International Journal of Information Systems and Project Management

IJISPM

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

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

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

Special issues

Proposals for special issues should be submitted to the Editor-in-Chief. E-mail: editor.ijispm@sciencesphere.org

Advertising information

The journal accepts advertising in the following categories: IT/IS events; IT/IS training and education; IT/IS entities. For full details, please contact the editorial office. E-mail: ijispm@sciencesphere.org

Correspondence and questions

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Table of contents

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 fourth number of the eighth volume of IJISPM. In this issue readers will find important contributions on social media in project management, project management baselines, digital transformation, and ERP implementations.

The first article, "Social media in project management: A systematic narrative literature review", is authored by Arash Daemi, Ritesh Chugh and Muralitheran V Kanagarajoo. Despite the adoption of social media in many business operations, evidence suggests that the usage of social media for project management activities is scarce. Through a literature review, this paper seeks to clarify the scope of the available knowledge, highlights the significance of new research agendas and addresses the principal reason for the limited use of social media in project management. A literature review was conducted to analyze the benefits of using social media in project management along with the areas in which it is used, the threats, barriers and enablers of social media adoption. Key areas where social media is used in project management include requirements management, communication management, policymaking, knowledge management and collaboration. Social media usage has shown to improve information sharing, engagement and relationships. Threats include a negative impact on reputation, employee productivity and information privacy. The reviewed literature highlights that the lack of a social media adoption strategy is the principal reason for the limited use of social media in project management.

The title of the second article is "Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization", being authored by Jukka Kääriäinen, Pasi Pussinen, Leila Saari, Olli Kuusisto, Martti Saarela and Kai Hänninen. Digital transformation (DT) refers to the changes in ways of working and business offering caused by adoption of digital technologies in an organization. Small and medium-sized enterprises (SMEs) are struggling with this transformation because of their limited resources and know-how. Thus, SMEs need practical grassroots-level help for DT that allows the companies to analyze where they stand in digitalization, and how they should proceed. This article discusses how SMEs can be supported in their DT by utilizing the DT model consisting of four consecutive phases for supporting companies' systematic development of digitalization. The article focuses on the first phase of the DT model, positioning, where company's digitalization status is analyzed in detail, and development ideas are identified. The positioning phase was conducted for 19 SMEs in Northern Ostrobothnia, Finland. The results indicate that the used process and tools were suitable to support SMEs for analyzing their digitalization status and identifying areas for improvement.

The third article, authored by Sagar Chhetri and Dongping Du, is entitled "Continual learning with a Bayesian approach for evolving the baselines of a leagile project portfolio". This article introduces a Bayesian learning approach for planning continuously evolving leagile project and portfolio baselines. Unlike the traditional project management approach, which uses static project baselines, the approach proposed in this study suggests learning from immediately prior experience to establish an evolving baseline for performance estimation. The principle of Pasteur's quadrant is used to realize a highly practical solution, which extends the existing knowledge on leagile continuous planning. This study compares the accuracy of the proposed Bayesian approach with the traditional approach using real data. The results suggest that the evolving Bayesian baselines can generate a more realistic measure of performance than traditional baselines, enabling leagile projects and portfolios to be better managed in the continuously changing environments of today.

"Expecting the unexpected during ERP implementations: a complexity view" is the fourth article and is authored by Guy Janssens, Rob Kusters and Harry Martin. Implementing an ERP (Enterprise Resource Planning) system is a complex, risky, time-consuming, and very expensive affair. Ticking off critical success factors (CSFs) and risks is supposed to take care of all intricacies during an implementation. However, complexity theory suggests no perfect foresighted knowledge can exist and one should always be prepared for new and unexpected events happening ("unknown unknowns"). Currently, ERP research does not explicitly address this unexpected behavioral aspect of complexity. Therefore, it seems relevant to explore whether this unexpected complexity aspect of ERP implementations can be observed in actual ERP implementations. The authors demonstrate through an in-depth and structured case analysis that even a normal, well-planned, and managed ERP project shows indeed unexpected behavior. That is to say, totally unforeseen major problems appear. From the observations, it is evident that ERP implementations can show significant unexpected behavior despite the best of knowledge, proper preparation, and project management practice. It seems relevant to perform more research into the relevance of appropriate control mechanisms based on acceptance of the inherent complex, i.e. unpredictable nature of ERP implementations.

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,

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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 of ProjMAN – International Conference on Project MANagement.

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Social media in project management: A systematic narrative literature review

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Abstract:
Despite the adoption of social media in many business operations, evidence suggests that the usage of social media for project management activities is scarce. Through this literature review, the paper seeks to clarify the scope of the available knowledge, highlight the significance of new research agendas and address the principal reason for the limited use of social media in project management. A literature review was conducted to analyze the benefits of using social media in project management along with the areas in which it is used, the threats, barriers and enablers of social media adoption. Key areas where social media is used in project management include requirements management, communication management, policymaking, knowledge management and collaboration. Social media usage has shown to improve information sharing, engagement and relationships. Threats include a negative impact on reputation, employee productivity and information privacy. The reviewed literature highlights that the lack of a social media adoption strategy is the principal reason for the limited use of social media in project management. This study contributes to both the project management practice and literature by introducing a model for social media adoption in project management.

1. Introduction

Interest in social media adoption to exploit organizational objectives demands new features. The emergence of new social media platforms which are equipped with an array of functions has provided businesses many opportunities [1]. The benefits that social media presents to organizations encourage greater integration of social media into business operations. Adoption of social media in projects is estimated to improve productivity by 25 per cent and to unravel up to $1.3 trillion of annual value globally [2]. Social media enables organizations to connect internally and externally with its diverse stakeholders and brings various opportunities, and tapping into this resource is vital [3].

Project management is a domain in which success is heavily linked to the systematic identification and application of best practices. Project management refers to processes that help to manage resources, complete a project within scope, time, quality and cost and mitigate uncertainty [4], and social media has a role to play. Using social media in managing projects requires standardized frameworks and methods to help retain control and operate effectively. Compromised security and disclosure of sensitive project data are some of the significant threats [5]. The application of social media in managing projects has raised concerns about the rigor of the methods used for the integration of social media in project management. Hence, a holistic social media adoption strategy is needed to ensure the effective usage of social media in project management.

The nexus of social media and project management is the crossroads for the literature synthesis in this study. According to Kaplan and Haenlein [6], "social media is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" (pg. 61). On the other hand, project management is described as "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" [7]. Therefore, in this study, project management areas are referred to as activities in the project life cycle where social media can be adopted to apply knowledge, skills, tools, and techniques to project activities for achieving project objectives.

Organizations undertake Information Technology (IT) projects to transform and grow [8]. When adopting social media for managing projects, organizations need to consider the factors affecting the complexity and success of its adoption. Megaprojects are generally exposed to underperformance [9], hence do not resemble the best setting for social media adoption, as no specific framework or methodology is recorded in the literature for managing complex IT projects [10]. For the strategic integration and use of social media in project management, the associated benefits and risks need to be explored. Project managers could benefit from social media use in addressing the challenges of current practices. Documentation of design projects and traceability of decisions and revisions is of high importance [11] and is an example where social media use can be beneficial. In managing risks, a holistic approach is needed to probe the threats at both a project and an organizational level [12]. Hence, a comprehensive review of the benefits and risks of social media use in project management is imperative.

A better understanding of social media use in project management will enrich a social media strategy. As of writing this paper, no prior literature review was found that holistically explored social media usage in project management through a review of the literature, particularly with regards to the project management areas where social media can provide benefits. The work undertaken by Kanagarajoo et al. [1] and Zhang et al. [13] reviewed different aspects of social media's contribution to the project communication area only. Moreover, a comprehensive amalgamation of the aspects from which social media adoption in project management areas are probed in literature is imperative for researchers and practitioners. Additionally, for broader social media adoption in project management and unlocking its potential for organizations, it is of significant value to clarify and catalogue the reported benefits of social media use. Despite a list of opportunities and benefits showcased by Hysa and Spalek [5], other scholars such as Ninan et al. [14] called for further scouting of social media adoption benefits from different perspectives. In the project management context, threats are uncertain and, if materialized, they will negatively impact project objectives [7]. Equitably enumerating the threats of social media use in project management is of grave importance to curtail uncertainty and encourage social media adoption. Furthermore, threats of social media in project management which are explored by Rosenberger et al. [15] are distinctive from those reported by Hysa and Spalek [5]. Any formulated strategies for social media adoption in

project management would lack efficacy where barriers and enablers of social media usage are neglected or left unexplored under a combined lens. To the best of our knowledge, an exhaustive record of these factors is not explored nor contrasted in any previous studies and this study endeavors to fill the gap.

Hence, through the lens of a systematic narrative literature review, this study examines the project management areas in which social media is used. After setting the context, the benefits and threats of using social media in projects are investigated. Furthermore, the barriers and enablers of social media use in management are explored as they influence the success of social media adoption. The insight gained through this review provides significant value for the development of social media adoption strategy in project management.

This paper is structured as follows. The next section outlines the research method adopted in this study. It is followed by the section in which the project management areas where social media is used are outlined. The benefits and threats of using social media in project management are described next. Barriers and enablers follow. The discussion section outlines the significance of the findings, in light of the existing literature and presents a social media adoption model. Subsequently, further research areas are reviewed, and the conclusion summarizes critical aspects of the study along with the limitations.

2. Research method

This study aims to provide a synthesis of the previously published studies about the use of social media in project management. Through this literature review, the paper seeks to clarify the scope of the available knowledge and highlight the significance of new research agendas. Thus, a systematic narrative literature review is chosen as the primary research method for this study. Comprehensiveness is the fundamental characteristic of the narrative review, which caters for broad coverage of the studied issues [16]. The narrative literature review provides a robust platform for a comprehensive study, analysis and synthesis of existing literature. However, the criteria for selecting specific sources for review are not always apparent to researchers [17]. Unclear selection criteria of the researched literature could raise legitimate concerns about the outcome of the study. These concerns could question the biased selection of the researched literature and the intention of researchers to narrate the findings selectively. This study has used a systematic search to select the relevant articles to eliminate these possible biases. A systematic search was formulated with an explicit inclusion and exclusion criteria. In addition, the researched terms and methods are outlined to enable the readers to replicate the same range of literature. Critical assessments were also conducted to appraise the relevance of the extracted data with the researched topic. These steps enabled the research to overcome the lack of transparency which is a side effect of the narrative literature review. All relevant databases were included to ensure the literature of social media usage in project management has been covered extensively. For conducting this systematic narrative literature review, the guideline provided by Denyer and Tranfield [18] was followed in which the selection process took place in three stages – planning, conducting and reporting.

2.1 Planning the review and computer search

To design the review, the purpose and protocols of this study were established [18]. The research protocol in this study is defined by the research questions, search strategy, inclusion and exclusion criteria, database search and duplicate elimination, and data extraction strategy.

2.1.1 Research questions

The following research questions were defined to perform the systematic narrative literature review:

RQ 1. What are the project management areas in which social media is used?

RQ 2. What are the benefits of using social media in project management?

RQ 3. What are the threats of using social media in project management?

RQ 4. What are the barriers and enablers of social media usage in project management?

2.1.2   Search strategy

As part of the search strategy, the required actions were planned to return appropriate answers to the defined research questions. The usage of social media and project management literature is intended to be captured by searching the relevant databases. Through assessment and refinement, appropriate keywords for searching were established. It was also decided to conduct a few initial searches to test search terms and combinations. A shortlist of the relevant databases was also narrowed down, along with the development of the inclusion and exclusion criteria.

2.1.3   Inclusion and exclusion criteria

In order to set boundaries for the search, inclusion and exclusion criteria were established. Table 1 describes the inclusion and exclusion criteria for this study.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Exposure of interest	Social media in project management	Social media in other domains
Language	Written in English	Written in any other language
Type of publication	Peer-reviewed journal articles	Book reviews, editorials, and papers in conference proceedings
Period	2014 - 2019	Before 2014

Available resources and language expertise prevented this research from investigating published works in any language other than English. Peer-reviewed journal articles were chosen to maintain quality standards and a scholarly level of analysis. In the last five years, due to its pervasive merger with workplace operations, social media has paved its way into the project management domain. This phenomenon has raised many concerns about the appropriate usage and integration of social media into project management. Hence, this study explores the highlighted aspects of the usage and integration in the published literature over the past five years.

2.1.4   Database search and duplicate elimination

EBSCOhost, Emerald, Oxford Academic Journals, ProQuest, ScienceDirect, Scopus, Springer Link, and Web of Science were the selected databases to ensure relevant academic sources are captured. To ensure appropriate articles are obtained, the title and abstract field of the database was used. Further filtering of titles removed duplicate papers.

2.1.5   Data extraction strategy

After applying the inclusion and exclusion criteria, the articles were examined against the research questions to remove irrelevant literature. The data analysis was then performed by reading the selected papers.

2.2   Conducting the review

The systematic literature search was executed between August 2019 and September 2019. During this stage, the databases were extensively examined. Table 2 demonstrates the utilized string and the generated search output numbers for each database prior to the screening stages comprising of sixty-six search results.

Table 2. Database search results

Database	Used terms and operators	Search Field	No. of peer-reviewed studies	No. of studies within (2014-2019)	No. of studies in English	No. of studies as journal articles	No. of studies before screening stages
EBSCOhost	"project management" AND "social media"	AB Abstract	7	5	4	2	2
Emerald	"project management" AND "social media"	Abstract	66	42	42	33	5
Oxford Academic Journals	"project management" AND "social media"	N/A	158	129	129	101	7
ProQuest	"project management" AND "social media"	Abstract AB	5	3	3	3	2
ScienceDirect	"project management" AND "social media"	Abstract	8	8	8	7	7
Scopus	"project management" AND "social media"	TITLE-ABS-KEY	145	97	96	23	17
Springer Link	"project management" AND "social media"	N/A	2,115	1,733	1,575	370	12
Web of Science	"project management" AND "social media"	Topic	39	31	30	15	14

After identifying and removing duplicates, the remaining publications were further investigated to ascertain the inclusion of social media in managing projects. Selection of the articles took place after a staged review of their topic, abstract and conclusion while maintaining the focus on the literature of most considerable pertinence to the research questions. A list of forty-three articles was shortlisted in relation to the usage of social media in project management. The next stage was to undertake a complete reading of all the shortlisted articles to ensure the articles helped in addressing the research questions. This led to a final shortlist of twenty-nine articles, which formed the premise for the analysis. Table 3 illustrates the articles came from twenty-five journals, with the most number of articles published in 2017 over the past five years.

Table 3. Journal listing

Journal Title	Number of articles from the journal	Year published
Advanced Science Letters	1	2017
Business & Information Systems Engineering	1	2019
Corporate Communications: An International Journal	1	2014
Global Journal of Flexible Systems Management	1	2016
Government Information Quarterly	1	2016
Heliyon	1	2019

Journal Title	Number of articles from the journal	Year published
Indian Journal of Science and Technology	1	2016
Information Systems Frontiers	2	2017, 2018
International Journal of Managing Projects in Business	1	2016
International Journal of Productivity and Performance Management	1	2019
International Journal of Project Management	2	2018, 2019
International Journal on Interactive Design and Manufacturing	1	2018
ITNOW	1	2014
Journal of Business Economics and Management	1	2014
Journal of Business Research	1	2019
Journal of Communication	1	2015
Journal of Computer-Mediated Communication	1	2016
Journal of Construction Engineering and Management	1	2016
Knowledge Management Research & Practice	3	2017, 2017, 2017
Perspectives on Public Management and Governance	1	2018
Project Management Journal	1	2015
The Learning Organization	1	2014
Transforming Government: People, Process and Policy	1	2017
Vision: The Journal of Business Perspective	1	2017
Water Policy	1	2018

2.3 Reporting the review

The purpose of this stage is to enable dissemination of the systematic narrative literature review of the selected topic among the potentially interested stakeholders by stating the findings of the study. As this study aimed to explore responses to the pre-determined research questions, a narrative analysis was carried out with the aim of constructing the results as the examination progressed. More specifically, a narrative thematic analysis was carried out in which content within the text was analyzed involving five stages: organizing data, deriving an overall view of the information, coding, identifying categories and interpretation [19]. Importantly, the codes were condensed into categories that helped in addressing the research questions. Interpretation involved making sense of the data and deriving meaning from it to provide insight into the use of social media in project management.

The narrative thematic analysis of the reviewed literature revealed that a lack of social media adoption strategy is the principal reason for the minimal use of social media in project management [1],[5]. The systematic review also confirmed that none of the reviewed literature in this study has developed nor presented a model for social media use in project management. Thus, due to its capacity for comprehensive study and analysis of the literature [16], narrative analysis was carried out to formulate a holistic solution for the highlighted problem. The proposed model in this study has emerged through a systematic narrative literature review.

3. Project management areas in which social media is used

Social media is used for a variety of purposes in project management such as managing requirements and configuration [20], communication management [21], policymaking [13],[22], and management of knowledge and collaboration with project stakeholders [1].

3.1 Requirements management

Requirements and configuration management could be a long and complicated process. Sharing acceptance criteria via social media enables the project team to commence testing of the released project components before completion of the entire requirements documents [20]. Application of social media provides flexibility and integrity for the management of the stakeholders' requirements. Using different social media features such as hashtags or bookmarks ensures project and configuration updates are retrievable at any point of the project lifecycle [20]. A hashtag is used as a label for the content being produced on social media. By searching a hashtag, every tagged content by that hashtag will be retrieved easily.

3.2 Communication management

Managing project communication is one of the essential areas in which social media is used [5],[21]. Conducting project meetings, reporting project progress and accomplished milestones, communicating project outcomes and sharing best practices are some examples of social media use in managing project communications [21]. Social media's capacity to provide broad communication channels with stakeholders, as well as the capability for prompt reflection on project issues, helps project managers to be more effective in their jobs [5]. In addition to social media's contribution to the effective decision making in projects, the potential to quickly share large volume project documents have made social media a competent means of communication for the project managers [1],[23].

Social media's role in communication and sharing knowledge is highlighted as a significant reason for organizations to use it in projects [1]. However, to exploit the benefits of social media adoption in projects, its usage must comply with predefined principles [5]. Stating the purpose and form of social media use, clarifying restricted and confidential project information, defining project members' scope of responsibility and establishing guidelines for distinguishing professional and private presence in social media are some of the underlying principles that need introspection [1],[5].

There are also case studies in the literature where social media is used as a communication channel in government projects. In a case study in India, social media was employed to broadcast progress updates, engage community members, advertise project vacancies and promote a national organizational brand [14]. The purpose was to boost the support of external stakeholders. In China, social media comments about the "south to north water transfer" project were analyzed to conceive interests and opinions of the community [13]. In another study in China, the government's decision to respond to negative comments through social media exhibited a two-way proactive communication approach to address potential public relation problems [22]. In e-government projects where the failure rate is expected to be high, the Twitter analysis method can be a sound practice. This method is used to track citizens' reaction to project failure and address those reactions with an appropriate communication management plan implemented through social media [24],[25].

3.3 Policymaking

There are instances where social media has been used for policymaking as a nexus of communication and collaboration between governments and citizens [13],[22]. Public opinion shapes the collaboration intensity between community and government. Governmental projects typically are enormous in scope and complexity. Any issue in a large complex project which engages a broad range of citizens could represent a social issue. Literature suggests, in such projects, governments must analyze social media content and monitor social opinions, trends and emotions [22]. By recognizing public interests through social media analysis, governments can make or modify project policies to maintain or enhance collaboration between them and citizens.

3.4 Knowledge management

Knowledge management has different aspects such as capturing lessons learned, updating organizational process assets and sharing or retrieving project knowledge. The use of social media in knowledge sharing for productivity improvement is increasing [26]. Social media enables knowledge sharing to take place instantly beyond defined boundaries in organizations [1]. Using social media, project staff establish knowledge repositories where they store cross-functional knowledge [27]. Literature suggests that knowledge sharing is facilitated by establishing close relations with others [5], and social media is an efficient means to do it. Some organizations are utilizing Enterprise Social Media (ESM) to conquer the knowledge sharing complexity imposed by their organizational structure [28]. Through the usage of ESM, project staff communicate with team members from other divisions, form inter-organizational groups, view messages or shared documents posted by other members and edit or reflect on posted topics by others [29].

Social media platforms are also used for capturing lessons learned in projects [1],[28],[30]. Social media facilitates both retrospective, and prospective learning practices [31] which are usually discussed in lessons learned sessions. Scholars suggest that some social media features are adequate for knowledge management activities [20]. Although characteristics of social media simplify cross-functional discussions and knowledge creation, concerns about the factors affecting the quality of knowledge management processes exist [32]. The effectiveness of knowledge management processes is dependent on the capacity of the used infrastructure and technology [32].

3.5 Collaboration

Cross-boundary communication and knowledge sharing between project staff and stakeholders increase collaboration in organizations. As previously highlighted, social media facilitates the creation of relationships between project staff and the broad community of stakeholders. Social media facilitates virtual team set up, thereby significantly reducing travel needs of project team members. This, in turn, translates into cost savings [5]. Real-time knowledge sharing is one of the main advantages of using social media for knowledge management. The reviewed literature demonstrates that the usage of real-time social media tools increases collaboration value by reducing coordination costs [5]. Hence, collaboration is another application area for social media in projects [5],[21],[33],[34].

Governments have also used social media for improving the collaboration intensity with the community [34]. Governments develop or modify policies based on the analysis of public opinion shared in social media platforms to intensify collaboration with communities. These collaborations are critical where governments seek to co-produce public services with community members [34].

4. Benefits of using social media in project management

Social media benefits justify its usage in project management. Hysa and Spalek [5] employed a quantitative questionnaire which measured the influence of using social media in project management in different fields. The research found that social media adoption in organizations is beneficial as improvements were reported in communication, collaboration, engagement, productivity and flow of knowledge and information [5].

Ease of access through computers and mobile devices enabled social media to become a quick and efficient information-sharing and communication tool [1],[23],[35]. The capacity to allow instant messaging helped project managers to establish reliable and efficient communication networks with the project participants and owners [5].

Social media could also be beneficial when used to improve collaboration in virtual teams [5]. A virtual team is a group of individuals who are geographically dispersed. To collaborate on assigned objectives, they use virtual communication technology such as email or video conferencing services. Social media provides cost-effective solutions when employed by virtual teams as it reduces costs associated with the required travel for the virtual team members and establishment fees for offshore call centers. Social media also helps to improve the project personnel's engagement [5]. It increases the participation of team members in project discussions, information sharing and decision making [1].

In knowledge management, social media facilitates instant and broad information exchange between the project participants and experts. When managed strategically, social media also enables knowledge depository and revisal through established mechanisms. Quick and cost-effective access to knowledge and communication channels, when coupled with the encouraging participation and collaboration, boosts the project team's synergy and productivity [5]. Social media is also beneficial for managing external stakeholders and resources. Building relationships with project partners [21], customers, community members and future talents [36] are some examples.

Governments have explored opportunities in collaborative policymaking with the participation of the community members [15]. Ninan et al. [14] reviewed a case study in India and reported the benefits of social media usage by the local government in a megaproject. Promoting the project's benefits, saving costs through crowdsourcing, publishing progress reports and engaging with the community helped to build a positive brand image for the mentioned project [14]. Another case study in China highlighted some similar benefits as well as the increased transparency and accountability yielded by the local government through the usage of social media in the management of a megaproject [34].

5. Threats of using social media in project management

The reviewed literature has limited yet insightful cases where the threats of using social media in project management are studied. Di Gangi et al. [37] classified social media threats as social, technical and legal. Social threats can impact the reputation of an organization and the confidence of customers in a business brand. In contrast, technical threats endanger organizational information technology resources as introducing malicious code (malware) into the organizational computing environment or harming digital devices, and legal threats can lead to corporate loss due to mishandling sensitive information of business partners [37]. Projects can also face similar threats when social media is used. Hence, awareness is vital.

In the communication area, Hysa and Spalek [5] have cited different social media threats including, disclosure and acquisition of confidential project data, incidences of various technical issues, and hacked project staff accounts. In collaboration and work productivity areas, they have found wastage of time on personal and non-work-related matters. In engagement and work productivity areas, they also cited the threat of occupational burnout due to blurred borderline of professional and personal time.

In managing projects, social media threats could be more extreme for governments. Losing citizens' trust should be avoided at both political and technological levels [15]. Inability to govern accident or failure news ethically can stimulate negative emotions of the citizens [14]. Governments are exposed to data privacy, data security, and data accessibility threats primarily when they use third-party social media platforms [15], hence caution should be exercised.

6. Barriers and enablers of social media usage in project management

Although many studies stated the benefits of social media usage, others suggest that some organizations are still reluctant to deploy social media tools. The absence of explicit social media enablers and the presence of barriers could dampen the interest of using social media in project management. This theme reviews the available literature to uncover the barriers and enablers of social media usage.

6.1 Barriers

Barriers should be considered in the strategic management of social media usage as they could hinder adoption initiatives. Empirical research [1],[5],[38] suggests that the fear of losing control over information and security is the primary barrier for social media implementation. Other restrictions are the technology used, time constraints, inadequate clarity of the business needs, and training requirements for social media integration [39]. The adoption of new technology demands changes, and undesired changes could stall the adoption process. Inadequate technology infrastructure or inclusive social media restrictions also inhibit usage [1].

Social media restrictions are practiced by governments to prohibit freedom of speech or to control the flow of information for political or national security purposes [1]. Furthermore, where tight delivery timeframes are set, the motive to explore and deploy social media tools is hampered. In business areas where social media adoption is a complex task and is vaguely defined, the adoption initiatives could halt [39]. Moreover, time, cost, and resources associated with social media training could undermine deployment benefits. In addition, Rimkunienė and Zinkeviciute [38] state that the lack of confidence in personnel's appropriate use of social media inhibits the adoption. Project managers are worried that project staff would waste time on social media channels over individual matters, provoking a decrease in productivity [5]. Additionally, the absence of a comprehensive strategy for social media management has been underlined as a significant inhibitor [1],[5],[38].

6.2 Enablers

Enablers are the factors which facilitate practical usage and management of social media in project management. Strong leadership, a culture of knowledge sharing, and business needs could ease social media adoption [39]. Where business leadership is invested, middle management and the project staff are compelled to explore opportunities to employ social media tools. Even in the presence of strong leadership support, the willingness to share learned experiences should be one of the values forming an organizational culture. Besides, the absence of a suitable communication channel for any business could accelerate the adoption of social media. Rimkunienė and Zinkeviciute [38] state that mapping appropriate social media tools with business needs and objectives is the business manager's responsibility. Inevitably, the quality of the communication rests on the competency of the deployed technology [40]. Another enabler is the convenience of accessibility on multiple devices as smartphone, tablet, and computer [1]. Personnel competency could minimize the required induction and training procedures. Expertise is recognized as an essential factor when deploying social media tools [23].

7. Discussion

The integration of social media into the value chain activities of organizations has become necessary. Project management processes are no exceptions as they are a vital part of organizational value chain activities. The findings of this study confirm that social media is used in projects for different purposes. However, the literature also suggests that social media adoption in projects is minimal [5],[21].

The lack of a social media adoption strategy is the principal reason for the limited use of social media in projects [1],[5]. The absence of a strategy discourages actions and may hinder attempts from delivering successful results. In developing a strategy, objectives must be clarified and translated into a practical roadmap to guide adoption. Thus, organizations must specify the purposes of social media use in their projects before formulating any strategy [1],[5].

Once the objectives are set, appropriate social media tools should be selected for the successful delivery of the determined purposes [1],[38]. Subsequently, manuals are needed to guide the proper usage of the chosen platforms.

Clearly defined guidelines improve understanding of a well-crafted strategy. A clearly drafted strategy is more likely to earn support and deliver successful results. Organizational social media policies summarize the guidelines for effective governance of social media in organizations. The scope of the responsibility [5] and the barriers and enablers of using social media also need to be addressed in social media policies. In the context of the organizational environment, a comprehensive social media policy needs to consider the consequences of social media misconduct from both individual and corporate perspectives [37]. In addition to the social media policy, updated Information and Communication Technologies (ICT) security policies are required to enable organizations to mitigate the security threats associated with the adoption of social media [1],[5],[37]. Finally, a receptive environment facilitates the successful implementation of social media in projects.

Identifying and sustaining critical success factors contribute to the successful implementation of strategies. The reviewed literature highlights the essential factors of success as:

- frequent training of social media and ICT policies [5],[37],[38];
- recognizing and rewarding the compliance and governance of the project team with the social media policies [37]; and
- documenting, sharing and applying the best practices of social media use in projects [21].

Figure 1 illustrates a social media adoption model for project management based on the findings of this study. As highlighted in the research method section, this model has emerged through a systematic narrative analysis of the literature. Four elements of the model are described here in order.
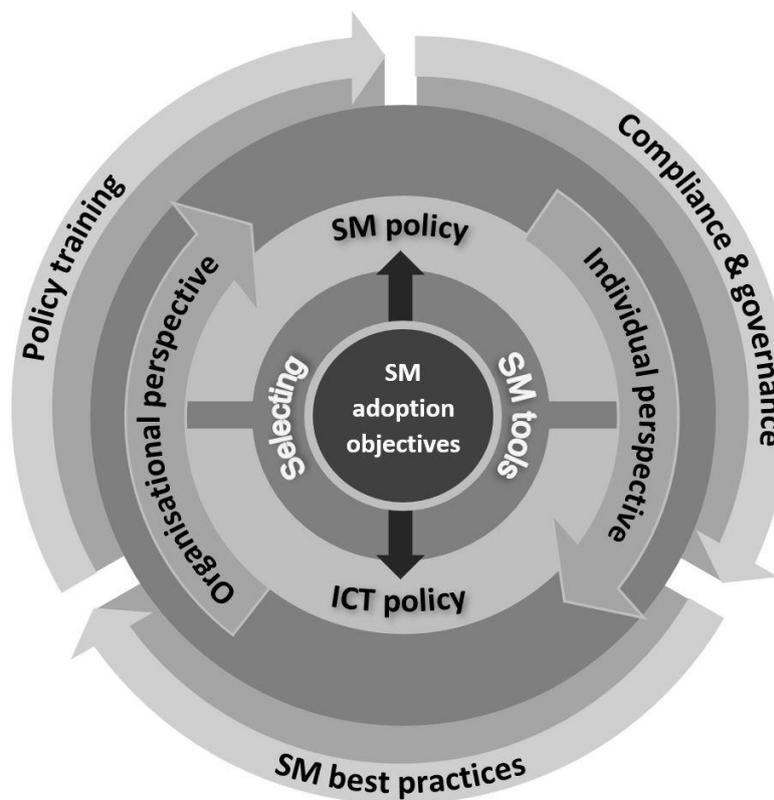
Fig. 1. Social media adoption model for project management

7.1 Setting the objectives

In this model, setting objectives for social media use is the foundation of a successful social media adoption strategy. It is imperative for organizations to clarify the objectives of social media use in project management before formulating any strategy [1],[5]. It enables the postulation of a clear vision to erect a model and performs as a decision-making compass too.

7.2 Selecting social media tools

After assessing the purposes of social media use in project management, businesses then need to decide which social media platforms best cater to their established goals. The selection of social media platforms must be aligned with the set objectives [1],[38], based on the characteristics of social media platforms, so the successful delivery of the determined objectives are provisioned.

7.3 Tailoring social media and ICT policies

Based on the selected platform, social media and ICT policies need to be tailored to address the threats and barriers of social media use at an individual and organizational level. For prevention and effective management of the threats of social media misuse, comprehensive social media policies must consider both individual and corporate perspectives [37]. Simultaneously, ICT security policies are also of importance in the prevention and mitigation of security threats where social media is used in organizations [1],[5],[37]. Thus, tailored social media and ICT policies enable organizations to govern the effective adoption of social media in project management. Any changes to the social media adoption objectives need to be reflected in the array of social media tools and governance policies to sustain the efficacy of the model.

7.4 Establishment of the critical success factors

The organizational environment could support or impede initiatives and the successful implementation of any model. The proposed model also recommends three critical success factors for an effective social media adoption strategy; frequent policy training, establishing a best practice culture for social media adoption and auditing the compliance and governance of social media and ICT policies.

- Organizations must frequently train their staff on the content and application of social media and ICT policies [5],[37],[38]. Frequent training sessions would ensure that staff are kept aware of social media and ICT policies, the latest updates made to each policy, examples of social media misconduct, individual and corporate level threats and consequences, the means to mitigate the threats, and effective application of social media to fulfil organizational objectives.
- Organizations must audit whether their staff's usage of social media complies with organizational policies and governance procedures. A recognition and rewards program enforces the appropriate application and reminds the consequences of non-compliance behavior [37]. A compliance and governance audit mechanism should be established once the social media and ICT policies training are developed. Training and appropriate audit mechanisms would jointly encourage appropriate social media use.
- Organizations must document, share and apply the best practices of social media use in project management [21]. Application of best practices is a practical approach to improve efficacy and consequently, the credibility of the employed model. Subsequently, the model could gain better support from different levels of an organization. Additionally, access to documented best practices boosts the confidence of project managers to adopt social media in the management of their projects [38], which could enhance social media adoption rate in project management activities.

The social media adoption model for project management signifies the importance of this study. Through a detailed review of the selected studies, this research synthesized multiple elements of the literature and converged them into a single social media adoption model. This model could aid in the integration of social media in project management and enhance project management activities.

8. Further research areas

For social media integration in project management, a holistic approach, alongside a thoroughly devised strategy, has a paramount role. Empirical research has unveiled that there is scant literature concerning the effective use of social

media for managing projects. The literature suggests that studies have only covered the social media application during the conceptualization stage of projects [41]. Thus, further studies are needed to explore the application of social media in other stages of a project too.

Where the adoption of social media is intended for internal purposes, scholars stressed their concerns about the lack of rigor in using social media and lack of studies to explore how policies and procedures should be used to govern social media use in project management [1],[5]. Social media policy robustness, human resource policy compliance with safe social media integration, security knowledge and discipline are other unexploited areas [37].

Furthermore, literature in using social media for external purposes is even more scarce. Ethical guidelines, information privacy and user permission, need to be handled delicately. The risk of losing citizens' trust has to be studied and analyzed at both political and technological levels [15]. Social media usage by citizens to collaborate with governments also stimulates the sharing of emotions. There are very few theories on how emotions should be dealt with in governance processes [42], and this could be investigated.

The absence of best practices for social media integration in project management has raised many concerns [21]. Rimkunienė and Zinkeviciute [38] concluded that the use of social media requires a holistic approach in which project management professionals need to rethink their communication approach, enhance their competence and usage practices. Appropriate policies can enable clear description and effective implementation of best practices. It was determined that traditional information technology policies do not cater for social media to exploit its full potential and appropriate policies and procedures are needed for the safe and effective integration of social media in project management [1],[5]. Further studies, particularly case studies that shed a real-world perspective, are required to explore the integration of social media in project management.

9. Conclusion

A review of the areas where social media is adopted in project management was carried out in this study to set the context for analysis of the benefits and threats associated with the integration and use of social media for project management activities. A synthesis of the literature suggests that social media adoption for project management is both beneficial and a menace for organizations. Key areas where social media is used in project management include requirements management, communication management, policymaking, knowledge management and collaboration. Social media usage has shown to improve information sharing, engagement and relationships. Threats include a negative impact on reputation, employee productivity and information privacy. Notably, social media is useful for projects and project management, where it allows overcoming organizational and contextual boundaries. It can also be risky where there is lack of governing guidelines. The effective management of social media in project management requires a holistic approach. The impact of barriers and enablers on social media adoption is beyond doubt. In the development of a social media adoption strategy, the barriers and enablers of social media adoption should be studied and considered.

As with any study, this one is not exempt from limitations either. It has the usual restrictions that apply to literature reviews, particularly the inability of not finding articles that were outside the scope of the chosen databases.

In response to the minimal use of social media in projects, this study presented a social media adoption model for project management intending to enhance social media adoption. The findings of this study also unveil the scarcity of literature concerning the effective use of social media in project management. This vacuum signifies the importance of this study. Further research areas were also highlighted. The absence of best practices for social media integration in project management requires project management practitioners and scholars' attention. From a practical and theoretical standpoint, social media has untapped potential for managing projects.

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Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

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Abstract:
Digital transformation (DT) refers to the changes in ways of working and business offering caused by adoption of digital technologies in an organization. Small and medium-sized enterprises (SMEs) are struggling with this transformation because of their limited resources and know-how. Thus, SMEs need practical grassroots-level help for DT that allows the companies to analyze where they stand in digitalization, and how they should proceed. This article discusses how SMEs can be supported in their DT by utilizing the DT model consisting of four consecutive phases for supporting companies' systematic development of digitalization. The article focuses on the first phase of the DT model, positioning, where company's digitalization status is analyzed in detail, and development ideas are identified. The positioning phase was conducted for 19 SMEs in Northern Ostrobothnia, Finland. The results indicate that the used process and tools were suitable to support SMEs for analyzing their digitalization status and identifying areas for improvement. The DT model and piloted tools have been published as a free-of-charge ApuaDigiin.fi online service to facilitate their widespread use in the future. In this way, public regional business development authors or research organizations can utilize the online service while supporting the digitalization of SMEs.

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

1. Introduction

Digitalization is one of the major trends changing business and society [1]. Previously, digital technology was seen as a niche market, but today, it is an everyday technology—the foundation of all modern innovative economic systems [2]. It is about transforming the core using digital tools and discovering and capturing new opportunities enabled by digital means [3]. Thus, digitalization can mean enhancing existing processes, finding new opportunities within existing business domains, or finding new opportunities outside existing business domains [4]. The effects of digitalization have been compared to the Industrial Revolution [5]. In this article, digitalization is referred to as a more fundamental change than just digitizing existing processes or work products. "Digitization" refers to the action or process of digitizing analogue data into digital form. According to the literature, digitalization, or digital transformation (DT), refers to "the changes associated with the application of digital technology in all aspects of human society" [6]. Parviainen et al. [4] define DT specifically as changes in ways of working, roles, and business offering caused by adopting digital technologies in an organization, or in the operation environment of the organization. Digitalization can enable and create new business opportunities and business models, change the roles of operators in a value chain, and even dislodge existing businesses [1],[7]. For example, digitalization may remove traditional players in a supply chain and create new ones.

Small and medium-sized enterprises (SMEs) represent the lifeblood of economies and are considered a driver of the European Union (EU) economy [8],[9]. Micro-enterprises, which refer to a subset of SMEs with fewer than 10 employees, represent more than 95% of European enterprises [10]. Digitalization is important for SMEs to stay competitive. DT is a key enabler for maintaining competitiveness and reacting to continuous changes and pressure. However, only 17% of SMEs in Europe are highly digitalized [10]. Whereas large companies are at the frontline of DT [11], SMEs are struggling with resource constraints and knowledge gaps that slow down their digitalization efforts [7],[12],[13]. Some of the strongest inhibitors to adopting (e-business) digital services and applications in SMEs are inadequate capabilities and limited resources to develop and maintain an e-business operation, limited information technology (IT) skills, low customer or supplier usage, and short planning horizons [14],[15],[16]. On the other hand, SMEs are agile, as they can be flexible in implementing projects and carrying out rapid openings [9]. But there seems to be a lack of guidance for SMEs to implement DT in practice [11]. Furthermore, it is important to understand that DT is not just about the technological dimension but also affects, for example, an organization's processes, culture, staff engagement, customer orientation, and business models [4],[7],[11]. Therefore, DT is characterized as multidisciplinary [17].

There are DT-related guides and models in the literature, for example [4],[11],[18]. However, there is a need for practical methods and tools to help SMEs assess their current position with respect to the DT process. Especially, there is limited research on how external organizations can help SMEs in this work [11]. The starting point for digitalization development work is to understand the overall current digitalization status of the organization and thus, create an overall picture of its strengths and weaknesses and possible improvement actions for the future; this is called the positioning phase. The aim of this research is to support SMEs to analyze their digitalization status to advance systematically in digitalization. The key question is: *How can SMEs be supported to analyze their current digitalization status and identify digitalization development ideas in their digital transformation process?*

This article is organized as follows. First, the literature background is presented in section 2. Then, the research design is introduced starting from an overview of the DT model as well as proposed tools used in the first, positioning, phase of the model. Next, the procedure for how the positioning phase was piloted in case companies is explained in detail. In section 4, the results and experiences of the company piloting are described with feedback given by case companies. Furthermore, the main lessons learned are discussed with literature reflection in section 5. Finally, the results are summarized, limitations discussed and future research targets and conclusions are suggested in section 6.

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

2. Literature review

This section summarizes the background of digital transformation models or processes and the tools and methods applied in SMEs to support their digitalization cases. A survey of relevant literature was conducted focusing on published peer-reviewed research articles.

Barann et al. [11] presented a two-phase procedure model for DT consisting of orientation and iterative transformation phases. They emphasized practical approaches for DT for SMEs, not abstract and conceptual. Their process model incorporates an intensive interface with publicly funded support units and tackles DT in pragmatic steps taking into account the nature of SMEs. However, the procedure has not yet been empirically tested. Li et al. [19] presented a process model of digital transformation by SME entrepreneurs. Their model focuses on capabilities building and change practices when entering cross-border e-commerce (CBEC). In addition, the role of digital platform service providers is discussed, as they could facilitate the DT of SMEs. Parviainen et al. [4] presented a conceptual DT model with the positioning phase derived from synthesis of diverse industrial cases (including three SME cases) carried out and existing literature. They saw digitalization as a phenomenon that affects many aspects of organizations, including information technology, strategy and business models, products and services, internal and external processes, organizational culture, etc. However, the developed model is generic, is not piloted in the article, and needs more details to bring it to closer to practice. Szopa and Cyplik [18] showed two-step digital transformation model in which the first step (analyze and evaluate the current stage of digitalization) maps well to the positioning phase with the assessment and analysis of the current level of digitization in a company. They further proposed the use of a digitalization index to measure the level of digitalization and additional quality analyzes, such as the Ichikawa diagram, and SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). SWOT is intended to analyze current solutions in terms of their strengths and weaknesses and then determine the opportunities and threats regarding the current extent of digitalization and potential expansion opportunities. In a case study, Szopa and Cyplik [18] calculated the digitalization index of a manufacturer company. Pan and Lee [20] exploited Lewin's [21] theory of change ("unfreeze-change-refreeze") as a framework for understanding the digital transformation process. This model emphasizes how employees feel about new ideas, explores their feasibility, and finally, comes to consensus to accept the ideas. This approach is interesting, as it tries to understand how changes occur, in the context of an individual and a collective group. Furthermore, Pan and Lee [20] piloted this model to analyze an accounting case in an SME.

Understanding the starting position is an important part of the digital transformation process [4],[22]. Digital maturity assessment tools can be used to analyze the current level of the digital readiness and performance of an organization [23]. Rauch et al. [24] examined 13 existing assessment and maturity models for SMEs and presented a matrix of Industry 4.0 concepts and maturity levels. In this approach, the current level and the target level are identified and visualized with a radar chart. A gap-potential quadrant facilitates the selection of the next steps. The authors pointed out that small companies would benefit if detailed descriptions of each maturity level and practical examples were added. This is particularly important, as many SMEs do not have highly qualified employees who have experience with all concepts [24]. Teichert [22] analyzes different maturity models developed by practitioners and academics. Their also combine the most common maturity areas identified in included studies. North et al. [25] proposed a dynamic capability-based framework for assessing the digital maturity of SMEs. The proposed framework allows SMEs to assess their digitalization maturity level. Assessment helps SMEs understand their current status, identify required capabilities, and anchor pilot initiatives in an overall picture of DT.

Räisänen and Tuovinen [26] examined diffusion and adoption of digital innovations in rural micro-enterprises and proposed a workshop method for spreading information and encouraging a positive attitude toward digital innovations. The authors also presented a real-life case that used the method. This method is interesting, because it provides a tool for influencing small companies' understanding of digitization and increasing the positivity in developing their own company's digitalization. Kotarba [27] considered DT to express the modification or adaptation of business models. He exploited the segments of business model canvases (BMCs) and mapped them with ontology elements: classical mainstream, Wave 1: 1980–2000, and Wave 2: Beyond 2000. These elements bring the characteristics of the digitization of their own era to the different dimensions of the canvas. However, he defined digitalization mainly from a

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

technical point of view, that is, as information technology. He did not focus on SMEs but brought out an interesting development by combining a well-known tool (BMC) with the concept of digitalization.

Peillon and Dubruc [28] reported eight manufacturing SME servitization cases. According to the authors, servitization can lead to increased sales and productivity, as well as innovations in value creation and customer interaction. Furthermore, the authors listed three customer-related digitalization issues: how to implement CRM (Customer Relationship Management), how to monitor the use of equipment, and how to handle cyber security. Trenkle [29] focused on formulation of an SME's DT strategy and provided a framework with four strategic dimensions: use of technologies, changes in value creation, organizational changes, and financial aspects. These dimensions have a total of 14 strategic questions with prewritten multi-choice options and descriptions. The framework was piloted with seven SMEs.

The contribution of the articles discussed above are summarized in Table 1 according to how the articles addressed the following themes:

- Did the article present a model or process for digital transformation?
- Did the model or process include a phase where the current status of digitalization is discovered?
- Have the tools or methods been applied?
- Did the article contain SME cases, or were certain specific SME issues addressed?

Table 1. Contribution to the digital transformation model, its positioning phase, use of tools or methods, and SME cases or focus on SME issues

Reference	Title	Digital transformation model or process	Current status of digitalization (positioning)	Tools or methods	SME cases or viewpoints
Barann et al. [11]	Supporting Digital Transformation in Small and Medium-sized Enterprises: A Procedure Model Involving Publicly Funded Support Units	Two-phase procedure model: Orientation and Iterative transformation.	Orientation phase: position company		Eleven requirements for DT support models for SMEs
Li et al. [19]	Digital Transformation by SME Entrepreneurs: A Capability Perspective	A process model of digital transformation by an SME entrepreneur			7 SMEs, cross -border e-commerce with digital platform
Parviainen et al. [4]	Tackling the Digitalization Challenge: How to Benefit from Digitalization in Practice	Four-stage model for digital transformation	First stage: positioning a company in digitalization	SWOT tool as part of the first stage	3 SME background cases
Szopa and Cyplik [18]	The Concept of Building a Digital Transformation Model for Enterprises from the SME Sector	Two-phase digital transformation model for enterprises from the SME sector	Phase 1: Analyze and evaluate the current stage of digitalization	The digitization index with 21 sub-indexes, Ichikawa diagram, SWOT analysis	One SME case (digitalization index of a manufacturer of school and office furniture)
Pan and Lee [20]	Leveraging Digital Technology to Transform Accounting Function: Case Study of an SME	Transformation process framework based on Lewin's [21] theory of change			One SME accounting function case

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

Reference	Title	Digital transformation model or process	Current status of digitalization (positioning)	Tools or methods	SME cases or viewpoints
Teichert [22]	Digital transformation maturity: A systematic review of literature		Maturity models enable the assessment of digitalization and indicate a potential development path	Presentation of different maturity models	
Rauch et al. [24]	A Maturity Level-Based Assessment Tool to Enhance the Implementation of Industry 4.0 in Small and Medium-Sized Enterprises			Maturity model-based assessment tool for industry 4.0	Field study with 17 SMEs
North et al. [25]	Promoting Digitally Enabled Growth in SMEs: A Framework Proposal	Understanding and development of capabilities for DT		Dynamic capability-based framework for assessing the digital maturity of SMEs	Framework tested with SMEs
Räisänen and Tuovinen [26]	Digital Innovations in Rural Micro-enterprises			Workshop concept	Workshops used to support the diffusion of digital innovations in rural micro-enterprises. Real-life case
Kotarba [27]	Digital Transformation of Business Models			Business model canvases and the digital transformation	
Peillon and Dubruc [28]	Barriers to Digital Servitization in French Manufacturing SMEs				Eight manufacturing SME servitization cases
Trenkle [29]	Survival in the Digital Age – A Framework for Formulating a Digital Transformation Strategy in an SME			Four strategic dimensions in the digital transformation framework with 14 questions	7 SME cases, formulating digital transformation strategy

Published digital transformation methods or approaches typically include steps for current state analysis, the target state definition, the pathway from the current state to the target state, and implementation and monitoring [9]. This sounds logical and is in line with the idea of the well-known Plan-Do-Check-Act (PDCA) cycle. However, despite the substantial research on DT, it seems that there is a need for practical grassroots-level tool-supported approaches that are suitable and carefully tried-and-tested for SMEs. Especially, there is a need for a process model incorporating external support units into DT work to support SMEs in digitalization efforts [9].

3. Research design

Our first research related to digital transformation was conducted in 2015 by gathering feedback and experiences from case companies to create and publish the first conceptual framework of the DT model [1],[4], as well as to develop the first digital maturity tool, called DigiMaturity tool [23], targeted for the positioning phase of DT. Regarding to the research presented in this article, in the beginning of 2018, an investigation of the DT phenomenon in the context of the DT model began, from the viewpoint of how companies' DT process can be guided, managed, and implemented

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

systematically in the environment of SMEs. A case study research approach [30] was selected to create better understanding of applying the DT model with the proposed tools in case companies. The main goal of the research was to validate the DT model and tools with SME case companies and understand how they needed to be further developed. The research focused on the first, positioning, phase of the DT model (see the next section for the model and its phases). The work was conducted between 2018 and 2019 in the project funded by European Regional Development Fund (ERDF), four regional development organizations and one SME in Northern Ostrobothnia, Finland.

3.1 Digital transformation model

Digitalization is not a big-bang change that will be done once in a lifetime. A company typically proceeds in small steps, and in practice, digitalization means systematically taking small steps instead of one giant leap. In this research, we apply the DT model that is based on our previous research [4] identifying a four-step model for the DT process based on literature and industrial cases. The DT steps are positioning, current state review, roadmap, and implementation (Fig. 1). The model has been equipped with practical tools and process for SMEs to carry out each step, bearing in mind that DT is an iterative process. This paper focuses on the practical implementation of the positioning phase of the DT model.
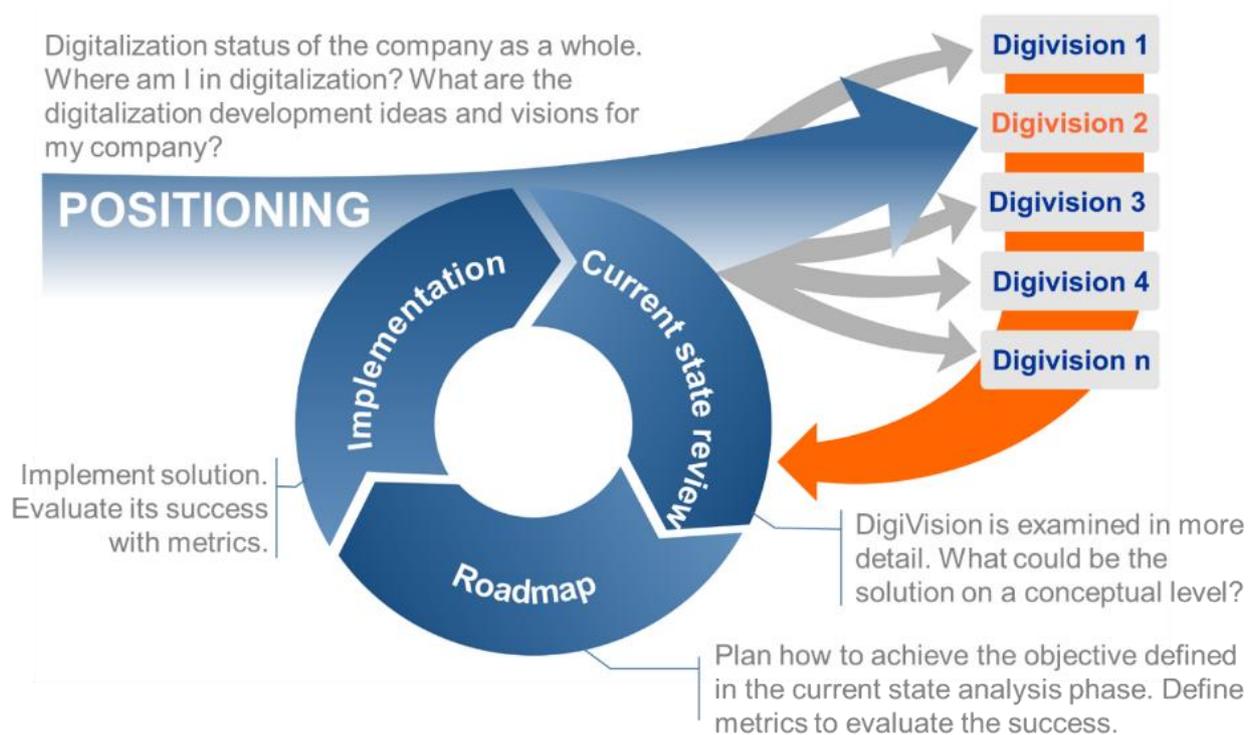
Fig. 1. Digital transformation model

The first step, the positioning phase, examines the digitalization status of the company as a whole. Where is the company with regard to digitalization? What are the digitalization development ideas and visions? Developing digitalization, usually comprising many development actions to perform at the same time, can be challenging. Therefore, it should be broken down into smaller pieces and implemented step-by-step taking one vision at a time for

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

analysis and implementation. Positioning is an ongoing process and should be done periodically taking into account changes in the company's operating environment and technological developments.

In the current state review phase, the selected digitalization vision is examined in more detail. This includes identifying the functions that are affected by the digitalization vision, as well as analyzing the processes and tools currently in use in the organization. Next, the solution concept is designed for the selected digitalization vision: What could be the solution on a conceptual level (objective)? It is important to think broadly and examine different options.

The roadmap phase aims to plan how to achieve the objective defined in the current state review phase. The step should describe possible alternative implementation paths, what kinds of resources are needed to implement the solution, and define metrics for evaluating the success of the implementation. Development work typically takes place in iterations. Therefore, the work should be broken down into manageable iterations: Each iteration brings the solution closer to the objective.

In the implementation phase, the starting point is the roadmap defined in the previous phase. Different methods and models can be used in the implementation. When piloting the solution, it is important to evaluate its success with metrics. Planning and implementation are often done iteratively. In the first stage, for example, a small-scale prototype or Proof-of-Concept (PoC) solution is implemented to test the feasibility of the solution before a larger-scale implementation.

3.2 Analysis toolset for the positioning phase

The toolset for positioning phase contains three tools (Fig. 2), starting from digital maturity analysis via SWOT analysis to DigiTriangle that sums up the digitalization development visions for the company. These visions are digitalization targets that the company wants to develop within a short- or long-term period.

Fig. 2. Digitalization status analysis tools (positioning phase).

The DigiMaturity tool [31] is a free-of-charge web-based digitalization self-assessment tool for organizations [23]. It was created for directors, managers, and experts to better understand the concept of digitalization and to assess their current digital maturity level. The DigiMaturity tool contains questions for companies structured under six dimensions: strategy, business model, customer interface, organization and processes, people and culture, and information technology. Therefore, the tool measures the digitalization status from a broad perspective, not only technological aspects. The self-assessment is done by selecting the most suitable option of the presented written answer alternatives. The tool calculates the maturity level value (from 0 to 4) for each dimension [23],[31]. Then, the respondents get a diagram (radar chart) that shows where the company stands in digitalization and where the company is compared to the average of other respondents. A specific comparison based on the domain or size of the company can be made if there are enough respondents in the reference group. The digital maturity baseline is valuable information for the company, but further understanding and concretization are required to allocate the development resources and activities so that the best possible impact and value can be created [23].

The DigiSWOT tool is used to analyze the strengths, weaknesses, threats, and opportunities of digitization in a company. The tool is based on the SWOT template and equipped with questions about how to apply it for analyzing the

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

strengths, weaknesses, threats, and opportunities of digitalization in an organization. Based on the SWOT analysis, the company should consider the following issues and define actions based on them:

- How can digitalization strengths be utilized better?
- How can digitalization weaknesses be turned into strengths?
- How can opportunities be seized?
- How can threats be avoided?

The DigiTriangle tool is used to classify the digitalization vision priorities of a company. In practice, the tool is a template that divides the digitalization visions into three areas where digitalization visions are filled in, internal efficiency, external opportunities, and disruptive change, as described in Parviainen et al. [4]:

- *Internal Efficiency:* Describes the digitalization ideas related to improving the internal company performance. For example, new IT solutions to streamline internal processes or the creation of a roadmap for information system development;
- *External Opportunities:* Describes the digitalization ideas related to the company's external capabilities when dealing with customers or partners. For example, new service ideas for customers, offering existing services in a new digital way, e-marketing, or cloud-based IT solutions for exchanging documents with partners;
- *Disruptive Change:* Describes the radical digitalization ideas of an organization that can enable completely new business for an organization or new partnerships, or lead to a completely new role for the organization in the value network.

The purpose of the triangle is to help the company structure and present its future digitalization visions as a basis for development work (successive steps of the DT model after the positioning phase). Some visions are short-term that could be practical and concrete, whereas others are long-term that are more like generic development ideas that will be specified in more detail in the future. Furthermore, it is important to outline the impact chains of solutions. For example, if a company aims for a smooth document exchange with a business partner, the company's internal document management must be in order first. Therefore, the DigiTriangle tool can also be used to outline development steps for prioritization and decision-making. In large organizations, the responsibilities of different internal and external improvement activities are typically separated. However, in small organizations, the person responsible for different improvement activities can be the same person. In the worst case, development work is done ad hoc alongside other tasks, which slows down the systematic development of digitalization. Even in this case, the DigiTriangle tool offers a framework for prioritization to advance systematically in digitalization.

In fall 2019, we published the DT model and associated tools as an open online service [32] (currently in Finnish) to allow free-of-charge access for companies and other organizations to utilize the developed DT model and tools in digitalization development. This service contains also a toolset for positioning phase making DigiMaturity, DigiSWOT and DigiTriangle tools available.

3.3 Piloting positioning phase of the digital transformation model with case companies

The tools and process for the positioning phase were tested in SME cases (Table 2). We conducted a positioning phase for 19 SMEs representing a wide range of sizes, domains, and businesses. The selection of case companies was supported by the ERDF project's four regional development organizations because they had good understanding and access to SMEs in their own area. The main issue was that companies were willing to improve their digitalization. The key digitalization person(s) in each company participated in the positioning phase. The case studies were conducted between spring 2018 and fall 2019. The company size classification was the following:

- Solo entrepreneur: one person;
- Micro-enterprises: more than one but fewer than 10 persons;
- Small companies: 10 or more but fewer than 50 persons;
- Medium-sized companies: 50 or more but fewer than 250 persons.

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

Table 2. Case company profile

Company	Size	Domain/business	Position phase participant in company (company participant(s))
C1	Solo entrepreneur	ICT/IT solutions	Owner-manager
C2	Solo entrepreneur	Real estate activities/real estate business	Owner-manager
C3	Solo entrepreneur	Service/photographic studio	Owner-manager
C4	Micro	Built environment/construction	Managing director
C5	Micro	Manufacturer/steel construction	Managing director
C6	Micro	Retail/clothing store	Managing director
C7	Micro	Service/gym	Managing director
C8	Micro	Service/restaurant & hotel	Managing director
C9	Micro	Service/rehabilitation	2 owner-managers
C10	Micro	Service/restaurant and hotel	Managing director, Sales assistant
C11	Small	Electric power industry/energy	Managing director, Network manager
C12	Small	Service / property maintenance	Managing director
C13	Small	Service/business development	Managing director, Business developer
C14	Small	ICT/solutions for automating knowledge work	Chief operating officer
C15	Small	Built environment/construction	Managing director
C16	Small	Service/logistics	Managing director
C17	Medium	Manufacturer/HVAC provider	Chief information and marketing officer
C18	Medium	Built environment/construction	Senior system administrator
C19	Medium	Manufacturer/machine construction	System specialist

Practical process and tools for the positioning phase are depicted in Fig. 3. The figure presents steps and tools as well as roles that participated in the analysis. The idea was that the company conducts the analysis in cooperation with public actors (research scientists). Next, the steps for piloting the tool with 19 case companies in practice are considered in more detail:

1. In the first step of the positioning phase, the SME participant was invited to respond to the DigiMaturity tool questions (self-assessment). As a result, the company participant received a digitalization maturity profile from the tool (a radar chart).

2. Next, the research scientists (two persons) analyzed the maturity profile and then compared it with the same domain and/or similar-sized companies in the DigiMaturity tool database [31]. This analysis was based on the answers of the DigiMaturity tool from the previous year (the answer rate for the DigiMaturity tool questions is about 100 organizations per year ranging from solo entrepreneurs to large companies). Furthermore, the research scientists became acquainted with the background of the company based on its web pages and news articles.

3. Then, approximate 1.5-hour interview and workshop session were arranged for each company. The position phase participant in the case company (one or two participants) and two research scientists attended this session. One research scientist was responsible for asking questions and leading the discussion during the session, and the other was responsible for documenting the discussion. These sessions were arranged as face-to-face sessions and

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

were recorded so that the research scientists could check the discussion afterward if something was left unclear when compiling digitalization status analysis summary document. The session contained the following agenda:

▪ Background interview questions about the company's history, business, and domain;

▪ Semi-structured interview with frame based on the DigiMaturity tool questions. The intention was to understand and document in more detail what was behind the respondents' answers, lessons learned from digitalization and if there were possibilities for improvement (digitalization improvement ideas);

▪ The DigiSWOT tool questions were answered with the company participant in workshop session indicating the strengths, weaknesses, threats, and opportunities of digitalization in the company and potential digitalization improvement ideas for the company;

▪ Furthermore, in the workshop session the DigiTriangle tool was filled in with improvement ideas based on the interview and DigiSWOT, and they were discussed and elaborated to express the company's short- and long-term digitalization ideas. These ideas were called the case company's digitalization visions, and they were classified and documented according to the DigiTriangle areas;

▪ At the end of the session, research scientists asked the companies for comments about the tools and the digitalization status analysis session: how useful they saw the analysis for the company, feedback about the tools and process used, and what kind of improvement ideas they had for the tools and process.

4. After the session, the research scientists compiled a digitalization status analysis summary document for each company containing the analysis results: Where is the company in terms of digitalization? Threats and opportunities? Digitalization visions: short-term, long-term? This summary was sent to the company participant for comments, and based on them, the research scientists finalized the summary document that was sent to the case company.
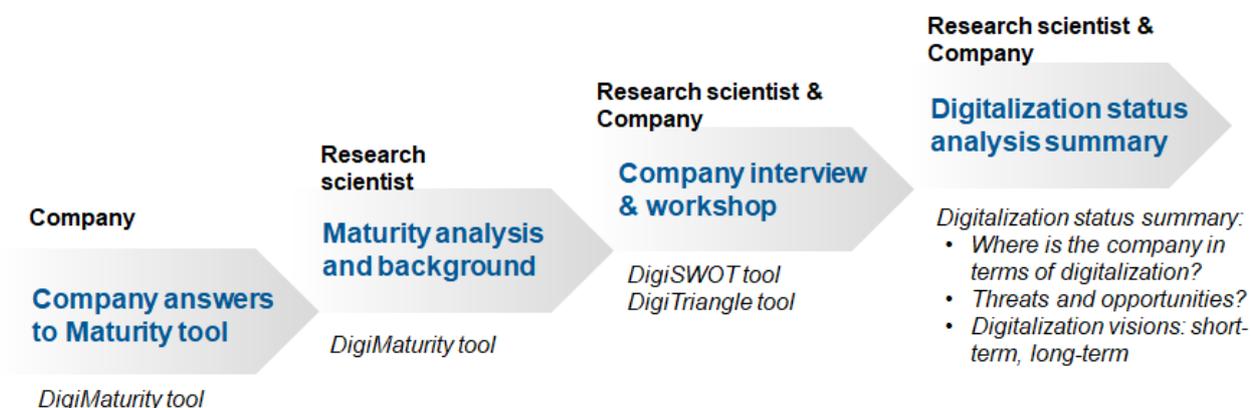
Fig. 3. Tools and process for the positioning phase of the DT model.

4. Results

4.1 Tools and process for the positioning phase of DT model

This research considers how SMEs can be supported to analyze their current digitalization status and identify digitalization development ideas in their digital transformation process. Our approach was to equip the positioning phase of the DT model with an analysis process and tools. Then we carried out 19 company cases where the tools and process for the positioning phase were applied to identify and analyze the status of the digitalization in the case companies. This resulted in a tried-and-tested positioning phase process and toolset (Fig. 3) for analyzing SMEs'

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

current digitalization status and finding improvement visions for future. The comments of the case study participants indicated that companies found the systematic digitalization status analysis useful for understanding their digitalization status and initiating digitalization development. This was emphasized, for instance, by companies C17 and C14 as follows:

> *The digitalization status analysis gave us a good understanding where we stand in digitalization. The approach transforms a complicated phenomenon into a clear model that guides the assessment and development of digitalization. (Chief information and marketing officer of C17 company)*

> *We are a leading developer of license-free robotic process automation products and services. Our company obtained in the digitalization status analysis an excellent insight into our digitalization strengths and improvement needs. (Chief operating officer of C14 company)*

In the case studies, it was notable that for micro-enterprises, one bottleneck is time. Based on these case studies, it seems that micro-enterprises in particular need support in identifying digitalization opportunities and brainstorming new solutions. Furthermore, smaller companies found it useful to discuss digitalization with an external person to gain understanding and new insights. These issues were highlighted by the managing director of C6 company:

> *Systematic-supported approach in digitalization status analysis and identifying digitalization visions was important in the hectic everyday life of a small company. Otherwise, more far-reaching digitalization development work would have easily been overshadowed by acute everyday operations. The company's digitalization status has become clearer, and our understanding of the digitalization possibilities has increased. Furthermore, the digital service ideas to be developed have become more concrete.*

However, some small micro-enterprises saw the current version of the DigiMaturity tool as challenging, especially the terminology and how the questions and response options are posed. These case companies also needed concrete digitalization examples as the basis for the questions of the DigiMaturity tool. The owner-manager of C2 company stated:

> *DigiMaturity tool terminology is not clear for the solo entrepreneur ... term "strategy" could be "operational development plan" ... term "organization" means for the solo entrepreneur just one person ... practical examples related to DigiMaturity questions would make it easier to understand the questions and facilitate the selection of right answer alternative.*

DigiTriangle was found to be a good way to collect digitalization visions into one figure classifying which to target for improvement of internal efficiency, better utilization of external opportunities, or more radical disruptive change. The chief information and marketing officer of C17 company stated that "*for us, the DigiTriangle proved to be a good tool for conceptualization in our digital development*".

The open online service [32] was only published in fall 2019, but we already received positive feedback about it. "*ApuaDigiin.fi is a good start and a toolkit for companies to develop their digitalization*" told the managing director of C13 company. The tools and process that were used to analyze the digitalization status and find improvement visions are now freely available. However, the webservice needs further development and improvement in usability.

4.2 Digitalization visions and lessons learned from company cases

Next, the digitalization visions that emerged during the positioning phase are considered. Digitalization visions of companies' digitalization status analysis summaries were compared to determine whether common themes appeared in the visions of different companies. Certain themes emerged from the analysis. In Table 3, the most common themes are shown.

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

Table 3. Most common digitalization vision themes in case companies.

		Internal efficiency				External possibilities			Disruptive change	
		Description of current strategy, processes and/or use of tools	Development of a roadmap to clarify the company's IT / digitalization development	Information systems, integration and document sharing	Automation of knowledge work	Offering services through digital channels or improvement of existing digital services	Exploitation of cooperation and partnerships	Digital marketing: sharing customer references in digital form, new digital channels for marketing and systematization of digital marketing	Ecosystems, networks, communities, platforms for developing solutions and providing products or services	Utilization of new technologies (IoT, real-time solutions, intelligence, augmented reality) in products and services
C1	Solo-entrepreneur						x	x		
C2	Solo-entrepreneur		x	x			x		x	
C3	Solo-entrepreneur	x					x	x		
C4	Micro	x	x					x		
C5	Micro	x	x		x		x		x	
C6	Micro						x		x	
C7	Micro		x	x		x	x	x	x	
C8	Micro		x	x			x			
C9	Micro		x					x	x	
C10	Micro	x	x			x	x	x		x
C11	Small	x		x	x	x			x	
C12	Small		x				x	x	x	
C13	Small	x		x		x			x	x
C14	Small	x				x				
C15	Small	x	x					x		x
C16	Small	x	x			x		x	x	
C17	Medium				x	x			x	x
C18	Medium	x			x	x			x	x
C19	Medium		x			x			x	x
TOTAL		**10**	**11**	**5**	**4**	**9**	**9**	**9**	**12**	**6**

Next, the digitization visions and experiences of case companies are discussed based on interview and workshop sessions.

Internal efficiency: Especially in small and micro-enterprises, a company's strategy, processes, and use of IT tools can be informal and undocumented. As a company grows, it becomes increasingly important to describe them and systematize the processes and the use of tools. Furthermore, lessons learned indicate that the digitalization basics, such as information systems, communication tools, document management, and websites, must be put in order before further digitalization. Then, a company can start to build solutions for automation and integration. In particular, we found that in medium-sized companies, automation is increasing, and new technologies, such as software robotics (robotic process automation, RPA), are already in use or are being piloted to automate routine IT tasks. The development of

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

digitalization and IT systems should be carefully set out in a roadmap, and the organization must not be stifled by new solutions. Staff needs time to get used to new information systems and processes in their own work before new ones are introduced. Furthermore, it was stated that finding a good IT or digitalization partner can be difficult for small and micro-enterprises. This does not decrease the importance of a company's own digitalization planning. A company should have an understanding of its own digitalization situation and the digitalization needs of the domain and customers, so that the company can start to advance along the digitalization pathway based on its own (internal and external) situation. Some entrepreneurs said that they had utilized available online educational (e.g., Google's Digital Garage) and marketing material or watched digitalization-related webcasts to improve their digitalization skills.

External opportunities: Companies are increasingly planning to provide their services or products through digital channels or enriching services provided through existing digital channels. An example of this is enabling the purchase of additional services related to an existing service or a product. Development activities and needs related to digital marketing emerged in the interviews. Many companies are familiar with digital marketing, but especially small enterprises and solo entrepreneurs need more concrete digimarketing guidance and support (this was indicated by case companies). The versatile use of digital marketing channels, the utilization of customer references in digital form, and the systematization of digital marketing, in general, were on the companies' "to-do list." After all, digital marketing can give a small company broad visibility at a reasonable cost as stated by the owner of C9 company: "*Even a small company can be visible as well and extensively as large companies by taking advantage of digital marketing.*"

Disruptive change: Related to the disruptive change, companies' digitalization development activities often aim at a longer time period and contain many uncertainties, although some of the case companies had progressed toward disruptive solutions. According to the results, especially medium-sized companies have visions for disruptive change. In the company interviews, disruptive change was discussed at the company level as a radical new way of working in a company, for example, as a completely new business, a new kind of cooperation with other companies, or a new kind of "non-mainstream" solution for certain problem. However, this requires understanding of customer needs and purchase behavior which can be supported with digital tools. This better understanding of market needs was stated by the managing director of C13 company: "*Digitalization helps to understand customers' needs more deeply and to focus investments where the market of the future is.*"

Emerging technologies may provide new possibilities, such as the use of the Internet of Things (IoT), augmented reality (AR), or artificial intelligence (AI) in products or services, or using digital solutions to enable a completely new service business in addition to the product business. This was indicated especially by medium-sized companies. Furthermore, many companies of different sizes and in different domains indicated visions for ecosystems, networks, communities, and platforms for developing solutions and providing products or services.

5. Discussion

In this article, we explored how SMEs can be supported in the DT process in practice focusing on the positioning phase of the DT model. It and associated tools were piloted in 19 SMEs. The purpose was to test practical tools and process for the positioning phase of the DT model in real-life business cases. The need for a practical approach for DT was also emphasized by Barann et al. [11]. They stated based on their literature review that existing models are mainly conceptual, and ideal-theoretic steps are hardly aligned to actual practical needs of SMEs. The feedback received from the case companies in our research supported this interpretation. The starting point for the DT model was also generic [4] and therefore, had to be put into practice by defining tools and process and piloting them in company cases. This work started from the positioning phase of the model. According to the results of our research, the positioning phase with practical process and tools was found to be useful in analyzing digitalization as a whole in the case companies and systematizing its development.

Based on this research, solo entrepreneurs and microenterprises, in particular, seem to need practical support in identifying digital opportunities, brainstorming solutions, and structuring digital development. This is in line with the findings of Räisänen and Tuovinen [26], who stated that microenterprises, especially, need help with exploiting

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

digitalization. To support this, they presented a possible workshop method for promoting the diffusion and adoption of digital innovations. Such workshops are one opportunity for the public actor to inform SMEs about the potential of digitalization and to help change attitudes toward digitalization. This method might be used to orientate and motivate micro-enterprises for improving their digitalization and scan potential candidates for public actor supported DT in future. Barann et al. [11] discussed how to incorporate external organizations, such as competence centers or research institutions (i.e., support units), to help SMEs to understand and implement DT initiatives. The authors stated that small companies require a practical approach for digitalization focusing on feasible and tangible goals. The approach is highly iterative and includes the formation of an inter-organizational planning team (the company CEO and members of the support unit) to analyze the digitalization of the company in practice [11]. Our approach presented in this article involves company representative(s) and research scientists in analyzing the digitalization status of the company and determining improvement targets. Furthermore, this approach has been published as an open online service [32] making the DT method and tools available to other publicly funded organizations to help SMEs in their digitalization efforts. A future target is that publicly funded support organizations could also enrich the online service with new digitalization-related tools, methods, and experiences. The openly available tools and the DT method can also be used by SMEs that want to analyze their digitalization status and find improvement ideas on their own without support from external organizations. However, this kind of "self-service" should be considered and tested in future company cases (i.e., are the tools and process consistent and easy to use so that companies can perform the whole analysis as a self-service without support from external organizations?).

In our approach, the companies responded to the DigiMaturity self-assessment tool. The feedback showed that the use of the tool was challenging for some micro-enterprises and especially for solo entrepreneurs. They commented that there are development needs regarding the vocabulary/terms and how the questions and response options are posed. Furthermore, some respondents needed concrete digitalization examples to clarify the questions. Similar attention was paid by North et al. [25] who stated that a framework designed for SME entrepreneurs must have a simple structure, utilizing visualization, and maturity levels should be described in comprehensible language. Rauch et al. [24] stated that detailed descriptions and practical examples in maturity models make it easier for SMEs to determine their own maturity level. The authors emphasized that this assistance is particularly important, as many SMEs do not have highly qualified employees who have experience with all concepts. Digital maturity assessment can be as self-assessment or 3rd party assisted assessment [22]. In our model DigiMaturity tool is intended to be self-assessment and must therefore be clear and simple. Based on the results, we are developing a new variant of the DigiMaturity tool for micro-enterprises and solo entrepreneurs to make it easier for them to answer the DigiMaturity tool questions. This ongoing research will be presented in Kuusisto et al. [33].

Based on the positioning phase pilots, it can be stated that the case companies that participated in this research have digital development activities planned or ongoing, which are related to the companies' internal efficiency and external opportunities. In addition, some companies are pursuing a more radical change, such as a completely new type of business or service. In the longer time period, many companies seek collaboration networks or ecosystems with other companies, or even platform business. It has been stated that the most prominent digital growth strategy involves the use of digital platforms, as two key drivers behind growth are the platform's high scalability potential and network effects [17]. Verhoef et al. [17] further illustrated business growth opportunities enabled by digital platforms. For SMEs, digital platforms enable many opportunities for joining in an ecosystem based on digital platforms created by someone else and for creating potential ecosystems based on their own digital platform (make or join decisions). Doing business on someone else's platform comes with a cost, such as sharing revenues with the platform provider and being under its control, as the platform provider usually sets out the rules of the platform (and the way business is conducted on the platform). However, Li et al. [19] discussed that digital platform service providers can also help SMEs in DT when joining a digital platform (by mentoring, facilitating and rulemaking).

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

6. Conclusions

This article considered digital transformation (DT) in the context of SMEs. Digitalization is not just about making existing manual processes digital. Companies should rethink their current operations and business models from new perspectives enabled by digital technologies. This could lead to completely new businesses or new partnerships or to a completely new role in the value network. It is important to understand that DT is not just about the technological dimension. DT also affects an organization's processes, culture, staff engagement, customer orientation, and business models, all of which must be considered in DT. The goal of the article is to support SMEs to analyze their digitalization status and advance systematically in digitalization, that is, how SMEs can be supported to analyze their current digitalization status and identify digitalization development ideas in their digital transformation process.

This article explored how to help SMEs in DT, especially during the positioning phase, in practice. The DT model and associated tools for the positioning phase were piloted in 19 SME case companies. Based on the results of the research, the positioning phase with tools and process were proven to be useful and suitable for analysis when a company representative does it in cooperation with a support organization (in this case, with the research scientists of a research institute).

The research has certain limitations. First, the results of the evaluation are based on cases with 19 companies which is limited sampling, and more evidence is needed. Second, digitalization visions represent artefacts that are plans for future; it is not self-evident that they are exactly the right actions that the company should take. Therefore, it would be interesting to follow company cases as longitudinal cases to verify their business impact on the company in the future (i.e., did we find the right digitalization visions with DT positioning process and tools?).

The research increased understanding of DT in SMEs but also opened up new research questions as well as development paths. The following future research and development actions have been identified:

- More company cases should be conducted to get more evidence about the tools and process, as well as longitudinal case studies to see how identified digitalization visions have been realized in case companies and what kind of business impact they have had;
- There is a need to expand the study to the other stages of the DT model defining detailed practical tools and processes and piloting them in company cases. This research should utilize existing models and approaches that have been reported in literature;
- Other publicly funded organizations should be involved to validate the approach to get evidence about its suitability for different types of publicly funded organizations (e.g., regional business development organizations, universities, universities of applied science). What kind of guidelines do these organizations need for using positioning-tools, to be able to help SMEs in digitalization status analysis and identification of improvement visions?
- Openly available tools and DT method can also be used by SMEs that want to analyze their digitalization status and find improvement ideas on their own without support from external organizations. Company "self-service" should be examined and piloted in future company cases (i.e., are the tools and process consistent and easy to use so that companies can perform the whole analysis as a self-service without support from external organizations?);
- The new variant of the DigiMaturity tool that is under construction for micro-enterprises and solo entrepreneurs should be piloted, and experiences collected in case companies;
- Case companies brought out the important role of ecosystems and platforms as a disruptive goal. Therefore, there is a research need for guidelines, tools, and case examples to help SMEs better understand ecosystems and platforms, what kind of business opportunities they may provide, and how to build this kind of business.

IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

This article summarized the main findings and lessons learned in applying the positioning phase of the DT model in challenging environments of SMEs. The results showed that the proposed process and tools were useful and suitable for digitalization status analysis and identifying potential digitalization development visions.

Acknowledgments

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IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

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IJISPM

Applying the positioning phase of the digital transformation model in practice for SMEs: toward systematic development of digitalization

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Continual learning with a Bayesian approach for evolving the baselines of a leagile project portfolio

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Abstract:
This article introduces a Bayesian learning approach for planning continuously evolving leagile project and portfolio baselines. Unlike the traditional project management approach, which uses static project baselines, the approach proposed in this study suggests learning from immediately prior experience to establish an evolving baseline for performance estimation. The principle of Pasteur's quadrant is used to realize a highly practical solution, which extends the existing wisdom on leagile continuous planning. This study compares the accuracy of the proposed Bayesian approach with the traditional approach using real data. The results suggest that the evolving Bayesian baselines can generate a more realistic measure of performance than traditional baselines, enabling leagile projects and portfolios to be better managed in the continuously changing environments of today.

1. Introduction

Today's project management environment is much more dynamic and complicated than it has been in the past few decades. These days, organizations often need to continually change their product requirements to adapt to changes in the project environment [1]. Furthermore, the increased demand for fast project delivery with changing conditions has underlined the necessity for project managers to look for better project management solutions and resources.

According to a report on the talent gap for the years 2017–2027 published by the Project Management Institute (PMI), by 2027, for the 11 countries analyzed, employers will need 87.7 million individuals working in project management-oriented roles [2]. This surge in demand for employees could result in a $207.9 billion loss globally. Moreover, the effectiveness of project management execution is rapidly decreasing [3]. The 2018 CHAOS Report found that only 14% of projects completed in 2017 were genuinely successful; the remaining 86% accounted for challenged or failed projects [4]. McKinsey and Company reported that 17% of large information technology (IT) projects with project budgets over $15M go extremely wrong, threatening the existence of the whole company [3]. Project complexity negatively impacts project success, and the percentage of projects with high complexity rose from 35% in 2013 to 41% in 2018 [5]. Increasing project complexity poses significant challenges in assessing project performance. Continually evolving projects and portfolios require an evolving scale of measurement to accurately identity failures and successes. It is certain that the project management world will experience an increase in the complexity of IT projects, where traditional tools and models like the waterfall model will not be sufficient to measure the performance of modern dynamic projects [6].

The published studies discussed in this article (refer to literature review section) mainly focused on the growth of project complexity and the negative impact of massive project failures, risk factors, and success criteria; however, none of them explored whether the scale of the performance measures used in the current project management industry was effective for modern projects. The aim of this study is to establish a new straightforward tool (refer to the proposed evolving baseline method section) for managers that will allow them to measure leagile project and portfolio performance with respect to dynamic and evolving baselines. Specifically, a statistical model is developed (refer to methodology section) to assess the evolving baselines of leagile projects by incorporating continual learning from immediate past performance (refer to results and analysis section). This will facilitate the adoption of leagile project management in a broader range of projects (refer implication of the study section), improving their management and chances of success.

The paper is organized as follows. Section 2 reviews the existing work in project/portfolio management; continuous planning delivery improvement; comparisons of leagile, Scrum, and plan-driven approaches; and existing project management challenges. Section 3 describes the methodology of this study and the SharePoint optimization data used for the evaluation. The methodology outlines the Bayesian continual learning framework and a comparison study to validate the proposed model against the traditional plan-driven model. Section 4 presents the results of this study. Section 5 provides the conclusions and limitations of the current study as well as recommendations for future studies.

2. Literature review

This section presents the findings from related research and case studies to expand the current perceptions about project and portfolio management processes. It begins with traditional plan-driven approaches and the agile delivery model, then explains the latest leagile continuous planning and delivery process.

2.1 Project management approaches and challenges

Theories and concepts about project management are ancient and have been rooted deep in all cultures from the stone age to the modern age. Project management has only become a formal discipline for delivering and managing novel ideas comparatively recently. As defined by the PMI, a project is a unique endeavor that delivers a new or enhanced but always unique solution [5]. It must always have a definitive start and end dates, and is a combination of quality, risk,

procurement, time, cost, schedule, resource management, and most importantly, scope, integration, and the communication of management disciplines [5].

Project and portfolio management processes have improved since their inception; however, their failure rate has not decreased [12]. KPMG (Klynveld Peat Marwick Goerdeler) International Limited conducted a survey in New Zealand on projects managed in 2010 and 2012. It found an unexpected increase in project failure rates in 2012 when compared with the 2010 survey data [7]. Similarly, the PMI analyzed their project performance in 2015 and found only 64% of the projects met their goals; the failed projects either had scope creep or simply could not survive [8]. The report recommended the use of lessons learned to improve the project success rate. Furthermore, the 2013 CHAOS Report [9] found a similar result, where only 39% of the projects succeeded. The 2014 CHAOS Report further found that the rate of success—on-time and on-budget— was only 9% [10]. Similarly, a study was conducted to understand the confidence level of project managers regarding project success [11]. It suggested that about 75% of managers lack confidence that their projects will be successful in the end. Most respondents claimed that the uncertainty associated with success criteria makes it difficult to deliver to expectations consistently [11], [13]. A recent study [14] confirms this fact that the larger sized projects are extremely complex; thus, the successful completion rate of such larger projects is much lower than smaller projects. Basit et al. [15] looked into why projects are failing a lot more than past within recently published 33 relevant studies and found the top three reasons for in-house projects as "overrun budget & resources", "unrealistic estimated schedule," and "technical complexity". It is known that the complexity always increases with uncertainty [16] and demand for faster software development [18] are creating unrealistic schedules. These studies leave us with the conclusion that project performance measurement is changing over time [19]; the way we define and measure project success in a complex environment may be outdated [15], [12], [13] and a change is required to establish a common language for success [21], [20].

Traditional plan-driven approaches like waterfall models are falling short in delivering the right product in the modern environment, especially when the project idea is extremely new and the execution happens in an uncertain and complex environment. A plan-driven approach estimates everything during the early phases and the baselines (boundaries) are defined by fixed project plans [22]. Such an approach cannot learn and improve continually based on recent executed events. As a replacement for the traditional approach, multiple types of agile and lean models are emerging to provide better solutions. One of the most famous agile delivery models is scrum. Schwaber was the first known scholar with several publications to support agile scrum as a new iterative and complex adoptive system to deliver pieces of the product in iterations with minimal upfront architecture design and planning effort [23]-[27]. It was reported that waterfall requires ten times more effort than scrum, whereas the velocity of scrum is seven times faster than waterfall, and the customer satisfaction of scrum is significantly better than waterfall [28]. Agile itself has improved in diverse ways in the last two decades. The disciplined agile delivery (DAD) model has gained fame in the last few years. DAD is a people-first agile framework that is specifically generated by picking the best elements of other Agile models like XP, Scrum, and Kanban [29]. Disciplined Agile (DA) became so popular after 2012 that the PMI recently adopted it with four new different certification programs. The DA Toolkit supports continuous improvement and scalability while allowing team members to choose their way of working (WoW) [30].

A continuous process of learning and improvement is required to sustain competitive advantages and thrive in rapidly changing market conditions [31]. It is not an overnight process; continuous improvement, also popularly known as Kaizen, and the process of waste removal for value addition, a Lean approach, cannot be achieved immediately. It is a continually evolving process [31]. Traditional plan-driven and standard agile models still cannot comprehend the possibility of system evolution for a set of complex projects. It requires system thinking, which enables all three aspects: Kaizen, Lean, and Agility, like the leagile delivery model.

2.2 *Evolving leagile project portfolio baselines*

To incorporate lean strategies in agile projects, a new version of the project delivery model has emerged Lean-agile (leagile), as referred as LeAgile. In 1999, Naylor et al. [32] proposed the leagility philosophy for manufacturing production. Later, the leagile idea continued to evolve into many sectors like healthcare, professional services, and most importantly, into software development.[6], [32]-[38]. The leagile method applies lean management to reduce waste in

the process and uses agile's iterative strategy to support agility and faster delivery. In this model, lean thinking contributes towards project process evolution, and agile focuses on agility and continuous delivery. As a result, portfolio and project management processes are also continuously improved in the leagile model.

To transform the complexity of modern projects, leagile requires continuous planning and efficient decision-making strategies. In general, existing agile and leagile approaches invest in minimal upfront architecture design and planning; project teams are expected to deliver faster on "not-all-known" scope in smaller packages [24], [27]. In his book [27], Cline argues against the agile teams' mindsets of "no-up-front-anything" and "learning upfront is a waste of time." He suggests that minimal necessary planning and learning are required to deliver a product as expected by business versus no planning at all. In the software development domain, where projects are managed in a dynamic and complex environment, current versions of agile and leagile models are incapable of continually planning for the immediate future [35], [36]. One of the reasons is that these models have not been extensively used in software development, and another is that the technology of software itself is advancing faster than the software development life cycle. These existing project delivery models cannot efficiently address the evolving baselines needed to seek accurate performance measurements for the continuous planning of large project portfolios.

The standard portfolio management is defined as the coordinated management of interrelated projects by which an organization evaluates, selects, prioritizes, and allocates its limited resources to accomplish the best organizational strategies [39]. One of the critical steps in this process is portfolio prioritization based on project baseline measurements, which is prone to extreme missteps because of the complexities involved in decision making during project selection and project task allocation[40]. The traditional plan-driven approach uses a fixed portfolio baseline, which is created during the planning phase and stays fixed until the end of the project [41]. By contrast, the leagile model has a dynamic baseline that evolves over time [41]. Figure 1 illustrates a portfolio with four plan-driven projects and two leagile projects. Plan-driven projects have straight lines, representing the fact that there is no change in the baselines. By contrast, leagile projects have dynamic baselines that constantly shift. In reality, the measurement of success in a complex and dynamic environment should follow evolving baselines rather than the fixed baselines of the plan-driven approach. Besides, a study by Fadaki et al. [19] found that if both leanness and agility equally embedded in system and continually evolved, then the higher performance is achievable.
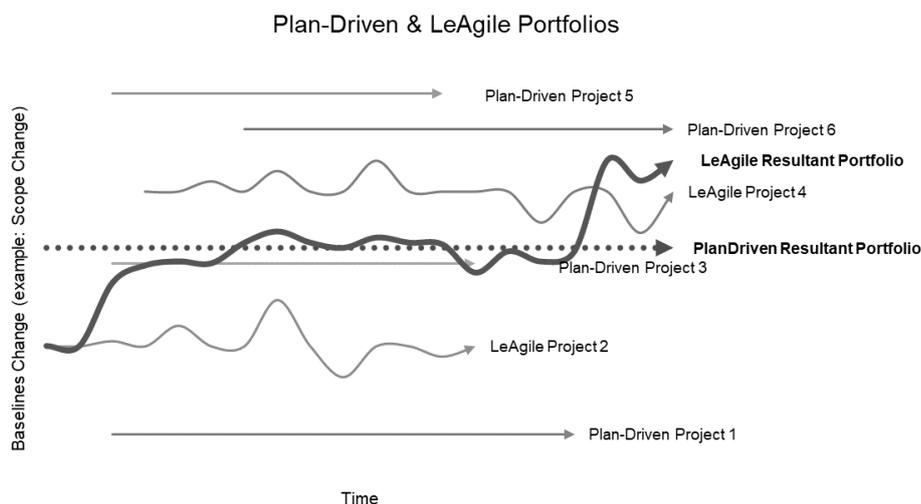

Fig. 1. Portfolio baselines for plan-driven projects and leagile projects

Similarly, the study [40] proposed an IT portfolio management process framework, which references the concept of continually self-organizing portfolios based on learning from the analysis, screening, continuous optimization, and adjustment of the portfolio to achieve evolution and success. In a rapidly changing environment, a portfolio becomes exceptionally complex. The plans and strategies will not work if they stay static throughout the life of the portfolio; instead, they should continually evolve with the experience gained from recent past events [40]. Continuous planning and improvement are crucial in keeping the portfolio alive (reduced risk) given modern complexity [37], [42].

In the IT project management context, according to Fitzgerald and Stol [43], the only forms of continuous planning used are sprint iteration planning, developed from the agile approach, and software release planning. Continuous planning has not yet become widespread throughout all organizations, especially in the context of software development [6]. In addition, a mindset to achieving consistent success has not been established. Only 2.5% of companies complete their projects successfully [44]. Consistently delivering successful projects is the key to the genuine success of a business [45]. Consistent success requires: i) direct "line-of-sight" feedback on project progress; and ii) incorporation of "learning from experience" for the continuous improvement of project management processes and practices [45], [34, p. 106-109].

In modern project management practice, it has become critical to establish a learning system that incorporates lessons from failures with immediate adaptation to sudden changes while maintaining the transparency of knowledge throughout multiple project teams to strategic portfolio leaders [45], [46], [47]. Furthermore, the recently published CHAOS Report [4] introduces a new definition of project success called "pure success." Pure success is the successful delivery of high customer satisfaction and the generation of a high return on value to the organization [4]. Classic success is the completion of the project on-time and on-budget based on predefined baselines and quality. The report compared pure success with the classic definition of success and found drastic changes in the rates of reported success [4]. When the new definition of success is used, the project success rate decreased to 14% from 36%, and the challenged project rate increased from 45% to 67% [4]. This report reveals that the traditional approach of estimating the performance and baselines produces inconsistent and inaccurate results for modern projects. To achieve pure success, the management team needs to continuously learn from executed tasks and change their product requirements to adapt to changes in the project environment. Pure success requires lean process improvement and learning. Few recent studies used computer-assisted algorithms to establish learning in a project, like learning and feedback loop system [48], work package size optimization for value improvement [49], Bayesian approach for portfolio risk identification and reduction [42], [50], Bayesian approach for traditional waterfall-type earned value planning [51] and modeling uncertainty [16]. The existing studies for success of leagile project system mainly focused on the risk factors, continuous improvement factors, complexity aspects, pros and cons, definitions, acceptance of agile or lean, and causes of failures [6], [15], [18], [27], [37], [38], [48]. However, we found no study which provided a practical and convenient solution for engineering managers on the implementation of learning to reduce these challenges and complexities. This finding supports systematic literature review study by Stefan et al. [20], suggesting IT project complexity is increasing and there are no practical tools and models available yet for managers to achieve true project success.

This article argues that the increase of failure in a large complex project is not just because of the task performance; rather, it is because of the static scale used to measure the tasks. The scale should increase or decrease based on the recent experience of prior tasks. To address these challenges, this study supplies a simplistic learning tool to measure the performance of modern projects. Specifically, the objective of this study is to seek a more accurate estimation of project baselines against which iterative tasks can be measured in a dynamic environment based on continual learning from prior experience.

The study moreover aims to answer whether the evolving baseline provides a better performance measurement scale than the static baseline of the traditional plan-driven approach. A likelihood ratio test and Bayesian model is developed (next section) for the continuous estimation of evolving project baselines based on learning from recent past performance.

3. Methodology

This study is one of the first efforts to establish a practical performance measurement using the Bayesian continual learning approach for leagile portfolio management. This article focuses on the actual process improvement for a whole portfolio using the project-level tasks' experience. The proposed framework provides a simple formula to achieve learning and reduce uncertainty. This study follows the principle of Pasteur's quadrant from systems engineering (Figure 2) to both enhance project management knowledge and realize the immediate use of Bayesian continuous learning [52]. Furthermore, the likelihood ratio test is performed to compare the accuracy of the proposed model against a traditional model (refer to section comparison of approaches).

Pasteur's quadrant was named after Louis Pasteur, whose work exemplifies both advancements in knowledge on the subject matter and results with high social benefits by making them immediately available for use.
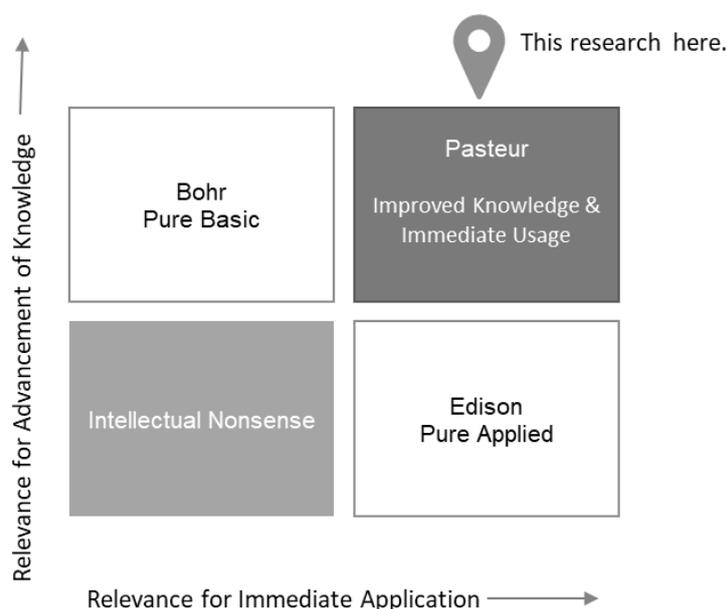

Fig. 2. Pasteur's quadrant

The static baseline approach in project management is an example of the Edison quadrant, which has high immediate usability but little improvement in knowledge, as presented by the bottom right block of Figure 2. Our proposed evolving baseline approach incorporates both the immediate applicability and improvement in knowledge located in the top right block of Figure 2. Specifically, Bayesian theory is used in our approach to estimate the evolving baseline by continually measuring the performance of executed tasks and predicting the confidence bounds of the baseline based on the newly learned posterior distributions. Figure 3 provides an overview of this study, which illustrates the proposed Bayesian evolving baseline approach, the traditional static baseline approach, and their comparisons to choose the model with the best performance.

This section is further divided into three subsections—the first subsection presents the details of the process flow and steps taken during analysis. The second subsection develops the proposed evolving baseline approach further by mathematically describing how the evolving baseline is generated from learning and Bayes rule. The third subsection presents a brief description of the traditional baseline approach used for comparison.

3.1 Methodology flow steps

In a traditional static baseline approach, the project team uses the historical lessons learned from past projects or make a rough order-of-magnitude estimation to establish baselines (e.g., mean, upper, and lower bounds of the probability of task failure) for future measurement. The baselines are often determined during the initiation and planning phases; they are then used throughout the entire life of the project.

For the traditional static baseline approach, as seen in the left section of Figure 3, the same POC baseline is used until the end of project life to measure performance. By contrast, in the proposed approach, the right section of Figure 3 continually updates its as soon as new learning occurs. In each measurement iteration, the count of failed tasks and total tasks from the completed bucket is grabbed and passed instantly to the Bayesian model. Measurement iteration in this article is defined as the cycle of measurements done for the completed tasks. It is not the same as the terms "iteration" or "sprint", which are used in adaptive models and agile scrum. A new event means a task or a set of similar jobs have been completed at a certain rate of success or failure when a measurement is collected.
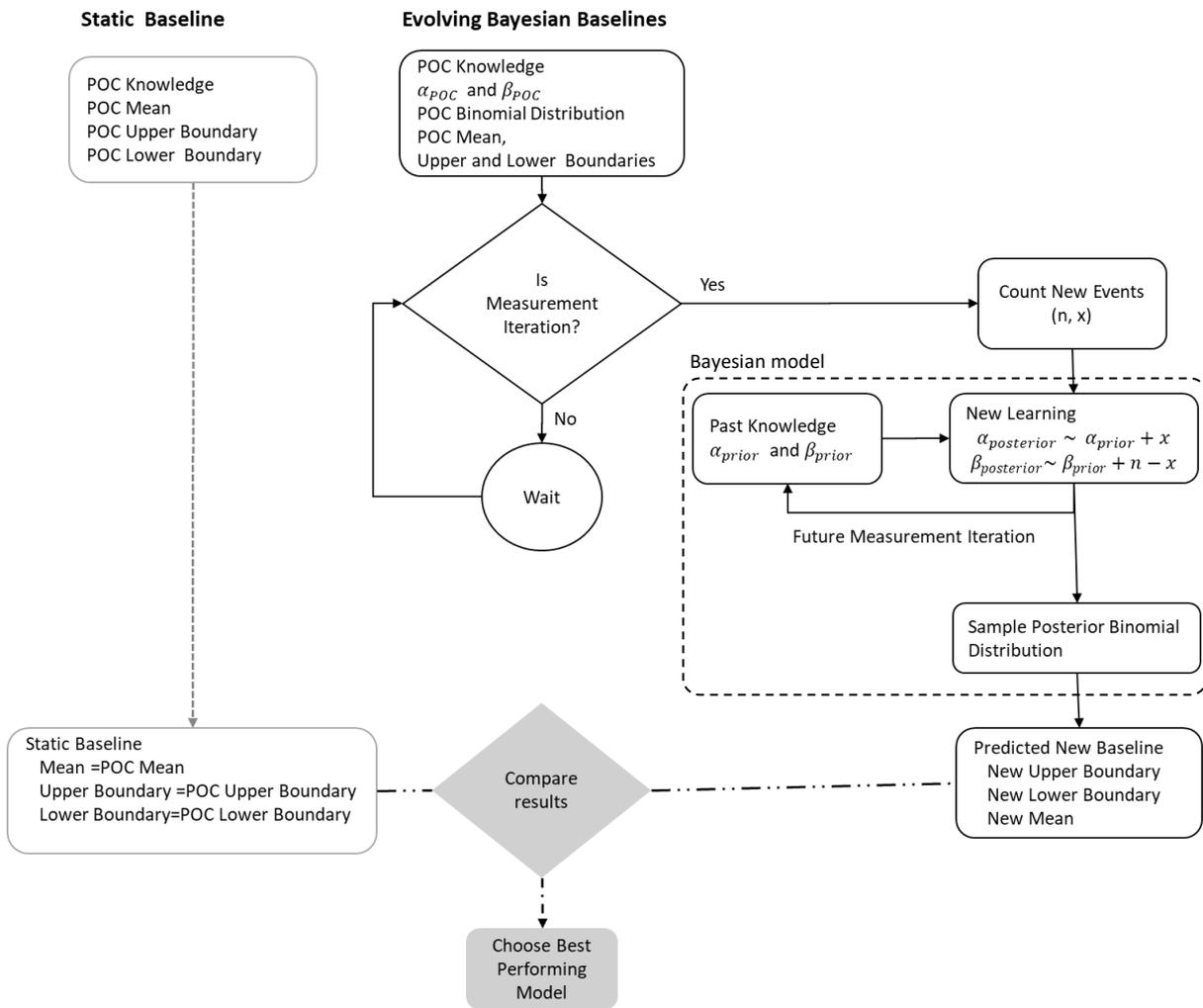
Fig. 3. Methodology: comparison of static and evolving baselines

In the last step of this study, we compare the traditional static baseline approach and the new Bayesian evolving baseline approach to identify the best performing model (refer to gray blocks in Figure 3 and section comparison of approaches). A baseline is often described by its mean and confidence bounds. The baselines generated by both approaches are compared with each other to evaluate their usability and accuracy. The model with the most realistic baseline is chosen as the best performing model.

3.2 Proposed evolving baseline method

The iterative nature of tasks and activities in a leagile type model creates the possibility of qualitative measurements of the smallest tasks or activities. Furthermore, quantifying task scope/deliverables depends on the approach to the work breakdown structure (WBS) [53]. It is practically impossible to implement continuous improvement without a quantifiable work package or task [53]. In project management, a "rule of thumb" for task estimation is the "80-hour" rule: it suggests decomposing the whole project scope until task size reaches 80 hours per deliverable. It helps in determining when to stop dividing deliverables into smaller elements. It is also followed in an agile scrum, where the standard sprint size is two weeks long. This study uses data with the "80-hour" rule to quantify the task as a failure or success (refer to the section on research data for details). This study uses success and failure probabilities to measure the performance of tasks and projects. A Bayesian model is used to derive the evolving baselines; the equations and computational steps are described in detail here.

As shown in Figure 3, the Bayesian model combines the lessons from the new events and past knowledge to continually predict the new posterior parameters, which provides an updated and more accurate estimation of the baseline parameters such as average success and/or failure probabilities as well as their upper and lower bounds. The posterior parameters also become prior parameters (past knowledge) for future measurement iterations. The mathematical details are described as follows.

Each task can either succeed or fail, which can be considered a Bernoulli trial. Therefore, the probability $P(x)$ of observing x failures in n tasks can be obtained from the binomial distribution as

$$P(x) = \binom{n}{x}p^x(1-p)^{n-x} \tag{1}$$

where p is the probability of failure per task. For complex projects/portfolios in a dynamic environment, the failure probability of each task may change as the projects develop. The failure rate may depend on shifts in market conditions, technological advancements, legal requirements, project environment, and resources. Therefore, it is crucial to continuously update the failure probability p based on learning from the immediate past. This can be achieved through the Bayesian learning algorithm described below.

In the Bayesian framework, priors $g(p)$ and likelihood $L(x|p)$ function are required to compute the posterior $g(p|x)$ as follows:

$$\text{Posterior } g(p|x) \sim \text{Likelihood } L(x|p) * \text{Prior } g(p) \tag{2}$$

where symbol "~" represents "directly proportional to" and the likelihood of observing x failure from n tasks can be calculated using the binomial distribution as

$$L(x|p) = \binom{n}{x}p^x(1-p)^{n-x}, \text{ where } x = 0,1,2,\ldots n \tag{3}$$

For binomial likelihood, a natural choice of the prior for failure probability p is the beta distribution [54], where the prior (beta distribution) probability density function (PDF)) $g(p)$ with shape parameters $\alpha, \beta > 0$ is given as

$$g(p) = \frac{p^{\alpha-1}(1-p)^{\beta-1}}{B(\alpha,\beta)} \tag{4}$$

where

$$B(\alpha,\beta) = \frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha+\beta)} \sim \frac{(\alpha-1)!(\beta-1)!}{(\alpha+\beta-1)!}$$

Further, using Equation (2), the posterior distribution of p can be derived as follows [54]:

$$g(p|x) \sim \frac{p^{\alpha+x-1}(1-p)^{\beta+n-x-1}}{B(\alpha+x, \beta+n-x)} \qquad (5)$$

The posterior distribution of failure probability p also follows a beta distribution with parameters $\alpha_{posterior}$ and $\beta_{posterior}$

$$\alpha_{posterior} \sim \alpha_{prior} + x \qquad (6)$$

$$\beta_{posterior} \sim \beta_{prior} + n - x. \qquad (7)$$

where α_{prior} and β_{prior} are the prior parameters α and β in Equations (4)–(5). The posterior beta distribution can then be used to estimate the baseline measurement, i.e., the failure probability and confidence bounds. Specifically, the following formulas can be used to estimate the baseline parameters.

The mean of the posterior beta distribution (i.e., the mean failure probability) can be computed using [54, p. 530]:

$$m(p) = \frac{\alpha_{prior} + x}{\alpha_{prior} + \beta_{prior} + n} \qquad (8)$$

The credibility interval of the failure probability (p) at 90% credibility can be calculated using the following equations [54, p. 530]:

Lower Credibility Interval: LCI $= BETAINV(0.05, \ \alpha_{prior} + x, \ \beta_{prior} + n - x)$ (9)

Upper Credibility Interval: UCI $= BETAINV(0.95, \ \alpha_{prior} + x, \ \beta_{prior} + n - x)$ (10)

where *BETAINV* is the inverse of the beta distribution. The posterior parameters are passed to the next iteration as new priors to continuously update the beta distribution of failure probability for baseline estimation. The proposed model offers a continually evolving baseline based on newly learned information as compared to the static baseline approach where the baseline measurements stay constant throughout the project lifetime.

3.3 Traditional static baseline method

In the traditional static baseline approach, the binomial distribution (Equation (1)) is used to calculate the POC baseline. Similar to the Bayesian approach where a 90% credibility interval is used, for the traditional approach we also used a 90% confidence interval. The upper and lower bounds of failure probability (p) at the confidence level 90%, given x failures in the n total tasks, can be calculated using the beta distribution as [54].

Lower bound: BETAINV$(0.05, x, n - x + 1)$

Upper bound: BETAINV$(0.95, x + 1, n - x)$

The POC baseline is static throughout the life of the project.

3.4 Research data

We used real case data from the ABC Health Care company for our "SharePoint optimization (SO)" portfolio. "ABC" is not a real name as the company wishes to stay anonymous. The main goal of the SO effort was to optimize the usage of SharePoint by incorporating continual learning from the performance of each SO task. The SO effort was initiated because of a sudden increase in the chargeback of the SharePoint service, which increased from $67 per Gigabyte (GB) in 2016 to $85 per GB in 2020. The business case for this SO portfolio was to realize a direct benefit of $19.28 M within two years.

Furthermore, the SO effort focused on establishing a self-learning process to continually optimize the performance of all SharePoint accounts. Six weeks of data were gathered for the first "outreach" phase of the SO effort. It included

3,113 SharePoint accounts with at least two site control admins and multiple site business owners. The SO portfolio followed a continuous delivery model with leagile strategies for process optimization. All SharePoint tasks of projects continually moved from the "to-do" bucket to "in-progress" and then to the outreach "completed" bucket.

Each task was associated with each SharePoint account and was completed independently by different site control admins and site business owners from a different department. Each task contained 17 questions to gather analytical data regarding the effective usage of the SharePoint account. The site control admins and site business owners had to run the few reports from their SharePoint dashboard to complete the task. The completed bucket contained all the project tasks completed successfully, and the failed tasks stayed in the in-progress bucket until they were fixed. We counted the task as failed if the task exceeded the due date. The due date for each task was set to two weeks after generation. Successful tasks were color-coded green. The failed and challenged tasks were grouped together and marked red. The overall portfolio status was measured every two weeks and reported in strategic leadership meetings. A breakdown of the project tasks for each measurement iteration is summarized in Table 1. A measurement iteration in this study is defined as a status-reporting cycle of the whole portfolio, a two-week cycle.

Table 1. SO outreach data

Measurement iterations	SO projects	Challenged (red)	Succeeded (green)
Iteration 1	59	17	42
Iteration 2	303	66	237
Iteration 3	267	22	245

The POC for process improvement and optimization was used before the start of the SO portfolio. Forty early adopters, who wanted to move to optimization as soon as possible, were engaged in the POC effort, which generated ten failed project tasks out of the 40 POC tasks, and this failure rate was used as the starting baseline for the whole project portfolio.

4. Results and analysis

4.1 Results for the traditional static baseline

The traditional plan-driven approach uses a historical point of reference to estimate all the baselines during the inception of the project. The baseline stays fixed and is the only baseline used to measure the performance of future tasks for all measurement iterations. Baseline estimates in the traditional approach is given in Table 2 and Figure 4, where the point estimation and the confidence interval of the point estimation are calculated respectively and stay the same over several iterations.

The point estimation of the failure probability of 0.25 is obtained, given that 10 out of 40 tasks failed in the project portfolio. As explained in Section 3 (Equation (5)), POC effort predicts that the estimated failure probability will fall within the lower confidence interval of 0.142 to the upper confidence interval of 0.387 at a 90% confidence level. The mean, lower, and upper bounds are presented in Figure 4 by solid, dashed, and dotted lines, respectively.

Table 2. Traditional static baseline results

Binomial distribution parameters	Historical knowledge	Iteration 1	Iteration 2	Iteration 3
Point Estimate (Mean)	0.25	0.25	0.25	0.25
Lower Conf. Interval	0.142	0.142	0.142	0.142
Upper Conf. Interval	0.387	0.387	0.387	0.387

Traditional Plan Driven Approach , Static Baseline

	week 1	week 2	week 3	week 4	week 5	week 6
Failure Mean	0.265	0.265	0.265	0.265	0.265	0.265
Lower Conf. Interval	0.142	0.142	0.142	0.142	0.142	0.142
Upper Conf. Interval	0.387	0.387	0.387	0.387	0.387	0.387

Project Schedule (Weeks)

—— Failure Mean   ▬ ▬ ▬ Lower Conf. Interval   • • • • • Upper Conf. Interval
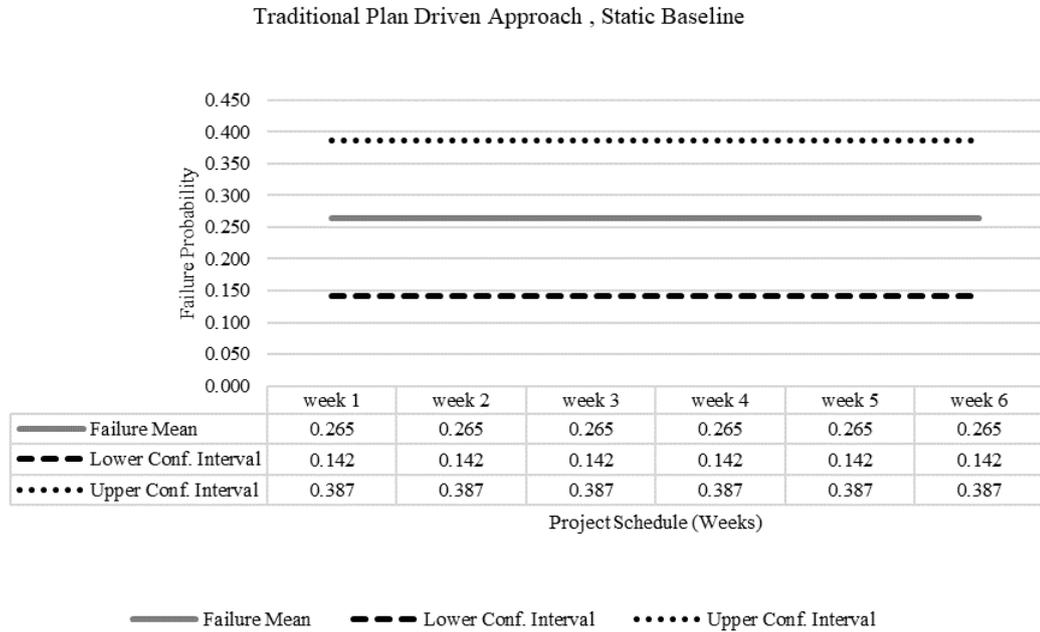
Fig. 4. Static baseline based on the POC effort

In a plan-driven approach, significant efforts are invested in controlling the baselines of project plans [22]. Changes in such models must usually go through a strict change control process, which is not efficient in a dynamic leagile environment. By contrast, enterprise leagile projects and portfolios continue to adapt to the changes in requirements and the environment. For the leagile model, it is critical to continually update the baseline and measure the success and failure adaptively as the projects and portfolios progress. In the next section, we illustrate the proposed continual learning strategy to dynamically update the baseline after each iteration as new failure data become available.

4.2   Results for the proposed evolving Bayesian baseline

In the previous section, the POC identified the prior failure probability of a portfolio, i.e., on average, 10 out of 40 SO outreach tasks failed. This information was used in the Bayesian learning approach to update the posterior distribution of failure rate at each iteration. The posterior produces a new baseline, which can be used to measure the performance of future tasks.

It is assumed that the initial failure probability from POC data (previous section) follows a beta distribution with parameters α_{prior} = 10 and β_{prior} = 30 before iteration 1 of Weeks 1 and 2. After iteration 1, failure data were collected (see Table 1), where 17 failures were observed out of a total of 59 SO targets. Following the equations given in Section 3, the posterior distribution of the failure probability p can be obtained as a beta distribution with the shape and scale parameters calculated as follows:

$$\alpha_{posterior} \sim \alpha_{prior} + x = 27$$

$$\beta_{posterior} \sim \beta_{prior} + n - x = 72$$

Here, $\alpha_{posterior}$ is α_{prior} increased by the number of observed failures x and $\beta_{posterior}$ is β_{prior} increased by the number of successes $(n - x)$, as shown in Equations (6) and (7).

Given the parameters of the posterior distribution of p, the average failure probability can be calculated using Equation (8) as follows:

$$m(p) = \frac{\alpha_{prior} + x}{\alpha_{prior} + \beta_{prior} + n} = 0.273$$

Accordingly, the LCI and UCI at 90% confidence level are

$$Lower\ Credibility\ Interval\ _{alpha=0.05} = 0.202$$

$$Upper\ Credibility\ Interval\ _{alpha=0.95} = 0.349$$

This procedure is repeated for multiple measurement iterations to update the baselines. As shown in Table 3, for each iteration, the posterior is updated, generating new Bayesian baselines for future tasks.

Table 3. Predicted Bayesian posterior and beta parameter results

Parameters	Prior	Posteriors		
		Iteration 1 [a]	Iteration 2 [b]	Iteration 3 [c]
α	10	27	93	115
β	30	72	309	554
$m(p)$	0.25	0.273	0.231	0.172
LCI		0.202	0.198	0.148
UCI		0.349	0.267	0.196

[a] Weeks 1 and 2, where failed x=17, total n= 59
[b] Weeks 3 and 4, failed x= 66, total n=303
[c] Weeks 5 and 6, failed x=22, total n=267

Figure 5 shows the evolution of the baseline based on the information learned from each iteration (every two weeks). The lesson from Weeks 1 and 2 suggests an average failure probability of 0.273 with an LCI of 0.202 and a UCI of 0.349. The estimated credibility interval from Weeks 1 and 2 will be used as the new baseline to measure the performance of Weeks 3 and 4. During Weeks 3 and 4, more tasks were assigned, and a few failures occurred; the mean reduced to 0.231 with a credibility interval of (0.198, 0.267) at a 90% confidence level. The failure probability for Weeks 3 and 4, shown by the middle three lines in Figure 5, stayed below the upper bound of credibility interval predicted by Weeks 1 and 2. This means that Weeks 3 and 4 performed better than Weeks 1 and 2. Moreover, the gap between the UCI and LCI of Weeks 3 and 4 is smaller than that of Weeks 1 and 2, which is an indication of the improvement in task performance during Weeks 3 and 4.

Similarly, information learned from Weeks 3 and 4 creates a new baseline for Weeks 5 and 6. The performance of the tasks for Weeks 5 and 6 is evaluated against the baseline from Weeks 3 and 4, as shown in Table 3. The mean failure probability from Weeks 5 and 6 is estimated as 0.172, which is also a sign of improvement in the performance during these Weeks when compared with the means and Credibility intervals of Weeks 3 and 4 and Weeks 1 and 2. Furthermore, the gap between the UCI and LCI has been reduced significantly in Weeks 5 and 6 when compared to those of prior iterations.

When looking at the whole iteration sets, as presented in Figure 5, the mean failure probability continued to decrease, nearing 17% in the last iteration. The failure probability decreased continually, and the performance of the task increased iteration by iteration. Similarly, the width of the credibility intervals gap reduced with each new iteration.

This confirms that the variations in task failure probability are decreasing, and that the task performance is becoming more consistent.
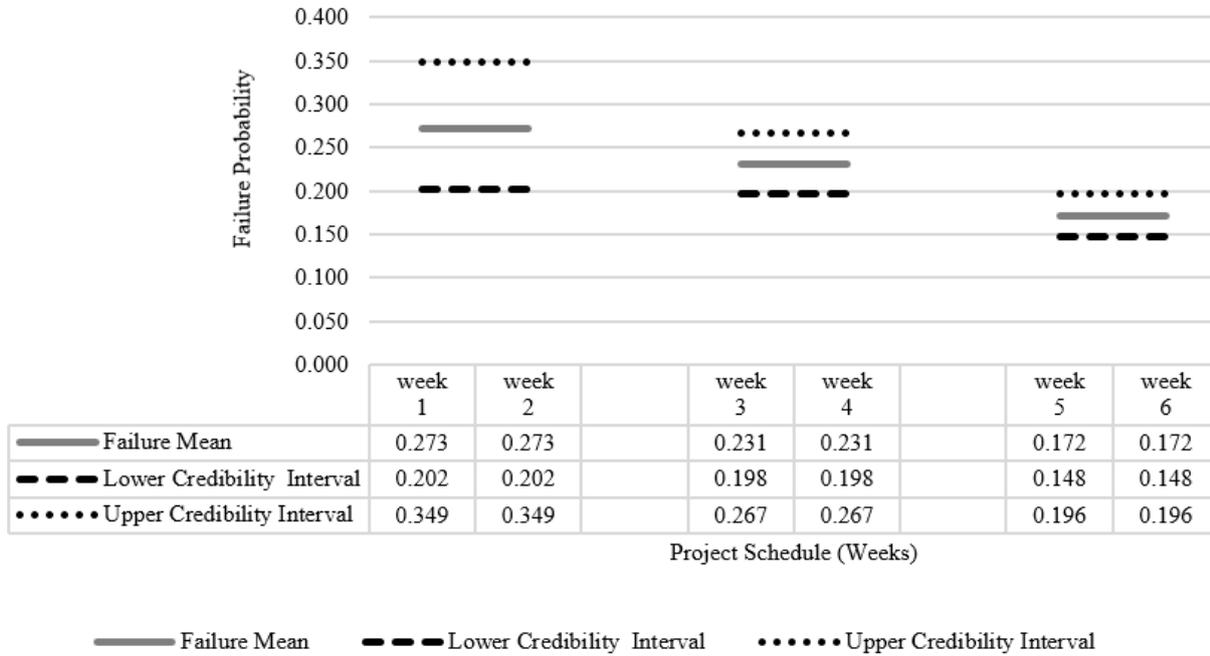

	week 1	week 2		week 3	week 4		week 5	week 6
Failure Mean	0.273	0.273		0.231	0.231		0.172	0.172
Lower Credibility Interval	0.202	0.202		0.198	0.198		0.148	0.148
Upper Credibility Interval	0.349	0.349		0.267	0.267		0.196	0.196

Project Schedule (Weeks)

——— Failure Mean   ■ ■ ■ Lower Credibility Interval   • • • • • Upper Credibility Interval

Fig. 5: Evolving baselines using the Bayesian learning approach
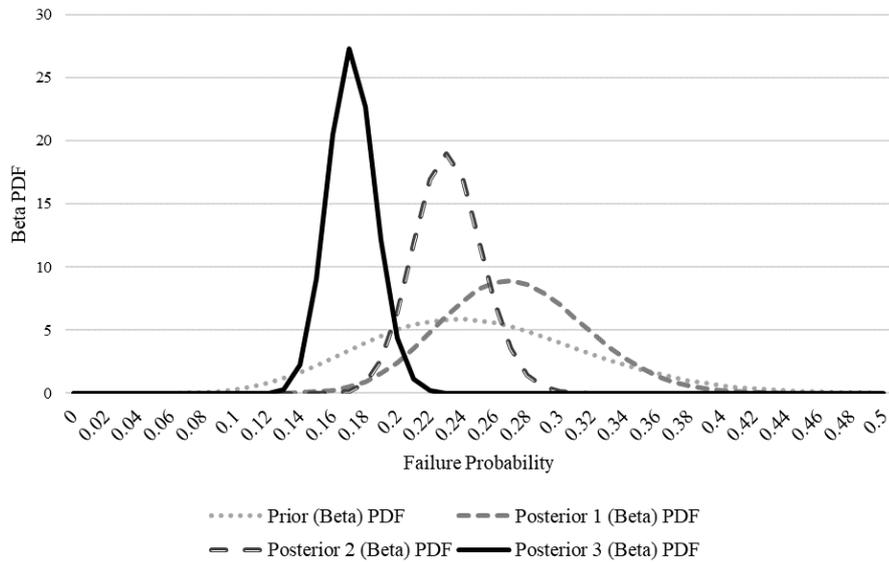
Fig. 6. Predicted PDF of the posterior distributions for each iteration result

Moreover, as the number of iterations increase, the PDF of the posterior distribution of the failure probability p moves left and its tails PDF become thinner (Figure 6). The posterior distribution of iteration 3 has a peak centered at 0.17 with thinner tails than the posterior distributions of iterations 1 and 2. This again shows continuous growth towards a lower rate of failure and tighter confidence bounds. In simpler terms, iteration 3 predicts that the failure probability of iteration 4 will stay within 0.148 to 0.196 at a 90% confidence level. If the failure rate in the fourth future iteration goes above 0.196, then the project portfolio is considered to be challenged, in contrast to the traditional approach, where the portfolio would not be considered challenged until the failure rate reaches 0.387.

The evolving baseline of the Bayesian approach showed a decrease in the posterior mean and a decrease in the spread between the upper and lower limits. This stands for the fact that with each iteration, the performance improves. That is, the failure rate (p) decreasing as effort count (n) increases—a genuine intention of the leagile delivery model [54].

4.3   Comparison of approaches

The traditional plan-driven approach identifies a baseline during the start of the project, and the baseline stays static throughout all iterations (Table 2 and Figure 4). By contrast, the evolving baseline approach continues to predict new baselines for future measurement iterations. As an example, the experience of the second measurement iteration predicts the new baseline for the third iteration. The failure probability of the task for the third iteration is predicted to be within 0.198 to 0.267 at a 90% confidence level. The task portfolio is considered to be challenged if the rate of actual task failure exceeds 0.267 in the third measurement iteration, versus the traditional approach where the task will not fail until the rate exceeds 0.387. As a result, the baselines evolved using the proposed Bayesian model are more accurate and realistic than those of the traditional approach.

A likelihood-ratio test (LRT) [55, p. 511] was conducted to find a better model of evolving project baselines. During LRT, we compared the llikelihood values of the traditional model against the proposed Bayesian model. The null hypothesis is defined as the performance of the Bayesian model is the same as the traditional model, and the alternative hypothesis is Bayesian model has better performance. The likelihood-ratio test statistic (LRT statistic) is calculated as $-2\ log_e(\frac{L_{traditional}}{L_{Baysian}})$, where $L_{traditional}$ is the likelihood values of the traditional model and $L_{Baysian}$ is the likelihood value of the Bayesian model. The LRT statistic is 5.919. This provides a significantly small p-value, 0.015. Reject the null hypothesis at $\alpha = 0.05$. The LRT test supports the fact that the Bayesian approach is a better model than the traditional model.

The Bayesian approach provides a more accurate measurement of project and portfolio performance than the plan-driven method. The Bayesian approach responds quickly to changing project variables that can positively or negatively impact project performance. These variables can be changes in the team environment, market, resources, law/regulations, technology, weather, or the recent coronavirus impact. The confidence bounds of the evolving baseline can increase or decrease and move up or down based on learning from the immediate past, unlike the static baseline of the traditional approach, where the confidence bounds stay the same throughout the project lifetime. Continuous forecasting is much easier if managers can immediately get a new predicted baseline for future iterations.

Our proposed approach recommends the maintenance of only two parameters (α, β) to estimate evolving baselines continually. Managing only two parameters simplifies the "applicability" of the proposed approach. The computation required to calculate the updated baseline is straightforward; anyone with Excel can use the built-in BETAINV function to obtain the posterior distribution, mean failure probability, and upper/lower confidence limits for new baselines.

5. Conclusions

It is evident in the project management world today that most organizations have moved towards agility and lean delivery models. Nevertheless, the leaders of project management offices and project managers are still trying to catch up with this trend. This transformation is rapid, and limited resources and tools are available to aid continuous planning and decision making. This article provided an applied framework (a Bayesian evolving baseline approach) for modern

leagile projects. The analysis demonstrated the advantages of the proposed approach over the traditional static baseline approach using SO portfolio data. The LRT findings of this study suggest that the evolving Bayesian baseline is a more accurate and realistic scale for measuring the success or failure of a leagile project and portfolio than the traditional static baseline. The result suggests that the continuous evolution of baselines based on learning can better estimate task performance for future planning. The proposed model can be easily integrated into any existing leagile project for continuous decision making. Furthermore, it is applicable to any type of project delivery model as long as the tasks of the project can be measured in terms of success or failure; they are independent and very similar in nature.

5.1 Discussion

Most complex enterprise projects are challenged more now than they were in the past few decades. The use of the outdated static baseline models to measure leagile project progress could be one of the reasons for the increase in project failures. The static baseline of the traditional plan-driven model does not apply to all types of contemporary projects and portfolios, especially when there is a constant change in the project scope, budget, resources, and environment. It is a known fact that a static baseline does not account for the recent changes in the project environment. This study showed that the performance measurement of a static baseline produces suboptimal results for modern leagile projects, as continuous learning and improvement are not considered in the traditional approach.

This article recommends the use of the Bayesian learning approach to estimate a continually evolving baseline and then use the learned baseline to measure success and reduce complexity. Our analysis found that the proposed evolving baseline provides more accurate performance predictions for the future effort of leagile projects/portfolios than the traditional static baseline. The evolving Bayesian baseline can closely capture the nature of project and portfolio progress despite the ever-changing project variables and environmental factors. The Bayesian learning-based evolving baseline approach can achieve both continuous learning and continuous planning in a joint framework for any leagile project portfolio.

5.2 Implications of the study

Learning from recent events has become a crucial element in complex projects with the unknown project scope. Projects that follow the leagile model for continuous delivery can benefit from the proposed strategy. This study developed a continual learning approach to estimate evolving baselines in a complex and dynamic project environment and proved that constant improvement is achievable through iterative learning. Evolving baselines generated from the continuously updated posterior predictions can incorporate "lines of sight" and "feedback loops" for a whole portfolio of leagile project systems.

This article is not limited to the data (SO optimization tasks) and the leagile model we used for our research. The mathematical solution provided by this study can be used in all types of projects and their portfolio as long as they maintain measurable task performance metrics like any simple work order to a complex project system. It can be implemented practically in any project as long as the work packages or tasks are iterative, measurable, and independent. It can benefit project and portfolio models such as DevOps, microservices, and leagile, which require continuous planning, continuous improvement, and continuous delivery. Furthermore, this study opens a new avenue for machine learning and artificial intelligence technologies to be applied in the software project management field to optimize existing project management processes and performance measurement standards.

In contrast to the static nature of the traditional approach, continual learning from recent experiences of proposed approach provides more accurate and reliable estimates of project and portfolio baselines. The continual learning from recent experiences is more recent and closely trails the changes in the project environment, thus reduces uncertainty. The justification for integrating Bayesian theory into project delivery models is that the Bayesian approach allows all possible subjective and objective input variables to be incorporated while producing quantifiable results. The outputs of the Bayesian model are measurable posterior metrics that are generated using continuously updated inputs due to changes in environments, changes in project structures, and even unknown priors. The prediction becomes more

accurate as it matures with new learning. The results are impactful, especially when the project environment and scope are dynamic, and the baselines continue to change. Hence, the major implications of the study are the following:

- The study provides a straightforward and accurate tool for forecasting the performance of leagile projects and portfolios;

- The study uses the binomial distribution, which is widely used in project management to measure task performance and status;

- The evolving baseline approach is easy to use, and users with minimal statistical knowledge can implement it in leagile projects or portfolios;

- The proposed tool can contribute to informing decision making and planning. For example, it will empower managers and leaders to obtain reliable estimations of the performance of in-progress tasks/teams/projects and accurately plan upcoming projects in the portfolio pipeline.

5.3 Limitations and further research

This study was limited to leagile-type projects and portfolios. It used the binomial distribution to ensure the straightforward applicability of the evolving baselines in leagile project and portfolio. The binomial distribution can easily incorporate the most popular approach of task status reporting (task failure or success) to model task performance and predict future events. However, other models like the exponential or proportional hazards models could be used to describe failure mechanisms concerning project time, budget, and cost. Additional reliability models and measurements, such as survival models, hazard functions, and reliabilities, were not fully explored in this article. Future studies could incorporate such reliability models to predict overall project portfolio system reliability. A comparison study can be done to identify the most accurate model with reliable performance estimates.

As a final remark for future works, it is important to note that the task experience and learned performance estimates used in the article are highly quantitative. They must be quantifiable enough to be used easily in the proposed solution in order to make exceptionally reliable decisions. Future work may attempt to use a qualitative learning approach or deep machine learning approach in a hugely dynamic project to identify if evolving baselines perform better than static baselines.

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Expecting the unexpected during ERP implementations: a complexity view

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Expecting the unexpected during ERP implementations: a complexity view

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Abstract:
Implementing an ERP (Enterprise Resource Planning) system is a complex, risky, time-consuming, and very expensive affair. Unfortunately, ERP implementations are often still over budget and time, and below expectations. Ticking off critical success factors (CSFs) and risks is supposed to take care of all intricacies during an implementation. However, complexity theory suggests no perfect foresighted knowledge can exist and one should always be prepared for new and unexpected events happening ("unknown unknowns"). Currently, ERP research does not explicitly address this unexpected behavioral aspect of complexity. Therefore, it seems relevant to explore whether this unexpected complexity aspect of ERP implementations can be observed in actual ERP implementations. We demonstrate through an in-depth and structured case analysis that a normal, well-planned, and managed ERP project shows indeed unexpected behavior. That is to say, totally unforeseen major problems appear. From our observations, it is evident that ERP implementations can show significant unexpected behavior despite the best of knowledge, proper preparation, and project management practice. It seems relevant to perform more research into the relevance of appropriate control mechanisms based on acceptance of the inherent complex, i.e. unpredictable nature of ERP implementations. This awareness should complement existing mechanisms as CSFs and risks.

1. Introduction

Despite some 20 years of practice and research, ERP (enterprise resource planning) implementations are often still over budget and time, and below expectations of stakeholders [1]. According to Amid, et al. [2]: "*It is said that about 70% of ERP implementations fail to deliver anticipated benefits and three-quarters of these projects are unsuccessful. These projects are, on average, 78% over budget, took 2.5 times longer than intended and delivered only 30% of promised benefit*". More recently a report from Panorama consulting [3] shows that in 2019 58% of the cases the project took longer than expected, 45% exceeded budget.

Therefore, the search for means and methods that can make implementations of ERP systems more successful continues to be relevant. A quote from Donald Rumsfeld (a retired American politician) inspired the ERP research in this article: "*Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say, we know there are some things we do not know. But there are also unknown unknowns- the ones we don't know we don't know*". The concepts "known knowns", "known unknowns" and "unknown unknowns" might prove to be of value in ERP implementation research approaches. A well-known approach for IT projects is research into critical success factors (CSFs) [4]. CSFs can be considered as 'known knowns' [5] for ERP implementation projects. The basic idea behind these 'known knowns' factors is that CSFs are expected to provide focus points that need to be addressed thoroughly to achieve a positive effect on the outcome and success of an ERP implementation. Using lists with critical success factors is widely popular in many areas, in particular in project management [6].

Also, considerable research has been performed into risks for ERP implementations. A project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives [7]. Risks can be identified in a project, but it is unknown whether or when an event caused by this risk will ever occur and to what extent. Therefore, risks can be considered 'known unknowns'.

Given all validated and exhaustive ERP CSFs and risks lists: why are ERP implementation projects still not more successful? Could it be that practice simply ignores existence and influence of 'unknown unknowns'. Is it possible that a third category, i.e. 'unknown-unknowns', as a generally ignored category, may have some effect in the success of ERP implementations? However, before research into 'unknown unknowns' can start, we should answer a fundamental question, i.e. do 'unknown unknowns' significantly influence ERP projects? To our knowledge, there is no ERP research which clearly proves the existence of these 'unknown unknowns' and their influence on success in ERP implementation projects. We surmise that in an ERP project 'unknown unknowns' manifests themselves as emerging unexpected troublesome issues.

Unexpected behavior of a system (e.g., an ERP implementation project) is a fundamental and well-identified phenomenon in complexity theory [8, 9]. Complexity theory suggests that in complex systems, no perfect foresighted knowledge exists and one should always be prepared for new and unexpected events (a.k.a. the "unknown-unknowns") [10, 11]. It therefore seems sensible to apply complexity theory as guidance for research into 'unknown unknowns', i.e. the unexpected behavior of ERP projects. Therefore, we will explicitly address the complexity of ERP implementations, and try to identify unexpected behavior (i.e. the 'unknown unknowns') in actual ERP implementations.

To do that, we will demonstrate through an in-depth and structured case analysis that a well-managed ERP project does indeed show these 'unknown unknowns', causing significant issues. Given our findings, we expect similar issues may be observed in other ERP implementation projects as well, and that there is sufficient reason to upgrade current control practices accordingly.

Following, first we present the concepts of ERP implementation, complexity of ERP implementations and motivations for research into unexpectedness of ERP implementations. Next, is presented the case study. After that, are presented the obtained results. Finally, are presented the conclusions as well as suggestions for future research.

2. Related work

Complexity is a concept that requires further explanation, as it is usually only used as a synonym for the concepts difficult or complicated in day-to-day language. However, the construct of complexity in research has its own value and meaning. Therefore, in this section we will first discuss the link between the construct of complexity and the topic ERP implementation. Next, we will review current literature regarding the unexpected aspect of complexity of ERP implementations.

2.1 What is complexity of ERP implementations?

ERP implementations introduce an entire ERP information system or parts of it into an organization. Although literature clearly describes and defines what an ERP information system embodies, we could not find an explicit definition regarding an "ERP implementation".

In most cases, ERP implementations are discussed and handled as projects, as is indicated by a vast amount of research into ERP projects as a subject [12-14]. Hence, we turn to project management as a base for our definition. In project management the building blocks or elements of projects are well known. A project always comprises activities. These activities need resources (human and non-human) which perform these activities. The results of these activities are products (and/or services). Products which are required by or are of interest to stakeholders. These activities, products and stakeholders are interconnected to each other and can influence each other [15]. Besides these project aspects of an ERP implementation, a fundamental aspect is its organizational impact [16, 17]. In most cases, using an ERP system changes the way an organization operates by altering its business processes. Research shows that organizational change [18, 19], and as a consequence change management, is a very important aspect of an ERP implementation in order to successfully implement an ERP system [20-23]

Thus, we propose to define an ERP implementation:

ERP implementation

All activities undertaken, resources needed, (sub)products produced, stakeholders, and their interrelationships to introduce (parts of) an ERP information system in an organization and the associated necessary organizational changes.

Our research aims to enhance the interpretation of complexity research in relation with ERP implementation. To do that, we also need to define ERP implementation complexity.

Edmonds profoundly explored the construct of complexity [8] and defined it as: '*That property of a model which makes it difficult to formulate its overall behavior in a given language, even when given reasonably complete information about its atomic components and their interrelations.*'

Based on the definition of complexity by Edmonds [8] and our research definition of ERP implementation, we combine both into one definition as follows:

Complexity of an ERP implementation

'*That property of an ERP implementation which makes it difficult to formulate its overall behavior, even when given almost complete information about its activities, resources, (sub) products, stakeholders, their interrelations, and the associated necessary organizational changes*'.

2.2 Use of the unexpectancy complexity aspect in current ERP implementation research

Since complexity behavior during ERP implementations forms the basis for our research, it is important to know to what extent current ERP research recognizes the impact of complexity in the topic of ERP implementation.

We performed a detailed, specific, and methodical search to retrieve a focused literature set on the impact of complexity in the topic of ERP implementation. We aimed at discovering literature showing a firm grasp of using "complexity" as a

key term in complexity theory as opposed to its day-to-day language use and how complexity is linked with ERP implementation. For instance: is it discussed methodically or merely mentioned descriptively?

We formulated the following assumptions about papers we were interested in:

1. A paper mainly discussing ERP will have the string "Enterprise Resource Planning" in its abstract.
2. A paper discussing ERP and complexity can have the strings "complex" or "complexity" in the title and/or abstract, but will always have the strings "complex" or "complexity" in its full-text.
3. A paper discussing ERP, complexity, and the construct of complexity itself probably contains definitions of complexity in the full-text.

In our search strategy, we combined these three assumptions by appropriate keywords and used the following search string:

((Abstract:("Enterprise Resource Planning")) NOT (Abstract:("complex")) NOT (Abstract:("complexity"))) AND ("define complex") OR ("define complexity") OR ("definition of complex") OR ("definition of complexity") OR ("what is complex") OR ("what is complexity") OR ("complexity theory") OR ("complex project") OR ("unknown unknowns")))

We searched in the literature databases of the Open Universiteit, which included amongst others: EBSCO, ACM, IEEE, DOAJ, AIS eLibrary, Sciencedirect and Springerlink.

At the time of this writing we retrieved in total 138 relevant papers.

The majority of the 138 reviewed papers uses the term *complex* or *complexity* related to ERP, or even related to non-ERP subjects, but do not define its meaning. They use these terms mainly as a qualitative property or characterization related to ERP systems, ERP projects, ERP implementation and ERP environment. Seven papers refer in their text to complexity theory. Of these, only five papers discuss the term *complexity* explicitly related to ERP implementation, as intended in our research. Of these, three [24-26] did not discuss the complexity of ERP implementation projects itself. Only two papers [27, 28] discussed complexity related to ERP implementation projects. Ghosh and Skibniewski [24] concentrated on indicating what complexity of an ERP project is, but not how to approach this complexity in ERP implementation research.

Fontana and Neto [27] discuss the change of complexity of organizations resulting from ERP implementations. Although they discuss complexity theory more extensively, they did not address the issue of unexpectedness in ERP implementations. All five papers we retrieved consider using complexity theory for research into ERP implementation to be useful in some way. Nevertheless, most of the retrieved ERP implementation research uses complexity descriptively rather than analytically.

As complexity theory suggests, we consider the unexpectedness of ERP implementations an important aspect which needs to be managed during an implementation project. However, we could not find any ERP research which clearly recognizes this. Therefore, it seems relevant to explore whether this unexpected complexity aspect of ERP implementations exists at all in practice.

3. Research design

If we consider ERP implementations following Edmonds definition [8] and Manson's complexity typology [11], it can be expected that an ERP implementation, being a social system, despite proper planning and management, will show unexpected behavior. Consequently, even in well managed and planned ERP projects by state-of-the-art knowledge and best practices, unexpected issues may arise and remain potentially undetected, possibly with increasing impact over time.

In our research, we will try to detect whether this unexpected behavior of ERP implementations can be discovered in practice. To do this, we have performed a case study, in which we evaluated an actual ERP implementation. Various project documents were scanned and a variety of stakeholders were interviewed for unexpected anomalies and suspect

events, i.e. issues which cannot be solved within the boundaries, abilities, and authorities of an ERP project itself. Following a deterministic complexity paradigm [11], all issues should be solved within the scope and boundaries of the project with proper planning and use of relevant experience from other ERP implementations. In general, we searched for issues which would need a higher level of involvement/authority in decision making exceeding a projects scope.

Our goal in this study is to discover the existence of unexpected behavior by discovering unexpected issues that are clearly out-of-scope of the implementation project and can only be solved outside the confinement of the project itself.

3.1 Issues and events

To achieve the research objective, we need to identify unexpected issues in practice. For this we will look at observable events. Analysis of these events can lead to the identification of underlying (not readily observable) issues. For each of these issues we then need to judge if their occurrence was 'unexpected'.

For example, an issue could be the refusal of a department to cooperate in an ERP implementation project. This refusal can cause the project to fail. Such an *issue* can be revealed by one or more *events*. Some examples of events are: a project activity is overdue, a resource is lacking, an alert is given that the functionality of the new ERP system cannot support a certain part of an organization, or an angry email is received from a manager stating that his department no longer will take part in the project.

Such vents are signs or symptoms of an underlying issue. For instance, if a project member calls in sick (an event!), the underlying issue could a touch of flu, but could also be a symptom of a poor relationship between the project manager and project member. Events call for a deliberate analysis for what issues have caused the event and to decide, whether and how to act. If the actions or lack of actions do not lead to a solution of an issue, the events may recur, or new events may be triggered. The issue is *recurring* and the chain of decision making, decisions and action recurs as well.

To validate our proposition that unexpected issues can have profound detrimental effects to an ERP implementation project we have to find such unexpected issues in actual ERP implementation projects. However, we expect that a substantial part of these issues in an ERP implementation project cannot be found. Some are never detected. Some are simply quickly forgotten or oppressed in people's memory, or their impact has not been fully comprehended or formally registered. Therefore, we must settle for the evident "big" issues that leave traceable evidence of their existence. With hindsight, the help of stakeholder "witnesses", formal project documentation and some detective work, we may uncover a few of these high-impact issues.

We expect that these events related to recurring issues can be more easily traced in documents and that participants in the ERP implementation project remember these events, so we will focus on detecting these *recurring unexpected issues* as main evidence for the existence of unexpected issues in our case study. We will focus on two characteristics of issues.

First, when events occur, and the underlying issue which causes these events is unclear to the ERP project, there is a probability that ineffective actions have been taken for that issue. These ineffective actions demonstrate that an issue has not been solved definitively, triggering subsequent events on the same issue. On the other hand, if events occur and the underlying issue is clear, we expect a higher probability that proper actions have been taken for that issue, and the issue has been solved. Therefore, we differentiate in issues that are clear and issues that are unclear (i.e. not well understood) to the ERP implementation project stakeholders.

Second, if the authority for solving the issue is unclear or not generally accepted, then we assume that the ERP implementation project has not been properly set up with appropriate authorities to solve these types of issues. If such issues would have been anticipated, proper authority would have been allocated to a project in the first place. Again, subsequent events on similar issues may reoccur. Therefore, we also differentiate in issues for which the decision authority is clear and present, and issues for which the decision authority is unclear of missing.

If we differentiate issues by these two characteristics: the clarity of an issue and the clarity and presence of an appropriate decision authority, then we can distinguish four types of issues as shown in table 1. In table 1 we also showed for every type whether it could be expected that that type of issue will trigger subsequent events.

Table 1. Types of issues

	decision authority clear and present (inside or outside the project boundaries)	decision authority unclear or missing
issue clear	Type A In an ideal situation, an issue is clear, and the authority for deciding on taking actions to solve that issue is clearly known.	Type C In a situation where an issue is clear, but the authority for deciding on taking actions is unclear, an issue might not be solved.
issue unclear	Type B If an issue is unclear, but the authority for deciding on taking actions is clear, then we expect an issue will not be solved right away and keeps on recurring. However, when more events occur related to the same issue, an issue might become clear in a way that appropriate decisions can be made and proper actions performed.	Type D In the worst of situations, an issue is not clear and also the authority for deciding on taking actions is not clear.

We labeled these issues type A, B, C and D.

Type C and D are the types of issues:

1. which we expect to generate multiple events;
2. due to unclarity of decision authority we can easily classify as unexpected issues;
3. we are most interested in, because they are easier to detect than other types of issues.

Therefore, C and D types of issues will be looked for in an actual ERP implementation project.

It is important to note that a detected list of events/issues is merely a minimal list and not the complete list of issues/events in this ERP implementation project case because:

- Not all events/issues may have been recorded in the documentation;
- Not all documentation may have been retrieved or made available;
- Not all events/issues may have been detected by the researcher in the documentation.

3.2 Case selection, information sources and research steps

We performed an intensive case study encompassing an actual ERP implementation project. In this case study, we gathered information from project participants and relevant documents in several steps. Arguing from this information we tried to determine whether this ERP implementation project had unexpected recurring issues.

For our appropriate research case we aimed for an ERP implementation with the following characteristics:

1. The ERP implementation must have taken place in a professional organization with a professional project management organization and up-to-date skilled and experienced project managers;
2. The project, as ERP projects mainly are, should be considered an important, large, and costly project, i.e. the stakes are high, ensuring significant management attention and a sound project management setup is required;

3. The ERP implementations has been completed fairly recently to ensure good recollection with the stakeholders (preferably no longer than three years ago);
4. The organization should be transparent and interested in this type of research, with no restraints or taboos;
5. We expect that for this type of ERP implementation certain information sources should be available to obtain information about issues;
6. Stakeholders with knowledge of and experience from that particular ERP implementation;
7. Documents which hold information about this particular ERP implementation: Project definition reports, management reports and other relevant reports dealing with the ERP implementation project.

Performing a case study as a primary research approach requires considerable effort and a sound case study selection is justified. Any selection process raises issues concerning external validity. In this research project we opted for purposive sampling [29] as the key motivation in case selection. Consequently, the external validity is bound to the characteristics of the selected case study. In turn, most of the characteristics are "purposively" chosen to maximize the chances to identify "known-unknowns", in a rather common and realistic context. Given the summary of characteristics, this means that we can claim external validity for contexts that can be characterized by the characteristics (1, 2, 4, 5, 6).

To retrieve information from the ERP project participants and documentation, we divided this case study into several steps. These steps are shown in figure 1.

Internal Validity

We used triangulation in our research design to assure that our findings are genuinely based on a critical investigation of all available data and do not depend on a few "convenient" examples. We analyzed all available ERP project related documents and inquired within the interviews after all issues of the project. As we wanted not to reveal the purpose of our research to the interviewees, we did not specifically ask for recurring issues, but we asked for issues/problems in general. For every potential recurring issue, we tried to detect objectively as possible (by triangulation) whether it was an issue which unexpectedly occurred indeed. By discussing every potential recurring issue in separate interviews in depth and documenting and verifying the results, we transparently underpinned the conclusions, i.e. whether unexpected issues existed in this ERP project.

We tried to enhance internal validity by first selecting an ERP implementation which consisted of several sub-projects, with their specific project leaders, steering committees, scopes et cetera, to increase the likelihood of finding events and issues. We then retrieved all issues (A, B, C and D issues) and only after applying the definition of recurring issues to it; we typified an issue as relevant or not.

A final check was performed by our contact person, independently from the researchers. Also, our findings and any intermediate steps were recorded for verification by others. To maximize a sound designation of issues to the types A, B, C or D, we made use of several well-informed persons as a source of triangulation.

External Validity

We carefully selected a case by purposeful sampling [29], to be able to apply our findings in other comparable situations (see section 1.4). But of course, we are aware that our results might not apply to situations which considerable deviate from our selected case type. In that case, more research into these deviating types should be performed.

Reliability

To improve a correct representation of the information we retrieved from the interviewees, we recorded every interview. Based on this recording, we carefully prepared a written summary for the interviewee which the interviewee confirmed and/or enhanced. Also, the selected issues by the researcher from the documentation was by the contact person as being a representative list of issues belonging to the ERP implementation project.

An important aspect of reliability is transparency of the research protocol. Therefore, we discussed the research steps in a previous section. Furthermore, the results from every step are available (privacy guidelines permitting) through the first author.
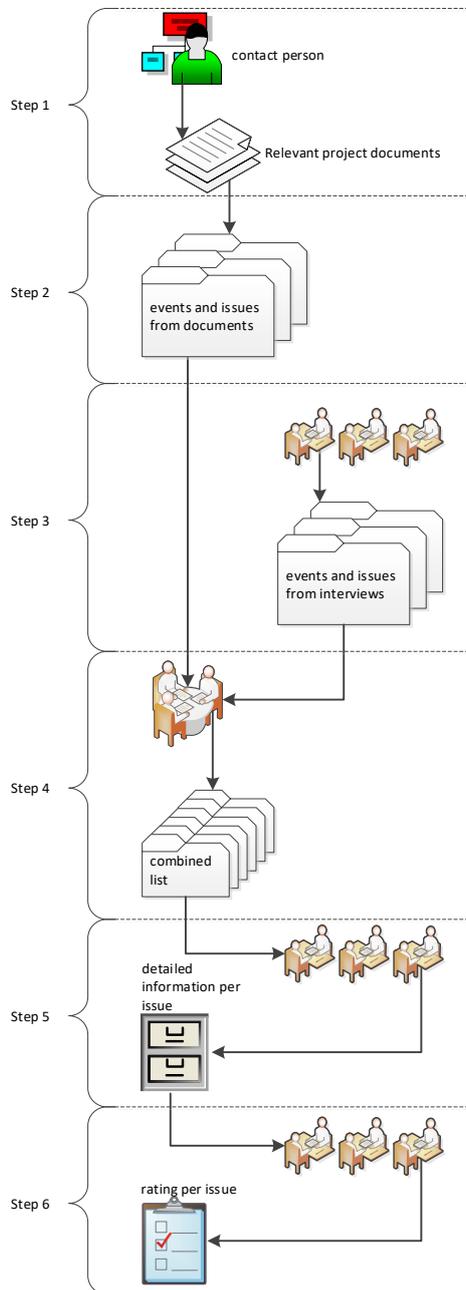
Step 1: Gain access to a contact person and assuring confidentiality

After selection and admittance to the case, in this step a main contact person within the case was requested. This contact person was well informed about the ERP project and had access to all managers, project participants and documents.

Step 2: Extraction of events and issues from project documentation

By studying the content of the provided documents, the researcher valuated these for potential events and issues. The researcher created a list of retrieved events/issues. The contact person from the case organization revised and validated this list.

Step 3: Extraction events and issues by interviews

Confirmation of this list and additional issues/events was obtained from ERP implementation participants. In consultation with the contact person relevant participants were selected with an extensive overview of the project.

This step served two purposes:

1. Discovery of events/issues not documented or missed in the documentation.
2. Confirmation of events/issues already discovered in step 2.

Step 4: Integration of events/issue lists

The main researcher combined the lists from step 2 and 3 into one list, which could be considered a fair representation of events/issues from the case. The research team and the contact person of the case checked the list.

Step 5: Profound potential C/D issue information retrieval

The information from the interviews and information from the documents was combined in a structured file per issue:

1. Background of issue;
2. Description of issue and events;
3. Description of settlement issue by decision-making processes, decisions, actions and if the issue was solved.

Step 6: Issue rating

Based on the gathered detailed information about the issues in the file from step 5, the research team classified the issues in A, B, C or D. The contact person and if a well-informed ERP stakeholder verified the definitive classification of the issues in A, B, C or D.

Fig. 1. Research steps

4. Research results

4.1 Case description

We were very fortunate to have obtained approval and cooperation from a large government agency in the Netherlands, which fits our pre-set requirements. This government agency had implemented and still was implementing ERP by means of a professional project organization. The selected case is an ERP implementation that affected large parts of the government agency itself.

This government agency already used Oracle's PeopleSoft ERP software [30] for financial management. The organization started with projects for implementing more PeopleSoft applications. The goal was to phase out several expensive legacy systems and create an integrated, cost and support efficient information system.

The government agency had a department dedicated to the implementation and support of ERP systems. This department contained several experienced IT project managers. Also, the government agency had a program department where every IT related project and subproject was assessed and monitored. Project management was performed in accordance with and by the standards of the PRINCE2 methodology [31]. The project managers had to be PRINCE2 certified.

Also, they contracted a consultancy firm to advise and assist for parts of the ERP implementation where they lacked knowledge and experience with PeopleSoft applications. The project managers were internal employees. The general managers of the staff services initiated and supported this ERP implementation.

Considering all these characteristics of the case project organization, project manager's profiles and in place project management standards, all case requirements were met. Consequently, we have ascertained that the case organization had a professional project organization and worked according to professional standards, and is suitable for our research goal.

The government agency was very much interested in our research and broadly recognized the problems and risks associated with large ERP implementations. They agreed to fully assist in the case study.

4.2 Results from main research steps

Step 1: Gain access to a contact person and assuring confidentiality

A suitable contact person was assigned to our research.

Step 2: Extraction of events and issues from project documentation

The researcher gained access to 129 documents, which were all electronic files. These documents consisted of the following types: agenda, audit, decision document, decision-making list, communication plan, leaflet, mail, memo, minutes, design document, presentation, program plan, project handbook, progress report and plan.

From these documents, 72 possible events or issues were distilled.

Step 3: Extraction events and issues by interviews

To get a clear picture of the project goals and settings, four authoritative participants (Table 2) were asked to provide an extensive overview of the project. All participants had at least a bachelor educational level.

Table 2. Respondents

Position	Experience in ERP implementations (years)	Assigned to current position (years)
Director of facility management and purchasing	2.5	5
Manager ERP competence center	16	2
Manager project professionals	15	4
Project manager ERP	2	2

A comprehensive list of events/issues was compiled via extensive interview sessions with the help of these participants.

Step 4: Integration of events/issue lists

The 72 distilled events by scanning the official documentation were also verified by this group of participants. In the end, an additional 42 issues/events were captured, which produced a list of 114 issues.

Step 5: Profound potential C/D issue information retrieval

Initially, it was intended to analyze every retrieved issue by performing interviews in detail to indicate which issues were from C or D type. However, the list of 114 discovered issues from step 4 was simply too big for detailed interviews. Therefore, a decision was made to add an intermediate step. We aimed at verifying the very existence of unexpected high impact issues that remained unsolved and not analyzing all 114 issues in detail. Therefore, a preliminary selection of 11 potential C or D issues was selected by the research team and discussed and verified with the contact person from the organization.

These issues were:

1. Too wide scope subproject A;
2. Failure to start 'Time registration project';
3. Part of organization does not want to change its ordering process in accordance with processes designed in subproject A;
4. Blueprint Phase for subproject A was very costly and time-consuming;
5. Additional costs and delay of activities within subproject A by performing line activities within this subproject;
6. Project B expires over budget and time because the short-term solution chosen is not optimal;
7. Low acceptance rate and not using PeopleSoft leave module;
8. Transfer of e-HRM to management failed;
9. Dutch railways business card solution too complex for support department;
10. Missing functionality in course administration;
11. single sign-on fails.

> **Example of a C/D issue (issue 7)**
>
> In this case the introduction of the timesheet module of their ERP system was considered a replacement of an in-use standard Excel spreadsheet. Managers and employees used their individual copy of this Excel spreadsheet to keep track of hours worked and leaves. Only during transferal of this in essence simple functionality to the ERP system, the project discovered the spreadsheet was also used as an informal rewarding system for managers to their subordinates. This informal and flexible system clearly was not possible in their chosen ERP system because of authorizations and the complete integration of data with other modules. Implementing this functionality would have led to inconsistencies. As a result, this hidden and informal but yet significant business process for rewards became a critical obstacle to acceptance of this part of that ERP module. The project management team did not have the authorization to change or end this informal reward method, or any means to ensure that the new ERP system would support this reward method.
>
> This issue was regarded in the project as a serious problem with consequences for the project. Some departments refused to use this part of the system.

This list shows a short title for every issue. A detailed description per issue (in Dutch) can be requested from the first author.

These 11 potential C/D issues were analyzed in four interviews for final verification. Four individuals to which the contact person attributed detailed knowledge about these issues were interviewed. To increase reliability, we assured that at least two individuals could provide information about every issue.

The information from the interviews and information from the documents was combined in a separate structured file on per issue.

Step 6: Issue rating

Based on this detailed filed information of the 11 issues in the file, the definitive classification of the potential C/D issues in A, B, C or D was performed.

The researcher first performed the classification based on the issue information. After that, the two co-researchers individually and independently checked the interpretations made and checked the consistency of the data based on the available filed information.

As a last check, a contact person at the case organization also performed independently the classification. This contact person was a former leading consultant of the government agency. The consultant advised during the implementation and therefore, had a complete overview of the project.

An issue was only designated positively as a C/D type issue if **all participants were in complete agreement**.

This is shown in Table 3.

Table 3. Results from issue rating

	Issue										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Researchers	y	y	y	y	n	y	y	n	y	n	n
Former consultant	y	y	y	y	n	y	y	n	y	y	n
Contact person	y	y	y	y	y	y	y	y	y	y	y
Final rating	**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**N**	**Y**	**N**	**N**

In the end, rating resulted in **7 issues of type C/D (Issue 1, 2, 3, 4, 6, 7 and 9)**

5. Discussion and conclusion

5.1 Conclusions

Our goal in this study was to detect the existence of unexpected issues that are clearly out-of-scope of an ERP implementation project. In our research we performed a case study to detect if such unexpected behavior of an ERP implementation exists.

Even though the scope of the sources of information has been limited for practical reasons, we discovered seven unexpected serious problems in this ERP implementation project. Seven issues, each of which had a significant impact. These issues could never have been avoided or detected in advance, for example, by using CSFs.

In addition, the current knowledge base of the CSF could easily be expanded to include additional issues and related discoveries ("known knowns"), but a list of CSFs naturally always lags behind new but undiscovered issues. This also applies to risks ("known unknowns"). In other words, by definition, CSFs and risks will always be incomplete in complex environments such as ERP implementations. To avoid unexpected issues, it is necessary to prepare for the unexpected for example by:

- Installing a thorough review process of issues discovered, especially if they seem to recur.
- Accepting that issues may be rooted in deeper or external out-of-project scope issues, not directly visible by a project team.

- Recognizing and accepting that a project manager can escalate such issues to higher managerial authorities, who need to take actions accordingly. Such an escalation should be professional project management practice, rather than a sign of a project managers incompetence.
- Recognizing that the world is dynamic. This always requires an open mind to expect truly the unexpected.

5.2 Discussion

We performed our case study in a large organization with a significant internal IT and other support staff. This IT and support staff were very experienced with implementations in a project structure. Also, the IT and support staff have been trained well in project management and in subject matter topics. The key players have an academic background and are assumed to be proficient in analyzing project issues. Therefore, we have selected a typical ERP implementation, which supports the external validity of our results.

Our results also show that there are recurring issues within several of the sub-projects in this ERP implementation, which supports the internal validity of our results.

In the Netherlands, government agencies must be transparent by law. The event detection depended on the availability of formal documents and the recollection of individuals who each had a specific role and perspective on the entire implementation project. Despite the required transparency of government agencies and good intentions, it cannot be avoided that some information may be lost or never recorded properly, because it was not part of the daily routine, forgotten or simply regarded as insignificant at the time. In our research we focused on negative events to detect issues. However, also positive events can exist, for instance: being ahead of schedule, or becoming aware that the functionality of the ERP software also can support other processes in the organization. These may also relate to unexpected issues. Despite of these limitations in detecting unexpected issues, we discovered seven very challenging issues which could have easily jeopardized the entire implementation. Therefore, it is fair to assume we may have just discovered the rather obvious ones, the so called "tip of the iceberg". Potentially, if we were able to access more information and people we could have detected even more hidden detrimental issues, only further strengthening our conclusion.

We have executed a single case study while explicitly taking measures to counter the standard research limitations inherent to such a study. Key issues are related to the subjective nature of data acquisition and analysis. To handle this, we have used triangulation for both data gathering and analysis, as described above. This, coupled with an explicit awareness to the issue is expected to reduce any bias issues that might arise. Similarly, generalization of results is often an issue with this type of research. After all, the conclusions are based on a single case study, albeit meeting broad selection criteria. However, given the relatively large number of issues found, we expect that similar 'unknown unknowns' will occur elsewhere. How widely is of course outside the scope of this study and requires further research?

A question that might arise is: if we see enough occurrences of 'unknown unknowns', can this then be used to enhance e.g. risk or CSF-approaches. By e.g. transferring them into 'known unknowns'. In essence, this is how these approaches were developed in the first place and resulted in useful contributions. However, in our opinion there is a limit to how far this can be stretched. The examples found in the case study were very specific and truly unexpected. Looking at them from a higher level of abstraction, it is surely possible to classify them under an already existing and recognized CFS or risk. But that did not help the organisation which looked at CSFs and risks before starting the project. The higher level of abstraction hides the specificity of an 'unknown unknown'. Hiding it in plain sight as it were. There are probably just too many things that can go wrong in such an extensive project. That is why imagining them in advance is an inadequate remedy.

5.3 Further research

In this research, we only searched for negative issues which disturb an ERP implementation. It seems worthwhile to perform also research into positive issues which as discussed previously also can disturb an ERP implementation. It might be relevant to determine whether the management mechanisms for solution for these positive issues should differ from the negative issues.

Performing research into management mechanisms which can better manage this type of unexpected behavior seems obvious. Possibly other control mechanisms than the ones from project management are more suited for dealing with these unexpected issues. For instance, program management owns control mechanisms that might cope with this unexpected behavior. As is discussed in "Gower handbook of programme management" [32] an aspect of programs is: *"Exist in a world that is constantly changing. These changes need to be constantly monitored and their impact on the programme and its projects controlled and managed"*. Ribbers also gave the suggestion that program management might be a suitable control mechanism for ERP implementations [33]. Therefore, it seems relevant to perform more research into the relevance of appropriate control mechanisms based on acceptance of the inherently complex nature of ERP implementation.

To maintain an attitude towards "expecting the unexpected" is no doubt difficult. Research into support for such an attitude is therefore required.

Given this relevance of unexpectedness it seems relevant for top management to be involved more hands-on with this type of projects. Therefore, research into what top management support looks like and how this can be obtained and executed, seems to be worthwhile.

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