus on IS management, ERP systems, and enterprise modeling.



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijspm.sciencesphere.org

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

Seclen-Luna Jean Pierre

Department of Management, Pontifical Catholic University of Peru
Universitaria Avenue 1801, San Miguel, Lima Peru
jseclen@pucp.pe

René I. Castro Vergara

Innovation Management Research Group, Pontifical Catholic University of Peru
Universitaria Avenue 1801, San Miguel, Lima Peru
r.castrov@pucp.edu.pe

Lopez Valladares Hellen

Department of Management, Pontifical Catholic University of Peru
Universitaria Avenue 1801, San Miguel, Lima Peru
hellen.lopez@pucp.edu.pe



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.sciencesphere.org

J. P. Seclen-Luna, R. I. C. Vergara, H. L. Valladares, “Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?”, *International Journal of Information Systems and Project Management*, vol. 10, no. 1, pp. 73-91, 2022.



Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

Seclen-Luna Jean Pierre

Department of Management, Pontifical Catholic University of Peru
Universitaria Avenue 1801, San Miguel, Lima Peru
jseclen@pucp.pe

René I. Castro Vergara

Innovation Management Research Group, Pontifical Catholic University of Peru
Universitaria Avenue 1801, San Miguel, Lima Peru
r.castrov@pucp.edu.pe

Lopez Valladares Hellen

Department of Management, Pontifical Catholic University of Peru
Universitaria Avenue 1801, San Miguel, Lima Peru
hellen.lopez@pucp.edu.pe

Abstract:

This paper aims to analyse the effects of the use of digital technologies on firms' net sales and productivity. The technology adoption approach is applied in empirical research using data from the National Enterprise Survey in Peru. Using the OLS method on a sample of 2,970 firms from creative and manufacturing industries in Peru, the effects of digital technologies on net sales and productivity are determined. Findings indicate that there is a positive relationship. However, these relationships can be different depending on the type of digital technology, the size of the firm and the manager's gender proportion. We found that most of these technologies are more commonly related to creative industries than manufacturing firms. These relationships have greater statistical significance to net sales in large companies within both types of industry. However, SMEs have greater statistical significance with respect to productivity in both types of industries. Lastly, given the positive effect on these relationships, we conclude by highlighting the importance of managers crafting their technology portfolio and digital capabilities properly and the need for further research to determine the performance of companies in the context of developing countries.

Keywords:

information technology; performance; productivity; manufacturing industries; creative industries; developing country.

DOI: 10.12821/ijispm100104

Manuscript received: 25 April 2021

Manuscript accepted: 13 February 2022

1. Introduction

In the era of digitalization, companies review how to build competitive advantage by drawing on their capabilities and using technology. It is recognized that Information and Communication Technologies (ICT), and especially digital technologies (DT) are fundamentally transforming business strategies, business processes, firm capabilities, products and services, and are even key interfirm relationships in extended business networks. In this context, a “digital business strategy” is required [1]. In fact, empirical evidence has highlighted the positive role of DT in increasing the productivity [2] and sales [3] of companies.

The technology adoption approach aims to understand which specific DT is used by firms or industrial sectors and what the effects are. Most of this stream of research has been addressed in developed economies, characterized by favourable environments for competitiveness. Thus, studies on this topic are almost exclusively based on studies from North American and European firms [4]. However, since the beginning of the past decade, there has been a growing interest in literature dealing with DT in Latin American countries on an aggregate level [5,6]. Despite this, the empirical literature still needs further developments to understand how DT affects the performance of firms in emerging economies.

Based on these arguments, this research poses a central research question: Do digital technologies have a positive effect on a firm’s performance? Thus, to address this issue, our article aims to empirically evaluate the effect of the use of DT on the net sales and productivity of 2,970 Peruvian firms through a sample of 979 firms from the creative industries and 1,991 manufacturing firms, using data from the National Enterprises Survey in Peru [7].

From a contextual perspective, in 2015, while the GDP of Latin America and the Caribbean presented a fall of 1% (reaching 0.3%) compared to 2014, the GDP of Peru experienced a growth of 0.9%, reaching 3.3%. At an industrial level, while manufacturing experienced a percentage variation in GDP of -1.5%, services showed a growth of 4.1% [8]. Within services, the creative industries have acquired special relevance since they have been able to articulate various sectors. One of the main promoters has been the Ministry of Culture of Peru. In this way, the creative industries have been positioned in the Peruvian scene [9]. Therefore, the current context of acceleration of the digital transformation of companies offers an opportunity to explore with greater attention which sectors have comparatively greater vocation for the adoption of DT, which can lead to an organization’s better performance. Nevertheless, the Economic Commission for Latin America and the Caribbean reported that in Peru the cost of technologies is higher compared to other countries in the region, and about 55% of population have access to social media [10]. In addition, according to the Digital Adoption Index, in 2014, Peruvian businesses were ranked 80th out of 183 countries [11]. So, our contribution aims to understand this phenomenon from the point of view of DT use.

Our research uses OLS regressions in the analysis and considers two subsamples according to the industries compared. The results show that there is a positive relationship between digital technologies and net sales and productivity in the Peruvian firms. However, these relationships can be different depending on the type of digital technologies, firm size, manager’s gender and the industry. Thus, we find that most of these technologies are more commonly related to creative industries than manufacturing firms. Specifically, these relationships have the greatest statistical significance in SMEs rather than in large companies, in relation to productivity. By contrast, large companies have the greatest statistical significance with net sales. In addition, manager gender shows positive statistical significance in these relationships for creative industries, while for manufacturing firms there are negative statistical significance. Therefore, our study contributes to the understanding of these relationships in the context of Peruvian creatives and manufacturing firms.

The paper is structured as follows: The second section introduces the literature review and leads to the research hypotheses. The third section details the datasets and tests the hypotheses. The empirical results are discussed in the fourth section. Lastly, the fifth section provides some brief conclusions, limitations, and suggestions for future research.

2. Literature Review and Hypotheses

Many researchers have considered that in adoption and diffusion theory, there are several factors that influence a person choosing a technology. Previous studies have highlighted the difference between the technologies adopted by consumers and that of firms [12]. However, technology adoption models change quickly because of the complex nature of modern information technology, so scholars have acknowledged that resources and new capabilities are necessary to effectively compete in a digital age [13]. Thus, there is a significant body of literature which studies models and determinants of technology adoption. In any case, differences in technology adoption result in divergences of productivity and economic growth [14].

2.1 ICT, Digital Technologies and Firm's Performance.

The strategic management literature recognized that firm performance is the result of multiple factors. For example, ICT adoption has drastically modified communication, sales, and information methods [15], thus enabling firms to achieve strong competitive advantage in production and in other areas of the company. Nowadays, the debate is focused on variables relating to ICT usage and ways of increasing the positive impact of ICT on firm performance. In fact, the degree of ICT adoption varies substantially between countries and even within sectors [16]. The impact of ICT in developing countries is an important issue due to its growth potential. The ICTs convert the systems of organizations and control the productive processes, and even allows for the production of merchandise to be adjusted to the needs of local, regional, and global clients. Therefore, ICTs are allowing the reorganization of the company and the realization of important changes in all functional areas of the company [17]. According to Breard and Yoguel [18], although companies do not follow a trajectory in the incorporation of ICTs, like the evolution of these technologies, companies usually adopt those most consistent with their objectives and strategies.

The impact of ICTs on the performance of companies has been extensively studied using a wide variety of indicators and methodological approaches. Pioneering studies have considered certain indicators, such as investments in hardware, software, and the number of PCs [19]. However, most studies have been concerned with knowing the factors or barriers that affect the adoption of ICT [20], emphasizing the role of the firm's size, age, the skills of the employees, the level of technology used, and productivity [21]. In any case, the literature recognized that one of the most used indicators to measure firm's performance has been the productivity [22]. This perspective suggests that productivity could increase due to the multiple technological configurations that companies adopt [16].

On the other hand, digitization has been increasingly recognized as a complex phenomenon encompassing a variety of different business strategies, ranging from purchasing new software or information technologies (IT) products to redesigning existing processes (e.g., interconnections among products, process and services), and promoting organizational changes [23]. In addition, it is important to note that there is no consensus on the concept of DT, in the literature it is recognized that the adoption of DT is used to carry out e-marketing, e-commerce, and e-business to increase the sales of a company [24]. However, other factors are likely to mediate the effects of DTs on firm's performance, as digital transformation not only involves investing in DTs, but also integrating them into the organizational structure of the company [25]. Recent empirical evidence has highlighted the positive role of DT in increasing the productivity of companies [2,16,25].

According to the previous background literature and given the large number of DT that exist today, we find it convenient to analyse the most representative technologies that positively affect a firm's net sales and productivity, such as broadband and intranet, digital training, digital consulting, websites, online selling, social networking, extranet, and enterprise information systems [3,26,27,28].

2.1.1 *Broadband and Intranet*

While on a macrolevel the literature supports the notion that broadband positively affects GDP growth and employment [29,30], there is no agreement of the effects on productivity at a firm level. For instance, Bertschek et al. [31] found no effect of broadband adoption on labour productivity, but positive effects on product and process innovation. In the same vein, Haller and Lyons [26] found no statistically significant effect of broadband adoption on firm productivity. Nevertheless, Grimes et al. [32] stated that broadband adoption boosts a firm's productivity by 7–10 percent. On the other hand, Intranet, as a standard internet technology, is a personalized interface where users can access information resources and services in a secure, consistent, and customizable manner. Several authors state that intranet facilitates knowledge sharing because it promotes cooperation among employees who are in various locations, making that information flow and improving overall business performance [33]. Moreover, intranet adoption enhances work productivity since it enables individual commitment, empowerment, and a personal sense of accomplishment. It enables a sense of empowerment because more work can be done whilst multitasking; one login can give access to all organizational data with a 24/7 availability of information [33]. Based on this evidence, we propose the following hypotheses:

Hypothesis 1a: There is a positive relationship between a firm's net sales and the use of broadband.

Hypothesis 1b: There is a positive relationship between a firm's labour productivity and the use of broadband.

Hypothesis 2a: There is a positive relationship between a firm's net sales and the use of intranet.

Hypothesis 2b: There is a positive relationship between a firm's labour productivity and the use of intranet.

2.1.2 *Digital Training and Consulting*

ICT applications need not only the implementation of technology infrastructure but the use of technical skills. To improve information system integrated results, user involvement and user training are key to ensuring better outcomes. By including and stimulating employees in the process of co-creation and the adoption of new technology, the organization can stimulate innovations both horizontally and vertically. The digital skills that contribute to ICT productivity, i.e., digital information evaluation, critical thinking, creativity and problem-solving, are considered 21st-century digital skills [34]. Gillard [35] suggests that training courses and initiatives should accommodate the more wide-ranging needs of those targeted for inclusion, especially older workers and women who are sometimes left out in organizations, which creates digital inequality. On the other hand, IT consulting firms play a new and major role in supporting the adoption of technologies because they switch from just giving advice to participating in the implementation of ideas and the technology of firms [36]. These authors noted that digital consulting also implies being a developer of hardware and software related to meeting the business objectives of organizations. Through projects in companies, IT consulting firms can increase productivity through the transfer of knowledge from one part of the business to another. This makes the learning process quicker and easier, mainly because it reduces the training time and can lead to the development of innovations [37]. IT consultants also facilitate communication between firms and clients because they give assistance in solving problems related to services and products [38]. As Liao and Cheung [39] claim, IT consulting increases client efficiency by using integrated information-based solutions in business process development, customization, and enhancement, therefore maximizing the client's resources. Based on this evidence, we propose the following hypotheses:

Hypothesis 3a: There is a positive relationship between a firm's net sales and investment in digital training.

Hypothesis 3b: There is a positive relationship between a firm's labour productivity and investment in digital training.

Hypothesis 4a: There is a positive relationship between a firm's net sales and hiring a digital consultant.

Hypothesis 4b: There is a positive relationship between a firm's labour productivity and hiring a digital consultant.

2.1.3 Website, Online Selling and Social Networks

The empirical literature has paid great attention to DTs related to e-commerce and e-marketing applications, such as websites [40], online selling [41], and social networks [42]. The overall aim of these studies is to investigate how and to what extent DTs directly contribute to increasing sales. Websites are perhaps one of the first ICT adoptions by firms around the world since this technology enables the inclusion of information which is easy to understand and useful to clients [43]. Moreover, the website is a medium for interactive communication, not only between clients, as a tool for customer relationship management and sales, but also from business-to-business and with other stakeholders [44]. Thus, a website aims to raise visibility and attract new customers [3]. According to these authors, workers can upload information easily, gather information without moving, and target multiple segments with the design selected. However, Teo and Pian [45] have found that cost saving is not the main benefit of a website, but rather differentiation and growth. In addition, Nurmilaakso [46] found that websites do not result in a significant influence on labour productivity, since a fancy website alone does not ensure business performance, however, this is more the case in B2B e-commerce. In this line, Tarafdar and Zhang [43] pointed out that to attract and retain traffic that allows more business transactions, characteristics such as usability, ease-of-navigation and security are significant. In any case, website design and development software should be available to IT employees and programmers to get better rates of productivity [47]. According to this evidence, we propose the following hypotheses:

Hypothesis 5a: There is a positive relationship between a firm's net sales and the use of website.

Hypothesis 5b: There is a positive relationship between a firm's labour productivity and the use of website.

Online selling refers to transactions along the value chain but using the internet platform together with the existing IT infrastructure. Several studies argue that e-businesses are efficient reducers of distance-related trade costs because firms can reach and expand to the global economy, being able to sell in places where distance or political systems made them previously unreachable [48]. For these reasons, its capacity to reduce trade barriers can lead to big cost savings. Along with cost reduction, earlier studies found benefits such as sales increases and new market penetration [49]. Xia and Zhang [28] discovered that the online channels have more repercussions on sales volumes over the long-term. To adopt online selling there is a process where organizations adapt their routines and even uses internal and external collaboration [50]. The author claims that business can present technical, economic, and legal barriers, preventing them from creating value added e-commerce operations. The use of e-commerce also shows a positive effect on the labour productivity of firms at a national level [51]; the highest growth happens in developing countries because they start from a much lower economic base. At the organizational level Nurmilaakso [46:10] found that "the importance of the ICT-integrated business processes, within and between firms, is evident in e-commerce" and it has positive effects on labour productivity. Thus, we propose the following hypotheses:

Hypothesis 6a: There is a positive relationship between a firm's net sales and the use of online selling.

Hypothesis 6b: There is a positive relationship between a firm's labour productivity and the use of online selling.

Social networks are a group of internet-based applications, mainly using foundations of web 2.0 for the creation and exchange of user generated content [52]. The most used social networks by firms are Facebook, Instagram, Twitter, and LinkedIn. Although there are exponential applications and adjustments organizations have made, there are different understandings about the outcomes and impact of social networks on business performance [27]. Some studies show that social networks positively affect the performance of the new product in the marketplace, because speed-time-to-market of these new products [53] allows sharing knowledge from outside and inside in real-time and reduces barriers between clients and intermediate costs. Other researches states that information from social networks is inaccurate and distorted because sources are unreliable and that, although it helps innovation, it did not translate into financial benefits [54]. Kurnia and Er [55] explain that successful social media usage depends on the interest and condition of the company planning to implement usable platforms. Despite these differences, there is some agreement about the effects on the organization. To begin with, social networks enable better engagement between employees and designers with clients because they receive information about preferences, allowing for demand forecasting and follow-up purchasing

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

activities. As a result, the areas of marketing, sales and customer management reduce their costs and cut down on physical transportation [56]. Thus, the information from external actors can be used with big data and analytics to improve the current products. In addition, the labour productivity generated is explained by the quality of knowledge acquired from social networks [57], that is, more creativity emerges in the workplace. According to this evidence, we propose the following hypotheses:

Hypothesis 7a: There is a positive relationship between a firm's net sales and the use of social networks.

Hypothesis 7b: There is a positive relationship between a firm's labour productivity and the use of social networks.

2.1.4 Extranet and Enterprise Information Systems

To date, little evidence has been collected for e-business and DTs, such as Extranet, ERP, CRM, and other basic information-sharing services [58]. While intranet is created for internal use, extranets connect to other actors outside the company. Vlosky et al. [59] explain that an extranet is a network that links business partners to another over the internet. Suppliers, customers, or other trading partners are linked to exchange various types of information. A study by Paswan et al. [60] suggests that the standardized data exchange with trading partners has a positive influence on labour productivity because firms integrate their business processes, especially in B2B and e-commerce. With suppliers, for instance, extranet gives the ability to place and secure orders in a transparent system where inventory levels and forecasts are transparent and accessible, creating online partnerships. With customers, extranet increases loyalty, commitment, and confidence [61], which in the long-term gives competitive advantage. Based on this evidence, we propose the following hypotheses:

Hypothesis 8a: There is a positive relationship between a firm's net sales and the use of extranet.

Hypothesis 8b: There is a positive relationship between a firm's labour productivity and the use of extranet.

Enterprise Information Systems (EIS) is essential for companies. For instance, enterprise resource planning (ERP) and customer relationship management (CRM), two of the most widely implemented business software platforms, allows this integration. Both support core corporate activities by incorporating best practices and information to facilitate rapid decision-making, cost reduction and greater material control [62]. A tangible benefit of these systems includes results in business process, mainly by increasing productivity. Karimi et al. [58] found that successful ERP implementation helps business efficiency, effectiveness, and flexibility because it reduces cost and cycle time, improves decision making and planning, and enables external linkages to customers and suppliers. The operational efficiency of an individual worker is related to the amount of time it takes to do a job. With ERP they can access data simultaneously, using less time to do a job. However, a successful ERP implementation requires sufficient and appropriate training, reliable internet connection, involvement of end-users, change management, as well as sufficient demonstration of the prospective ERP system [63]. CRM is more related to the evidence that confirms an increase in market shares and sale growth rates because the systems lead to a quick reaction to market opportunities [64] and enables the creation of opportunities and managing relationships. Based on this evidence, we propose the following hypotheses:

Hypothesis 9a: There is a positive relationship between a firm's net sales and the use of enterprise information systems.

Hypothesis 9b: There is a positive relationship between a firm's labour productivity and the use of enterprise information systems.

2.2 Other Characteristics of the Firm

In general terms, other characteristics of the firm, such as age, size, industry, and even gender of the managers, are useful in understanding the relationships between ICT adoptions and a firm's net sales and productivity. For instance, if we consider the age of the company as a proxy for experience, it could be argued that old companies are more likely to adopt ICTs than younger companies. In fact, formalization in the context of ICT is considered a technological strategy

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

within the company, which includes organizational planning and preparation [65]. This means determining how, why, and what improvements and benefits those technologies will bring to the company and then analysing needs and objectives in computing and conceiving a strategy for the long-term. It is a very essential factor in leading to the success and rapid spread of ICT adoption [66]. However, there is no consensus in these respects [3]. Accordingly, we present the following hypotheses:

Hypothesis 10a: The age of the firm has a positive relationship with the firm's net sales.

Hypothesis 10b: The age of the firm has a positive relationship with the firm's labour productivity.

In relative terms, the larger sized company has similar positive relationships due to it being related to the capabilities and resources available for ICT adoptions. In this regard, size is a fundamental factor directly influencing ICT; for example, SMEs are mostly dependent on external interactions for ICT adoption because of their critical size [67]. Previous research has emphasized that business size is the most important discriminant for the adoption or non-adoption of ICT [68]. In any case, literature has not reached a consensus about this relationship [3]. However, there is stronger evidence for a positive relationship between firm size, ICT adoption and firm performance. Accordingly, we present the following hypotheses:

Hypothesis 11a: The size of the firm has a positive relationship with the firm's net sales.

Hypothesis 11b: the size of the firm has a positive relationship with the firm's labour productivity.

Gender diversity literature acknowledges that firms with greater gender diversity in top management teams show lower risk and deliver better performance [69]. Specifically, the proportion of women in top management tends to have positive effects on a firms' performance [70]. Furthermore, recent empirical research on digital transformation has shown the role of top management and their experience and skills in promoting and executing digital transformation [71]. Thus, the level of technological awareness at decision-making levels also affects the incorporation of ICTs [72]. In any case, it was decided to incorporate this variable since, at the regional level, creative and cultural industries are one of the sectors with the highest numbers of working women. Accordingly, we present the following hypotheses:

Hypothesis 12a: Higher proportion of female manager's has a positive relationship with a firm's net sales.

Hypothesis 12b: Higher proportion of female manager's has a positive relationship with a firm's labour productivity.

Finally, several studies in different countries have considered that business type and sector of activity are among the factors influencing ICT adoption and performance. For many years, business type has also played a large part in deciding the structure and architecture of ICT, that is, barriers influencing ICT adoption in production companies are different from those of service companies. In this respect, Thong and Yap [73] have noted that the sectors with the greatest intensity of information activities tend to adopt ICT more than those which are less intense. Therefore, the particularities related to the sector or branch of activity can affect both the process of incorporating ICTs and the firm's performance [18]. Accordingly, we present the following hypotheses:

Hypothesis 13a: Creative firms have a greater positive effect on the relationship between the use of digital technologies and net sales than manufacturing firms.

Hypothesis 13b: Creative firms have a greater positive effect on the relationship between the use of digital technologies and labour productivity than manufacturing firms.

Figure 1 presents the hypotheses formulated in a research model.

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

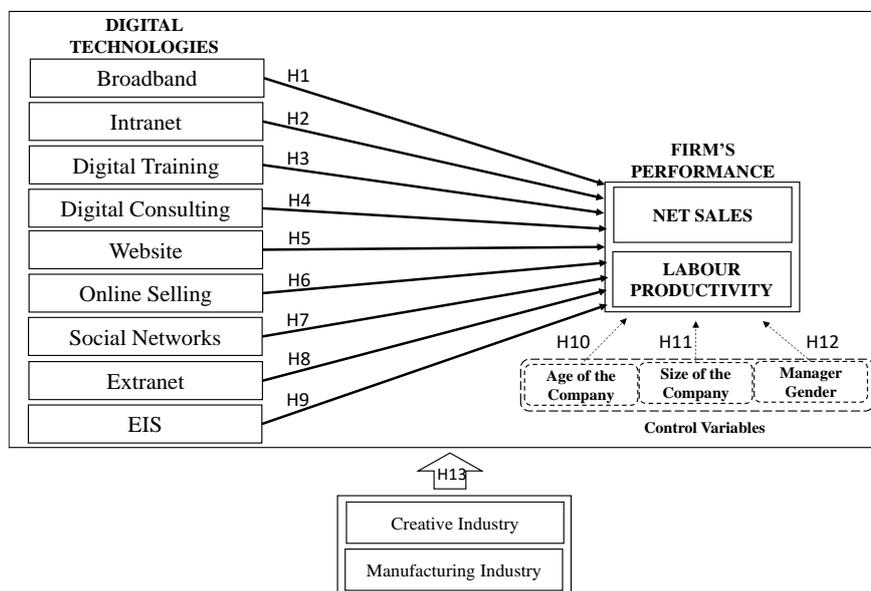


Fig. 1. Research model

3. Data Collection and Methodology

3.1 Data Description

The data is obtained from the National Enterprises Survey in Peru (ENE, by its acronym in Spanish) in 2015. For its part, the ENE data is collected by the Institute of Statistics and Informatics of Peru every three years. The survey consists of an exhaustive questionnaire oriented to obtain information on the business environment of the firms through direct face-to-face surveys with firm managers and owners who participate in the company's decision-making. The population of the survey is made up of large, medium, and small Peruvian companies totalling 13,592 companies from all industries except for the education and health industries. The ENE uses stratified random sampling by location, size, industry, and other country-specific information. In accordance with our research objectives (to know whether there is a relationship between the use of digital technologies and the firms' net sales and productivity), the final sample used consists of 979 firms from the creative industry and 1,991 manufacturing firms.

Table 1. Sample composition

Characteristics of the firm	Creative Industries		Manufacturing	
	#	%	#	%
<i>Firm size by worker number¹</i>				
Micro	433	44.24	426	21.41
Small	372	38.00	669	33.6
Medium	110	11.22	687	34.47
Large	64	6.54	209	10.52
Total	979	100.00	1991	100.00

Note: 1/ Include managers and employees (permanents and temporary)

Source: Own elaboration from ENE (2015).

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

3.2 Description of Variables

There are two dependent variables: net sales and labour productivity. The first is calculated as the total net sales of products and services of the companies, and the second is calculated as the ratio of net sales per worker considering only the permanent staff of the company. This measure aims to proxy firm efficiency in using production inputs, thereby providing a basis to compare performance across firms [74]. The independent variables are nine types of DT that approximate the degree of digitization achieved by the company in the back office (intranet, digital training, and digital consulting), in the front office (websites, online selling and social networks), as well as for both types (broadband, extranet and enterprise information systems). To control heterogeneity across the sample, we include age, size, and gender. Table 2 provides a definition of the variables used in the study, whilst Tables 3 and 4 present the summary statistics of those variables and the results of the differences in means tests for creative and manufacturing firms.

Table 2. Definition of variables

Variable	Definition	Scales
Net Sales	Net sales of products/services	Logarithm
Labour Productivity	Net sales per total workers (only managers and permanent)	Logarithm
Broadband	A value of 1 indicates that the firm reported that they have internet with broadband; 0 otherwise	Dichotomous
Intranet	A value of 1 indicates that the firm reported that they have intranet; 0 otherwise	Dichotomous
Digital Training	A value of 1 indicates that the firm reported that they invest in digital training for their workers or owners; 0 otherwise	Dichotomous
Digital Consulting	A value of 1 indicates that the firm reported that they invest in digital consulting; 0 otherwise	Dichotomous
Website	A value of 1 indicates that the firm reported that they have a website; 0 otherwise	Dichotomous
Online Selling	A value of 1 indicates that the firm reported that they sell products or services online; 0 otherwise	Dichotomous
Social Networks	A value of 1 indicates that the firm reported that they have a social network account on Facebook or Twitter; 0 otherwise	Dichotomous
Extranet	A value of 1 indicates that the firm reported that they have extranet; 0 otherwise	Dichotomous
Enterprise Information Systems	A value of 1 indicates that the firm reported that they have enterprise information systems; 0 otherwise	Dichotomous
Firm's Age	Time from foundation of the firm, except firms with three or less years	Logarithm
Firm's Size	Number of total workers (only managers and permanent workers)	Logarithm
Manager's Gender	Percentage of executive women	Logarithm

Table 3. Summary statistics

Variables	(1) Manufacturing Industry		(2) Creative Industry		(3) Difference in Means		
	Mean	SD	Mean	SD	Diff.	t-test	p-value
Broadband	0.914	0.28	0.87	0.337	0.044	1.858	*
Intranet	0.362	0.481	0.375	0.485	-0.012	-0.309	
Digital Training	0.302	0.459	0.41	0.493	-0.107	-2.846	***
Digital Consulting	0.274	0.446	0.23	0.421	0.044	1.236	
Website	0.721	0.448	0.745	0.436	-0.023	-0.659	
Online Selling	0.247	0.431	0.365	0.482	-0.117	-3.259	***
Social Networks	0.389	0.487	0.615	0.487	-0.225	-5.709	***
Extranet	0.129	0.335	0.115	0.319	0.014	0.531	
Enterprise Information Systems	0.9	0.299	0.84	0.367	0.06	2.348	**

Note: The CIU 3211 is excluded because it is common in both industries. P-value significant at 99%***, 95%**, and 90%* SD: standard deviation.

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

Table 4. Summary statistics in Levels

Variables	(1) Manufacturing Industry		(2) Creative Industry		(3) Difference in Means		
	Mean	SD	Mean	SD	Diff.	t-test	p-value
Net Sales	1.46e+08	7.93e+08	3.26e+07	7.25e+07	1.13e+08	2.008	**
Labour Productivity	881258.4	5354798	466528	1847175	414730.4	1.0752	**
Firm's Size	242.915	520.642	95.005	196.655	147.910	3.929	***
Firm's Age	23.023	17.574	17.675	15.397	5.348	3.866	***
Manager's Gender	.438	.260	.507	.290	-.068	-3.148	***

Note: The CIU 3211 is excluded because it is common in both industries. P-value significant at 99%***, 95%**, and 90%* SD: standard deviation.

3.3 Method and Regression Model

In accordance with our research objectives, we estimate the effects of DT adoption on two firm performance proxies through the OLS method. Thus, the models took the following form in the case of firm productivity:

$$\text{Productivity}_i = \beta_0 + \beta_1 * \text{DT}_i + \beta_2 * \theta_i + \varepsilon_i \quad (1)$$

where the sub-index i refers to the firm. DT is a vector that grouped the nine proxy variables of digital technologies that were presented in Figure 1 (broadband, intranet, digital training, digital consulting, website, online selling, social networks, extranet, enterprise information systems). θ is a vector of control variables, such as firm age, size, and gender. ε is the error term. To support the hypotheses, β_1 and β_2 need to be positive. An alternative model is estimated considering the net sales of the company as a dependent variable.

4. Result and Discussion

The results indicate that some DTs are important determinants for the net sales and performance of the companies. Table 5 shows the results of the models estimated through the OLS method, both for creative and manufacturing industries. In columns 1 and 2 the effects of the use of DTs are estimated with respect to the net sales of the companies, and columns 3 and 4 with respect to labour productivity. First, if we analyse column 1, we can see that the use of almost all DTs analysed (broadband, intranet, digital consulting, websites, extranet, and enterprise information systems) has a positive relationship on the net sales of companies in the creative industry. Therefore, these results support hypotheses 1a, 2a, 4a, 5a, 8a, 9a, respectively and are consistent with previous studies [3,33,39,61,64]. However, we found that digital training, online selling, and social networks have negative relationships. One possible explanation could be not only the low adoption of these technologies (41% and 37%), but probably also scarce digital capabilities [34] and companies do not effectively manage their social networks, as evidenced in previous studies [54]. Furthermore, it is important to note that the firm's age, size, and manager's gender also have a positive relationship. Therefore, these results support hypotheses 10a, 11a and 12a, respectively. Thus, these results suggests that large firm in the creative industry with experience in the market and with some proportion of female managers position can affect positively on their net sales, in addition to the use of DT. In this way, our results are consistent with previous studies [65,68,70,71].

Second, if we look at column 2, we can see that the use of almost all DTs analysed (broadband, digital consulting, websites, extranet, and enterprise information systems) has a positive relationship on the net sales of manufacturing companies. Therefore, these results support hypotheses 1a, 4a, 5a, 8a, 9a, respectively and are consistent with previous studies [3,39,61,64]. However, we found that online selling and social networks have negative relationships. One possible explanation could be not only the low adoption of these technologies (25% and 39%), but probably also scarce digital capabilities [34] and companies that do not effectively manage their social networks, as evidenced in previous

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

studies [54]. This argument can also be used in the case of the use of intranet and digital training (36% and 30%), since they do not present statistical significance. Furthermore, it is important to note that both age and size of the firms also have positive relationships. Thus, these results support hypotheses 10a and 11a, respectively. Therefore, these results suggest that large manufacturing firms with experience in the market can affect positively their net sales, in addition to the use of DT. However, the low proportion of female manager position has a negative relationship. In this way, these results concur with previous studies [65,68,70,71]. At this point, it is important to mention that the RMSE in both models (1 and 2) according to net sales shows satisfactory significance (0.998 and 1.157) and the R square (0.68 and 0.72) is considerably strong [75], respectively.

Table 5. Regression Models

Variables	Net Sales		Labour Productivity	
	Creatives Industries (1)	Manufacturing (2)	Creatives Industries (3)	Manufacturing (4)
Broadband	0.30*** (0.10)	1.16*** (0.09)	0.30*** (0.10)	1.16*** (0.09)
Intranet	0.51*** (0.09)	0.10 (0.07)	0.51*** (0.09)	0.10 (0.07)
Digital Training	-0.22** (0.09)	-0.10 (0.07)	-0.22** (0.09)	-0.10 (0.07)
Digital Consulting	0.34*** (0.10)	0.24*** (0.07)	0.34*** (0.10)	0.24*** (0.07)
Website	0.28*** (0.11)	0.24*** (0.06)	0.28*** (0.11)	0.24*** (0.06)
Online Selling	-0.19** (0.09)	-0.24*** (0.06)	-0.19** (0.09)	-0.24*** (0.06)
Social Networks	-0.48*** (0.08)	-0.29*** (0.06)	-0.48*** (0.08)	-0.29*** (0.06)
Extranet	0.99*** (0.17)	1.11*** (0.13)	0.99*** (0.17)	1.11*** (0.13)
Enterprise Information Systems	0.35*** (0.10)	0.37*** (0.08)	0.35*** (0.10)	0.37*** (0.08)
Firm's Age	0.32*** (0.06)	0.55*** (0.04)	0.32*** (0.06)	0.55*** (0.04)
Firm's Size	0.94*** (0.03)	0.74*** (0.03)	-0.06* (0.03)	-0.26*** (0.03)
Manager's Gender	0.29*** (0.07)	-0.51*** (0.06)	0.29*** (0.07)	-0.51*** (0.06)
Constant	10.55*** (0.17)	9.31*** (0.13)	10.55*** (0.17)	9.31*** (0.13)
N	979	1,991	979	1,991
R-squared	0.68	0.72	0.27	0.27
Adj. R-squared	0.679	0.719	0.265	0.268
Root MSE	0.998	1.157	0.998	1.157
Wald chi2	173.5	425	30.39	61.65

Note: Coefficients estimated to be significant at 99%***, 95%**, and 90%*, SD in parentheses.

Third, if we focus on column 3, we can see that the use of almost all DTs analysed (broadband, intranet, digital consulting, website, extranet, and enterprise information systems), have a positive relationship with the labour productivity of companies in the creative industries. Therefore, these results support hypotheses 1b, 2b, 4b, 5b, 8b, 9b, respectively and are consistent with previous studies [32,33,36,47,58,60,62]. However, we found that certain DTs have negative relationships, such as digital training, online selling, and social networks. Perhaps one reason could be the low adoption of these technologies (41% and 37%), or maybe scarce digital capabilities [34] or training courses should accommodate the more wide-ranging needs of those targeted for inclusion, especially older workers and women who are sometimes left out in organizations, which creates digital inequality [35], and companies who do not effectively manage their social networks, as evidenced in previous studies where it was found that this technologies did not

translate into financial benefits [54]. Furthermore, it is important to note that both firm age and manager's gender also have a positive relationship. Thus, these results support hypotheses 10b and 12b, respectively. However, firm's size has a negative relationship. So, it seems that creative SMEs with at least one woman as managers can affect positively on their productivity, in addition to the use of DTs. Thus, our results are consistent with previous studies [3,66, 70,71,72].

Fourth, if we focus on column 4, we can see that the use of almost all DTs (broadband, digital consulting, websites, extranet, and enterprise information systems) have a positive relationship with the labour productivity of manufacturing companies. Therefore, these results support hypotheses 1b, 4b, 5b, 8b and 9b, respectively and are in line with previous studies [32,36,47,58,60,62]. However, we found that certain DTs have a negative relationship, such as online selling and social networks. Regarding online selling, probably there are still several technical and non-technical limitations that prevent organizations getting all the benefits [50]. In this study, only 25% of the companies use this sales channel. In addition, like in recent studies, manufacturing companies show that social networks mainly effect creativity, job satisfaction and motivation, but not productivity [54]. Moreover, we found that both the use of the intranet and investments in digital training do not present statistical significance. Perhaps, among other things, this is because their use is also scarce, only 36% and 30% of manufacturing companies carried out these activities, respectively. Furthermore, it is important to note that the firm's age also has a positive relationship, thus, this result supports hypotheses 10b. Nevertheless, both the size of the firm and the manager's gender have negative relationships. These results suggest that manufacturing firms with experience in the market can affect positively on their productivity, in addition to the use of DTs. Furthermore, it seems that large manufacturing firms with low proportion of female managerial position may be prone to not adopting these DTs. Thus, our results are consistent with previous studies [3,65,70,72]. At this point, it is important to mention that the RMSE in both models (3 and 4) according to labour productivity shows satisfactory significance (0.998 and 1.157) and the R square (0.27) is slightly moderate [75], respectively.

Fifth, if we make a comparative analysis between the creative and manufacturing industries, with respect to net sales (columns 1 and 2), we can see some differences. For example, large creative firms with experience in the market, some proportion of female managerial position and those that adopt DTs (broadband, intranet, digital consulting, websites, extranet and enterprise information systems), have positive relationships with a firms' net sales, while large manufacturers with experience in the market, with low proportion of female manager position and adopt DTs (broadband, digital consulting, websites, extranet and enterprise information systems), have positive relationships with a firms' net sales. Despite this, creative firms use a greater number of DTs that have positive and significant relationships with net sales compared to manufacturing firms. Therefore, the results support hypothesis 13a. In addition, if we focus on labour productivity (columns 3 and 4), the results show that there are slight differences. For example, creative SMEs with experience in the market, some proportion of female managerial position and those that adopt DTs (broadband, intranet, digital consulting, websites, extranet and enterprise information systems), have positive relationships with their labour productivity, while SME manufacturers with experience in the market, a low proportion of female managerial position and those who adopt DTs (broadband, digital consulting, website, extranet and enterprise information systems), have positive relationships with their labour productivity. Despite this, creative firms use a greater number of DT and have positive and significant relationships with labour productivity compared to manufacturing firms. Thus, these results support hypothesis 13b. In any case, we can affirm that the particularities related to the activities of the company can affect the adoption of DTs [20,73] and in turn, these influence on the performance of the companies [18].

Lastly, it's important to mention that the mere existence of a technology may not secure the outcomes or performance desired, thus, digital capabilities are necessary to effectively compete in a digital age [13]. Although recent empirical research has suggested which dynamic capabilities are necessary to compete in a digital economy [77,78] and has identified a range of sub-capabilities of those capabilities; it remains unexplored in the academic literature [13]. Unfortunately, our research could not measure these capabilities due to a lack of available data in the survey.

5. Conclusions

From a theoretical perspective, this article not only contributes to the technology adoption approach by reinforcing the arguments that digital technologies can affect the firm's performance [2,14,22,25] but also that this relationship may be different depending on the manager's gender [70,71,72], the size of the firm [3,66,67] and the industry [18,73]. In that sense, our study contributes empirically to showing that there is a positive relationship between the use of digital technologies and the net sales and productivity of the companies. Our results tested these theories originating in developed countries in the Peruvian context. The empirical analysis is based on a sample of 2,970 Peruvian companies from creative and manufacturing industries. We found that there are differences in adoption of DTs between both industries, where most of the digital technologies are positively related to net sales and productivity in creative industries rather than manufacturing firms. Furthermore, a more detailed analysis of these relationships shows that the greater the number of DTs used, the more positive significant with firms' performance. Despite this, we found that there are some DTs (online selling and social networks) that have negative significance on a firms' performance. This is, probably due to the fact that Peruvian companies can present technical, economic and legal barriers, preventing the successful implementation of these DTs, as other literature has recognized [50,55]. Such controversial evidence shows the ongoing debate between the use of DTs and firm performance, due to some dynamic capabilities being necessary to compete in a digital economy [77,78] and the use of DTs perhaps being insufficient.

On the other hand, when we factor in the sample considering the age of the company, the results suggest that firms with experience in the market can positively affect their performance, in addition to the use of DTs. However, the size of the company and the manager's gender shows controversial results that encourage debate. For instance, our results show that large firms are prone to positively affect firms' net sales, while SMEs are prone to affect firms' productivity in both industries. Instead, in the manager's gender, some proportion of female managerial position have positive relationships with a firms' performance in creative industries, in addition to the use of DTs, while the low proportion of female managerial position have negative relationships with performance in manufacturing firms. Thus, it would be relevant for future research to try to clarify these arguments and identify what practices or strategies are carried out by these companies in these respects, especially, when top management support in digital transformation may have positive or negative effects [79].

In practical implication terms, our results suggest that almost all DTs have a positive effect on net sales and productivity. However, these relationships can be different depending on the manager's gender, the size of the firm and the industry, as we mentioned above. Therefore, companies in both industries should improve their implementation of DTs, especially in the use of online selling and social networks, by proper management of the technology portfolio and capabilities [80]. Thus, the alignment between the functionality of digital technologies and organizational strategies is needed in order to take advantage of digital technologies [1], which requires suitable strengthening of workers' digital capabilities [13,80]. Additionally, more policy efforts should be put into making promoting gender diversity in top management positions. Similarly, the adoption of DTs may also require ad hoc policies, to the extent that they strongly associate with innovation processes within the company [81]. In that sense, the creation of advanced services should be encouraged to link innovation in manufacturing firms, especially to foster the servitization strategy [82], digital transformation [83] and industry 4.0 [84].

Lastly, this study has limitations that should be highlighted. First, despite the ENE survey being used, the low number of key variable observations limits the analysis at the intra-industry level, allowing only interpretations of the industry as a whole. Second, due to the timeline of the survey, which is cross-sectional in nature, our study does not assess digitalization dynamics, so future studies should focus on this issue. Lastly, because there may be other factors that have not been included in our models (especially digital capabilities), future research should corroborate our results in specific contexts in emerging countries.

Acknowledgments

The authors would like to thank two anonymous reviewers for their helpful comments. In addition, Jean Pierre Seclen-Luna acknowledges the support from the Program for High Performance in Research of the Pontifical Catholic University of Peru.

References

- [1] A. Bharadwaj, O.A. El Sawy, P.A. Pavlou and N. Venkatraman, “Digital Business Strategy: Toward a Next Generation of Insights,” *MIS Quarterly*, vol. 37, no. 2, pp. 471-482, 2013.
- [2] S. Popa, P. Soto-Acosta and D. Perez-Gonzalez, “An Investigation of the Effect of Electronic Business on Financial Performance of Spanish Manufacturing SMEs,” *Technological Forecasting and Social Change*, vol. 136, pp. 355–362, 2018.
- [3] A. Bayo-Moriones and F. Lera-Lopez, “A firm-level analysis of determinants of ICT adoption in Spain,” *Technovation*, vol. 27, pp. 352-366, 2007.
- [4] B. Kumar, A. Sharma, S. Vatavwala and P. Kumar, “Digital mediation in business-to-business marketing: A bibliometric analysis,” *Industrial Marketing Management*, vol. 85, pp. 126-140, 2020.
- [5] Organization for Economic Co-operation and Development, “Shaping the Digital Transformation in Latin America: Strengthening Productivity, Improving Lives” Paris, France: OECD Publishing, 2019.
- [6] Economic Commission for Latin America and the Caribbean, “Science, Technology and Innovation in the digital economy. State of the art in Latin America and the Caribbean”. Santiago, Chile: ECLAC, 2016.
- [7] Instituto Nacional de Estadística e Informática, “*Encuesta Nacional de Empresas*”, Lima, Perú: INEI, 2015.
- [8] Ministerio de la Producción, “*Las Mipymes en Cifras 2018*”, Lima, Perú: PRODUCE, 2020, pp. 14–17.
- [9] R. Castro-Vergara and P. Marquina-Feldman, “Impact of broadband uses on labour demand derived from the innovative behaviour of firms in creative industries,” *Creative Industries Journal*, vol. 11, no. 3, pp. 278-305, 2018.
- [10] Economic Commission for Latin America and the Caribbean, “*Análisis de la huella digital en América Latina y el Caribe*”, Santiago, Chile: Naciones Unidas, 2020.
- [11] World Bank Group, “*World Development Report 2016: Digital Dividends*”, Washington DC, USA: World Bank Group, 2016.
- [12] C. Forman, A. Goldfarb and S. Greenstein, “Technology Adoption”. In M. Augier and D.J. Teece (Eds.), *The Palgrave Encyclopedia of Strategic Management*. London: Palgrave Macmillan, 2018.
- [13] K.S.R. Warner and M. Wager, “Building dynamic capabilities for digital transformation: an ongoing process of strategic renewal,” *Long Range Planning*, vol. 52, no. 3, pp. 326-349, 2019.
- [14] International Monetary Fund, Chapter 4. “Is productivity growth shared in a globalized economy?” in *World Economic Outlook, April 2018: Cyclical Upswing, Structural Change*. Washington DC, USA: IFM, 2018.
- [15] H.C. Wang, J.G. Pallister and G.R. Foxall, “Innovativeness and involvement as determinants of website loyalty: I.A test of the style/involvement model in the context of Internet buying” *Technovation*, vol. 26, no. 12, pp. 1374–1383, 2006.
- [16] D. Pilat, F. Lee and B. Van Ark, “Production and use of ICT: A sectoral perspective on productivity growth in the OECD area,” *OECD Economic Studies*, vol. 35, pp. 47-78, 2002.

- [17] M. Falk, "ICT-linked firm reorganization and productivity gains," *Technovation*, vol. 25, no. 11, pp. 1229–1250, 2005.
- [18] G. Breard and G. Yoguel, "Patrones de incorporación de TIC en el tejido empresarial argentino: factores determinantes", en *El desafío de las TIC en Argentina: crear capacidades para la generación de empleo*. Santiago, Chile: CEPAL, pp. 207-247, 2011.
- [19] S. Sircar, J. Turnbow and B.A. Bordoloi, "A Framework for Assessing the Relationship Between Information Technology Investments and Firm Performance," *Journal of Management Information Systems*, vol. 16, pp. 69-98, 2000.
- [20] M. Chouki, M. Talea, Ch. Okar and R. Chroqui, "Barriers to Information Technology Adoption Within Small and Medium Enterprises: A Systematic Literature Review," *International Journal of Innovation and Technology Management*, vol. 17, no. 1, 2050007, 2020.
- [21] P. Taylor, "The Importance of Information and Communication Technologies (ICTs): An Integration of the Extant Literature on ICT Adoption in Small and Medium Enterprises," *International Journal of Economics, Commerce and Management*, vol. 3, no. 5, pp. 274–295, 2015.
- [22] V. Spiezia, "ICT Investments and Productivity," *OECD Journal: Economic Studies*, vol. 1, 2012.
- [23] Organization for Economic Co-operation and Development, "*Digital Economy Outlook 2015*". Paris, France: OECD Publishing, 2015.
- [24] T. Mazzarol, "SMEs Engagement with E-Commerce, e-Business and e-Marketing," *Small Enterprise Research*, vol. 22, no. 1, pp. 79–90, 2015.
- [25] E. Brynjolfsson and L. Hitt, "Computing Productivity: Firm-Level Evidence," *The Review of Economics and Statistics*, vol. 85, no. 4, pp. 793–808, 2003.
- [26] S. Haller and S. Lyons, "Broadband adoption and firm productivity: Evidence from Irish manufacturing firms," *Telecommunications Policy*, vol. 39, no.1, pp. 1-13, 2015.
- [27] G. Corral, H. Fryges and J. Jones, "Social media, open innovation & HRM: Implications for performance," *Technological Forecasting and Social Change*, vol. 444, pp. 334-347, 2019.
- [28] Y. Xia and G. Zhang, "The impact of the online channel on retailer's performances: An empirical evaluation," *Decision Sciences*, vol. 41, no. 3, pp. 517-546, 2010.
- [29] L. Holt and M. Jamison, "Broadband and contributions to economic growth: Lessons from the US experience," *Telecommunications Policy*, vol. 33, no. 10, pp. 575-581, 2009.
- [30] N. Czernich, O. Falck, T. Kretschmer and L. Woessmann, "Broadband Infrastructure and Economic Growth," *The Economic Journal*, vol. 121, pp. 505–532, 2011.
- [31] I. Bertschek, B. Wolfgang, H. Kai, K. Benedikt and N. Thomas, "The Economic Impacts of Broadband Internet: A Survey," *Review of Network Economics, De Gruyter*, vol. 14, no. 4, pp. 201-227, 2015.
- [32] A. Grimes, C. Ren and P. Stevens, "The need for speed: Impacts of internet connectivity on firm productivity," *Journal of Productivity Analysis*, vol. 37, no. 2, pp. 187–201, 2012.
- [33] N. Urbach, S. Smolnik and G. Riempp, "Determining the improvement potentials of employee portals using a performance-based analysis," *Business Process Management Journal*, vol. 17, no. 5, pp. 829-845, 2011.
- [34] S. Wechsler, M. Saiz, C. Rivas, C. Vendramini, L. Almeida and M. Mundim, "Creative and critical thinking: Independent or overlapping components?," *Thinking Skills and Creativity*, vol. 27, pp. 114–122, 2018.

- [35] H. Gillard, N. Mitev and S. Scott, "ICT Inclusion and Gender: Tensions in Narratives of Network Engineer Training," *The Information Society*, vol. 23, pp. 19-37, 2007.
- [36] A. Kumar, P. Grover, A.K. Kar and A.K. Pani, "IT Consulting: A Systematic Literature Review". In *Digital Nations – Smart Cities, Innovation, and Sustainability*, A. Kar et al. (eds) *Lecture Notes in Computer Science*, 10595, 2017.
- [37] J.P. Seclen-Luna and P. Moya-Fernández, "Exploring the relationship between KIBS co-locations and the innovativeness of manufacturing firms in Latin America," *Journal of Regional Research*, vol. 48, no. 3, pp. 69-84, 2020.
- [38] J.P. Seclen-Luna and J. Barrutia, "KIBS and Innovation in Machine Tool Manufacturers. Evidence from the Basque Country," *International Journal of Business Environment*. Vol. 10, no. 2, pp. 112-131, 2018.
- [39] Z. Liao and M. Cheung, "Internet-based e-banking and consumer attitudes: An empirical study," *Information & Management*, vol. 39, pp. 283-295, 2002.
- [40] E. Daniel, H. Wilson and A. Myers, "Adoption of E-Commerce by SMEs in the UK," *International Small Business Journal: Researching Entrepreneurship*, vol. 20, no. 3, pp. 253–270, 2002.
- [41] T.K. Liu, J.R. Chen, C. Cliff and C.H. Yang, "E-Commerce, R&D, and Productivity: Firm-Level Evidence from Taiwan," *Information Economics and Policy*, vol. 25, no.4, pp. 272–283, 2013.
- [42] H. Kim, L. Lee and C. K. Lee, "Building Web 2.0 Enterprises: A Study of Small and Medium Enterprises in the United States," *International Small Business Journal: Researching Entrepreneurship*, vol. 31, no. 2, pp. 156-174, 2013.
- [43] M. Tarafdar and J. Zhang, "Determinants of Reach and Loyalty. A Study of Website Performance and Implications for Website Design," *Journal of Computer Information Systems*, vol. 48, no. 2, pp. 16-24, 2008.
- [44] A. Payne and P. Frow, "A Strategic Framework for Customer Relationship Management," *Journal of Marketing*, vol. 69, no. 4, pp. 167-176, 2005.
- [45] T. Teo, and Y. Pian, "A contingency perspective on Internet adoption and competitive advantage," *European Journal of Information Systems*, vol. 12, no. 2, pp. 78–92, 2003.
- [46] J.M. Nurmilaakso, "ICT solutions and labour productivity: evidence from firm-level data," *Electronic Commerce Research*, vol. 9, pp. 173–181, 2009.
- [47] T. DeStefano, R. Kneller and T. Timmis, "Broadband infrastructure, ICT use and firm performance: Evidence for UK firms," *Journal of Economic Behavior and Organization*, vol. 155, pp. 110–139, 2018.
- [48] N. Terzi, "The impact of e-commerce on international trade and employment," *Procedia-Social and Behavioural Sciences*, vol. 24, pp. 745-753, 2011.
- [49] K. Zhu, K. Kraemer and S. Xu, "Electronic business adoption by European firms: a cross country assessment of the facilitators and inhibitors," *European Journal of Information Systems*, vol. 12, no. 4, pp. 251–268, 2004.
- [50] N. Sanders, "An empirical study of the impact of e-business technologies on organizational collaboration and performance," *Journal of Operations Management*, vol. 25, pp. 1332-1347, 2007.
- [51] M. Relich, "The impact of ICT on labour productivity in the EU," *Information Technology for Development*, vol. 23, no. 2, pp. 1-17, 2017.
- [52] A. Kaplan and M. Haenlein, "Users of the world, unite! The challenges and opportunities of social media," *Business Horizons*, vol. 53, no. 1, pp. 59–68, 2010.

- [53] G. Barczak, F. Sultan and E. Hultink, "Determinants of IT usage and new product performance". *Journal of Product Innovation Management*, vol. 24, pp. 600–613, 2007.
- [54] D. Roberts and M. Candi, "Leveraging Social Network Sites," *Journal of Production Innovation Management*, vol. 31, pp. 105-117, 2014.
- [55]. N. Kurnia and M. Er, "The Impact of Social Media Usage on the Sales Process in Small and Medium Enterprises (SMEs): A Systematic Literature Review," *Procedia Computer Science*, vol. 161, pp. 976–983, 2019.
- [56] J. Potts, S. Cunningham and J. Hartley, "Social Network Markets: A New Definition of the Creative Industries," *Journal of Cultural Economics*, vol. 32, no. 3, pp. 167-185, 2008.
- [57] J. Park and S. Chang-Soo, "Is social networking a waste of time? The impact of social network and knowledge characteristics on job performance," *Knowledge Management Research and Practice*, vol. 15, pp. 560–571, 2017.
- [58] J. Karimi, T. Somers and A. Bhattacharjee, "The Role of Information Systems Resources in ERP Capability Building and Business Process Outcomes," *Journal of Management Information Systems*, vol. 24, no. 2, pp. 221–260, 2007.
- [59] R.P. Vlosky, R. Fontenot and L. Blalock, "Extranets: impacts on business practices and relationships," *Journal of Business & Industrial Marketing*, vol. 15, no. 6, pp. 438-467, 2000.
- [60] A. Paswan, C.M. Wittmann and J. Young, "Intra, Extra, and Internets in Franchise Network Organizations," *Journal of Business-to-Business Marketing*, vol. 11, pp. 103-127, 2004.
- [61] R. Ling and D. Yen, "Extranet: A New Wave of Internet, S.A.M.," *Advance Management Journal*, vol. 66, no. 2, pp. 39-45. 2001.
- [62] J. H. Wu, and Y. M. Wang, "Measuring ERP success: The key-users' viewpoint of the ERP to produce a viable IS in the organization," *Computers in Human Behavior*, vol. 23, no. 3, pp. 1582-1596, 2007.
- [63] V. Hasheela-Mufeti and K. Smolander, "What are the requirements of a successful ERP implementation in SMEs? Special focus on Southern Africa," *International Journal of Information Systems and Project Management*, vol. 5, no. 3, pp. 5-20, 2017.
- [64] M.J. Schniederjans, Q Cao and V.C. Gu, "An operations management perspective on adopting customer-relations management (CRM) software," *International Journal of Production Research*, vol. 50, no. 14, pp. 3974-3987, 2012.
- [65] P. Cragg, M. King and H. Hussin, "IT alignment and firm performance in small manufacturing firms," *The Journal of Strategic Information Systems*, vol. 11, no. 2, pp. 109-132, 2002.
- [66] R. Spinelli, R. Dyerson and G. Harindranath, "IT readiness in small firms," *Journal of Small Business and Enterprise Development*, vol. 20, no. 4, pp. 807-823, 2013.
- [67] D. R. Gnyawali and B. R. Park, "Co-opetition and Technological Innovation in Small and Medium-Sized Enterprises: A Multilevel Conceptual Model," *Journal of Small Business Management*, vol. 47, pp. 308–330, 2009.
- [68] N. Michaelidou, N. T. Siamagka and G. Christodoulides, "Usage, barriers and measurement of social media marketing: An exploratory investigation of small and medium B2B brands," *Industrial Marketing Management*, vol. 40, pp. 1153-1159, 2011.
- [69] A. Perryman, G. Fernando and A. Tripathy, "Do gender differences persist? An examination of gender diversity on firm performance, risk, and executive compensation," *Journal of Business Research*, vol. 69, no. 2, pp. 579-586, 2015.

- [70] N. Smith, V. Smith and M. Verner, "Do Women in Top Management Affect Firm Performance? A Panel Study of 2500 Danish Firms," *International Journal of Productivity and Performance Management*, vol. 55, no. 7, pp. 563-599, 2006.
- [71] A. Singh, and T. Hess, "How chief digital officers promote the digital transformation of their companies," *MIS Quarterly Executive*, vol. 16, no. 1, pp. 1-17, 2017.
- [72] M.A. Raja Haslinda, M. Rosli, A.T. Yurita and A. Akilah, "The roles of top management and users in strategic IS planning: a perspective of SMEs," *International Journal of Information Systems and Project Management*, vol. 6, no. 4, pp. 61-80, 2018.
- [73] J. Thong and C. Yap, "Information technology adoption by small business: An empirical study". In *Diffusion and adoption of information technology*, K. Kautz and J. Pries (eds). London: Chapman & Hall, pp. 160-175, 1996.
- [74] M. Grazzi and C. Pietrobelli, "Firm Innovation and Productivity in Latin America and the Caribbean: The Engine of Economic Development". *Inter-American Development Bank Publication*, 2016.
- [75] J. Hair, W. Black, B. Babin and R. Anderson, "*Multivariate data analysis*". London: Prentice Hall, 2010.
- [76] R. Guesalaga, "The use of social media in sales: Individual and organizational antecedents, and the role of customer engagement in social media," *Industrial Marketing Management*, vol. 54, pp. 71-79, 2016.
- [77] D.Y. Liu, S.W. Chen and T.C. Chou, "Resource fit in digital transformation: lessons learned from the CBC Bank global e-banking project," *Management Decision*, vol. 49, no. 10, pp. 1728-1742, 2011.
- [78] C. Brosig, M. Westner and S. Strahringer, "Revisiting the Concept of IT Capabilities in the Era of Digitalization," *2020 IEEE 22nd Conference on Business Informatics (CBI)*, pp. 84-93, 2020.
- [79] A. Elbana and M. Newman, "The bright side and the dark side of top management support in Digital Transformaion –A hermeneutical reading," *Technological Forecasting & Social Change*, vol. 175, 12141, 2022.
- [80] T.T. Sousa-Zomer, A. Neely and V. Martinez, "Digital transforming capability and performance: a microfoundational perspective," *International Journal of Operations & Production Management*, vol. 40, no. 7/8, pp. 1095-1128, 2020.
- [81] J.P. Seclen-Luna and F. Ponce-Regalado, "Exploring the influence of innovation management tools on product innovation. The case of Peruvian innovative firms," *International Journal of Systematic Innovation*, vol. 6, no.2, pp. 42-52, 2020.
- [82] J.P. Seclen-Luna and J. Álvarez-Salazar, "Are Peruvian manufacturing firms' product-based or service-based businesses? Effects of innovation activities, employee level of education and firm size," *Technology Analysis & Strategic Management*, DOI: 10.1080/09537325.2021.1987409, 2021.
- [83] J. Kääriäinen, P. Pussinen, L. Saari, O. Kuusisto, M. Saarela and K. Hänninen, "Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization," *International Journal of Information Systems and Project Management*, vol. 8, no. 4, pp. 24-43, 2020.
- [84] G. L. Tortorella, A. MacCawley Vergara, J. A. Garza-Reyes and R. Sawhney, "Organizational learning paths based upon industry 4.0 adoption: An empirical study with Brazilian manufacturers," *International Journal of Production Economics*, vol. 219, pp. 284-294, 2020.

Effects of the use of digital technologies on the performance of firms in a developing country: are there differences between creative and manufacturing industries?

Biographical notes



Jean Pierre Seclen-Luna

is PhD in Economics from the University of the Basque Country, an institution where he was researcher at the Economics and Business Faculty. Currently he is Full Professor Associate at the Department of Management and Coordinator of the Research Group on Innovation Management at the Pontifical Catholic University of Peru (PUCP). Furthermore, he is member of the Latin-Ibero-American Association for Technological Management and Innovation (ALTEC) and is a member of the International Advisory Board of the Basque Economic Review. His research activity is focused on issues about innovation management, servitization and KIBS. His main publications have been in the Journal Sustainability; Technology Analysis & Strategic Management; Competitiveness Review: An International Business Journal; International Journal of Business Environment, among others. He has numerous participations in international conferences.



René I. Castro Vergara

is Economist and Master in Management and Policy of Innovation and Technology from the Pontifical Catholic University of Peru (PUCP). He has been a consultant for more than ten years in the areas of Productive Development, Innovation and Technology Management, Digital Transformation, and Economic and Social Development for many organizations, most of them from the public sector. He also has a specialization in Management of Companies and Cultural Initiatives and is a member of both the Innovation Management Research Group, belonging to the Management Sciences Academic Department of PUCP, and the Latin-IberoAmerican Association of Technology Management and Innovation (ALTEC). His publications are related to innovation processes in creative and cultural industries. He currently works as a specialist in evaluation of public interventions in the Public Expenditure Quality Directorate of the Ministry of Economy and Finance.



Hellen López Valladares

is MSc. in International Development from the University of Manchester, United Kingdom. Social Manager by the Pontifical Catholic University of Peru (PUCP). With postgraduate studies in Strategic Management of Corporate Social Responsibility and Inclusive Businesses and in Design, Execution and Evaluation of Public Investment Projects. She is currently an Associate professor and researcher at the Department of Management Sciences, Coordinator of the Social Mention of the School of Management, Coordinator of Working Papers Publications and founder and member of the Research Group on Business Growth. She has conducted research and consulting on business growth, social entrepreneurship, female entrepreneurship, and social innovation, publishing in conferences, journals, class materials and for the development of private and public organizations.



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijisp.science.sphere.org

ISPMSig

Information Systems & Project Management Success *interest group*

Detailed information available at: <https://ispmsig.dsi.uminho.pt>

ADVERTISING

Codes of Ethics

Information Technologies/Information Systems Ethics

Detailed information available at: <https://sites.google.com/view/codesethics>

ADVERTISING

ISRI

Information Systems Research Indicators

Detailed information available at: <https://isri.science.sphere.org/>

ADVERTISING

um



**International Journal of
Information Systems and Project Management**

ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X

Available online at ijispm.sciencesphere.org