Vol. 8 | No. 1 | 2020

SciKA

International Journal of Information Systems and Project Management

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

Available online at www.sciencesphere.org/ijispm

IJISPM

05

Moving enterprise resource planning (ERP) systems to the cloud: the challenge of infrastructural embeddedness

Eli Hustad
Vegard Sørheller
Emeli Jørgensen
Polyxeni Vassilakopoulou

23

The pivotal factors of IT projects' success – Insights for the case of organizations from the Federation of Bosnia and Herzegovina

Muamer Bezdrob
Sabina Brkić
Manfred Gram

44

The documentation of design decisions in engineering projects: A study in infrastructure development

Tara Kinneging
Robin de Graaf
Sander Siebelink
Tim van Dijck

67

W4RM: A prescriptive framework based on a wiki to support collaborative risk management in information technology projects

Rogério Soares
Marcirio Chaves
Cristiane Pedron

SciKA - Association for Promotion and Dissemination of Scientific Knowledge


SciKA

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

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

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

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

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

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

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

Table of contents

SPECIAL FEATURES

1 **Editorial**

João Varajão, University of Minho, Portugal

RESEARCH ARTICLES

5 **Moving enterprise resource planning (ERP) systems to the cloud: the challenge of infrastructural embeddedness**

Eli Hustad, University of Agder, Norway
Vegard Sørheller, Accenture, Norway
Emeli Jørgensen, Equinor, Norway
Polyxeni Vassilakopoulou, University of Agder, Norway

23 **The pivotal factors of IT projects' success – Insights for the case of organizations from the Federation of Bosnia and Herzegovina**

Muamer Bezdrob, American University in Bosnia and Herzegovina, Bosnia and Herzegovina
Sabina Brkić, American University in Bosnia and Herzegovina, Bosnia and Herzegovina
Manfred Gram, American University in Bosnia and Herzegovina, Bosnia and Herzegovina

44 **The documentation of design decisions in engineering projects: A study in infrastructure development**

Tara Kinneging, Witteveen+Bos N.V., The Netherlands
Robin de Graaf, University of Twente, The Netherlands
Sander Siebelink, University of Twente, The Netherlands
Tim van Dijck, Witteveen+Bos N.V., The Netherlands

67 **W4RM: A prescriptive framework based on a wiki to support collaborative risk management in information technology projects**

Rogério Soares, Nove de Julho University, Brazil
Marcirio Chaves, Pontifícia Universidade Católica do Rio Grande do Sul, Brazil
Cristiane Pedron, Nove de Julho University, Brazil

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

IJISPM

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

Editorial

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

It is our great pleasure to bring you the first number of the eighth volume of IJISPM. In this issue readers will find important contributions on enterprise resource planning (ERP) systems, information technologies (IT) project success, design decisions in engineering projects, and engineering projects, and risk management.

The first article, "Moving enterprise resource planning (ERP) systems to the cloud: the challenge of infrastructural embeddedness", is authored by Eli Hustad, Vegard Sørheller, Emeli Jørgensen and Polyxeni Vassilakopoulou. Cloud enterprise resource planning (ERP) solutions allow organizations to support and coordinate key business processes by leveraging virtualization. Nevertheless, moving ERPs to the cloud is not straightforward, and organizational cloud ERP initiatives raise multiple concerns. The authors conducted an in-depth systematic review of relevant research literature and identified six key concerns related to cloud ERP implementation: a) the introduction of new ERP work arrangements, b) the migration of legacy data, c) the assurance of compliance with extant rules and regulations for security, d) the continuous alignment between ERP functionality and business processes, e) the ongoing integration between ERPs and the rest of the organization's application portfolio, and f) the establishment of adequate reliability levels. The identified concerns are associated with both transition management and operations supported by cloud ERPs. All the identified concerns are also related to the need to achieve infrastructural embeddedness. This need sets ERPs apart from other types of cloud-based applications, such as office automation solutions that do not have as many dependencies and exchanges with other systems and repositories within an organization's information infrastructure.

The title of the second article is "The pivotal factors of IT projects' success – Insights for the case of organizations from the Federation of Bosnia and Herzegovina", which is authored by Muamer Bezdrob, Sabina Brkić and Manfred Gram. This research aims to investigate the circumstances and possible reasons for a very high and rather unexpected success rate of IT projects implemented in the Federation of Bosnia and Herzegovina. For that purpose, the existing literature was reviewed thoroughly, and an appropriate research design was formulated. In order to answer the research questions posed, a questionnaire was developed and a multivariate analysis of variance (MANOVA) was employed. The obtained results show that keeping the project size small significantly increases the odds for achieving IT project success, regardless of the organizational maturity level in project management. In addition, the higher the organizational maturity level in project management the higher IT projects success ratio. Results also revealed that the differences between IT projects' success ratio of different groups of organizations are primarily induced by the time and costs project constraints, but not with project scope.

The third article, authored by Tara Kinneging, Robin de Graaf, Sander Siebelink and Tim van Dijck is entitled "The documentation of design decisions in engineering projects: A study in infrastructure development". In most design projects, the documentation of design decisions is considered important. Among others, documentation of design decisions contributes to the traceability of decisions that shape a project's development process, helps deal with changes in the project and prevents the recurrence of old discussions. Yet, little attention is given to documenting design decisions in engineering literature. In this study, a theoretical framework for the key elements of this documentation process was developed. Four infrastructure projects were studied and compared to this framework by means of pattern matching. The findings demonstrate that accessibility of documentation for all involved project parties and division of documentation tasks are in accordance with literature. However, the documentation of design decisions and their rationale is not done as completely as is recommended in theory. Literature states that the documentation of interrelations and context of decisions should be described thoroughly, but that is barely done in practice. In addition,

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

the findings show that neither immediate documentation, nor periodical monitoring of documentation is applied. Based on these findings, this research proposes a strategy for improving the documentation of design decisions.

"W4RM: A prescriptive framework based on a wiki to support collaborative risk management in information technology projects" is the fourth article and is authored by Rogério Soares, Marcirio Chaves and Cristiane Pedron. Despite the positive influence of risk management in IT project results, many project managers are not managing risks or are managing them partially. To enhance risk management, collaborative project management has gained attention in recent years with the introduction of Web 2.0 tools. Project managers have used such tools to facilitate open communication and distribution of activities. This research introduces a prescriptive framework (W4RM – Wiki for Risk Management) based on a wiki to support collaborative risk management in IT projects. An exploratory focus group was set up and a series of interviews with practitioners was conducted to explore how a wiki can support risk management in IT projects. Findings show that project managers are facing difficulties managing risks and are the only ones responsible for identifying, registering and monitoring risks. By implementing a collaborative tool, managers can disseminate a collaboration culture and participate in risk management processes.

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

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

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

The Editor-in-Chief,

João Varajão

University of Minho

Portugal

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

www.shortbio.net/joao@varajao.com

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

Moving enterprise resource planning (ERP) systems to the cloud: the challenge of infrastructural embeddedness

Eli Hustad
University of Agder
Universitetsveien 25, 4630 Kristiansand
Norway
eli.hustad@uia.no

Vegard Uri Sørheller
Accenture
Rolfsbuktveien 2, 1326 Fornebu
Norway
Vegard.u.sorheller@gmail.com

Emeli Høvik Jørgensen
Equinor
Forusbeen 50, 4035 Stavanger
Norway
emelihj@hotmail.com

Polyxeni Vassilakopoulou
University of Agder
Universitetsveien 25, 4630 Kristiansand
Norway
polyxenv@uia.no

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

E. Hustad, V. Sørheller, E. Jørgensen, P. Vassilakopoulou, “Moving enterprise resource planning (ERP) systems to the cloud: the challenge of infrastructural embeddedness”, *International Journal of Information Systems and Project Management*, vol. 8, no. 1, pp. 5-20, 2020.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

Moving enterprise resource planning (ERP) systems to the cloud: the challenge of infrastructural embeddedness

Eli Hustad
University of Agder
Universitetsveien 25, 4630 Kristiansand
Norway
eli.hustad@uia.no

Emeli Høvik Jørgensen
Equinor
Forusbeen 50, 4035 Stavanger
Norway
emelihj@hotmail.com

Vegard Uri Sørheller
Accenture
Rolfsbuktveien 2, 1326 Fornebu
Norway
Vegard.u.sorheller@gmail.com

Polyxeni Vassilakopoulou
University of Agder
Universitetsveien 25, 4630 Kristiansand
Norway
polyxenv@uia.no

Abstract:
Cloud enterprise resource planning (ERP) solutions allow organizations to support and coordinate key business processes by leveraging virtualization. Nevertheless, moving ERPs to the cloud is not straightforward, and organizational cloud ERP initiatives raise multiple concerns. We conducted an in-depth systematic review of relevant research literature and identified six key concerns related to cloud ERP implementation: a) the introduction of new ERP work arrangements, b) the migration of legacy data, c) the assurance of compliance with extant rules and regulations for security, d) the continuous alignment between ERP functionality and business processes, e) the ongoing integration between ERPs and the rest of the organization's application portfolio, and f) the establishment of adequate reliability levels. The identified concerns are associated with both transition management and operations supported by cloud ERPs. All the identified concerns are also related to the need to achieve infrastructural embeddedness. This need sets ERPs apart from other types of cloud-based applications, such as office automation solutions that do not have as many dependencies and exchanges with other systems and repositories within an organization's information infrastructure. We argue that the challenge of embeddedness has different implications for organizations of different sizes, and we call for further empirical research.

Keywords:
cloud enterprise resource planning (ERP) implementation; organizational size; information infrastructure; embeddedness; transition management.

DOI: 10.12821/ijispm080101

Manuscript received: 18 April 2019
Manuscript accepted: 22 May 2019

1. Introduction

Cloud computing enables network access to a variety of information technology (IT) resources (e.g., computing power and storage facilities). These networked resources can be delivered as services over the internet (typically represented by a cloud symbol in technical diagrams). The various models of cloud service delivery are collectively known as "X-as-a-Service," where X can be the development platform as a service (PaaS), the infrastructure as a service (IaaS), or the software as a service (SaaS) [1],[2]. Such cloud services have increased remarkably in recent years, and business systems delivered as cloud solutions have become important parts of the market segments [3]. Unlike traditional on-premise solutions, cloud services can be rapidly deployed, while their total cost is easy to estimate since it is linked to actual use. Furthermore, cloud services can support distributed business processes, facilitating globalization and potentially strengthening the competitive position of businesses.

The advent of cloud computing led to the development of cloud-based enterprise resource planning (ERP) solutions. ERPs are combinations of software modules that use common data repositories, allowing the integration of transactional data and business processes [4]. ERP systems have been introduced in organizations to increase efficiency [5], but the traditional ERP implementation has proven to be highly complex and demanding [6],[7]. Virtualization creates new possibilities for swift and cost-efficient ERP deployment [8]-[11], triggering the interest in moving ERPs to the cloud [12]. ERP systems delivered as cloud services (SaaS) are hosted remotely, and access is provided on demand, usually via a thin client, such as a web browser. The users do not own, manage, or operate the underlying infrastructure or individual ERP application capabilities [13]. The benefits of cloud-based ERPs are related to swift deployment, cost effectiveness, scalability, and ease of updates [10],[14]. Despite the alluring potential benefits of cloud ERPs, their adoption rates are very low compared with other cloud-based business applications [15]. For instance, organizations have quickly embraced cloud services for office automation applications and email exchanges but are reluctant to move their ERPs to the cloud. To gain an understanding of organizations' concerns about cloud ERP implementation, we reviewed the related research literature.

Specifically, we looked for recurring cloud ERP implementation concerns beyond strategic aspirations. The identified concerns are associated with both *transition management* and *operations* supported by cloud ERPs. Transitioning concerns include the introduction of new ERP work arrangements, the migration of legacy data, and the assurance of compliance with extant rules and regulations for security. The concerns related to operations include the continuous alignment between ERP functionality and business processes, the ongoing integration between ERPs and the rest of the organization's application portfolio, and the establishment of adequate reliability levels. All the identified concerns are related to the need to achieve infrastructural embeddedness. This need sets ERPs apart from other types of cloud-based applications, such as office automation solutions that do not have as many dependencies and exchanges with other systems and repositories within an organization's information infrastructure.

Overall, our study identifies, analyzes, and integrates a critical mass of research on cloud ERP implementation, offering a sound base for researchers and practitioners interested in the introduction of cloud ERPs in organizations. To ensure robust results, we performed a systematic literature review [16] guided by the following question: "*Which concerns related to the implementation of cloud-based ERP systems have been addressed in previous research literature?"* Our contribution is threefold. First, we identify recurring cloud ERP implementation concerns, explaining their limited diffusion. Second, we map the identified concerns to different sizes of organizations, pointing to the implications of size. Third, we synthesize our findings in a concise framework, revealing that infrastructural embeddedness is the key challenge for cloud-based ERPs.

We have organized the remainder of this paper as follows. In Section 2, we present the method used for selecting and analyzing the articles for this review. In Section 3, we offer a synthesis of our findings in two concise concept matrices. In Sections 4 and 5, we discuss the findings and draw conclusions by pointing to implications for research and practice and directions for further research.

2. Method

In this section, we first describe the scope of the literature review and the process we followed to select relevant articles. We then explain the method we applied to code and synthesize the findings of the selected articles. Overall, we conducted the systematic literature review by following the process proposed by Kitchenham [16]. Figure 1 provides an overview of this process.

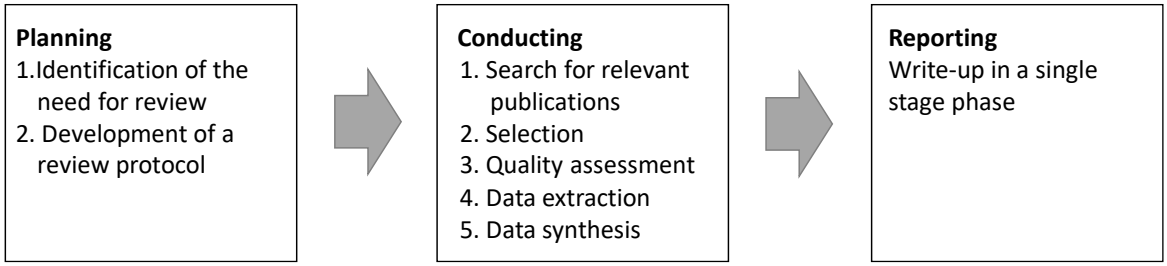

Fig. 1. Overview of literature review process (based on the process proposed by Kitchenham [16])

To identify and select the research articles for review, we used a set of search terms and a set of inclusion/exclusion criteria. The search terms and the inclusion/exclusion criteria were included in the review protocol. The use of a protocol is important for reducing selection bias and assuring the selected papers' quality and relevance [16]. We used 'cloud ERP' as the primary search term. To identify as many relevant articles as possible, we formulated the primary search term in a way that would ensure the inclusion of different alternative expressions. Specifically, the primary search string used was ('ERP' OR 'Enterprise Resource Planning') AND 'Cloud'. We used a set of additional terms to delimit the search within the research related to implementation. Specifically, the search word 'implementation' was added together with the related words 'adoption' and 'change' as alternatives. Thus, the complete search string used was (('ERP' OR 'Enterprise Resource Planning') AND 'Cloud') AND (('implementation') OR ('adoption') OR ('change')). By performing the search with the use of a compound string, we obtained a consolidated list of results, avoiding the problem of integrating and removing the duplication of the outcomes of different searches. The string was used to search publications by title, keywords, and abstract in Scopus. We restricted the search to publications that were peer reviewed, written in English, published in scientific journals and conference proceedings, and published until 2018.

The search yielded 183 unique articles in total. The next step was to read the titles and the abstracts of the identified articles, checking their relevance to the research question. For this step, we used the inclusion/exclusion criteria. Specifically, we excluded papers that only casually mentioned cloud ERP implementation but had a different focus (e.g., cloud computing in general or company disposition toward cloud ERPs). We also excluded papers published in outlets outside information systems (IS) research, computer science, business studies, and management research. Additionally, we disregarded articles focused on narrow domains (e.g., a specific type of farming, such as aquaponics). After this step, 49 papers were shortlisted.

Finally, the full text of each shortlisted paper was assessed for relevance by applying the inclusion/exclusion criteria to the full content. We also assessed the quality of the reported research by checking the rigorousness of each article's method description. After this step, a final corpus of 19 articles was selected. Figure 2 presents the sequence of these steps.

Table 1 presents the full reference list comprising the 19 selected articles. Additionally, Appendix A provides an overview of the key aims and insights of all selected articles.

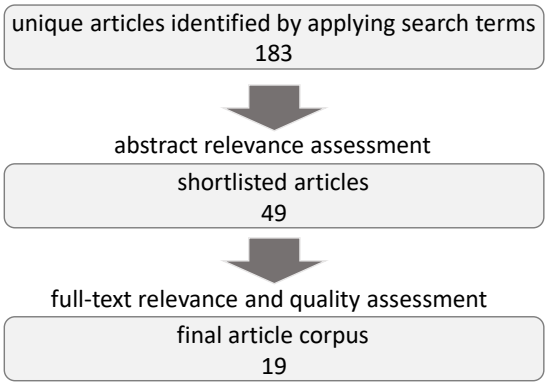

Fig. 2. Creating a corpus of articles for review: identification and selection process

We coded and synthesized the selected articles by following a concept-centric logic [17]. The coding of the articles was specifically focused on concepts related to implementation concerns, excluding other cloud ERP topics that were irrelevant to the research question. The first step involved identifying and listing key concepts while reading each article. After completing this step, we evaluated, consolidated, and refined all the identified concepts. Therefore, the concepts evolved inductively from the literature. The articles and the concepts were cross-analyzed to ensure consistency and comprehensiveness. The final set of concepts was used for the development of a concept matrix that would present the associations between the articles and the concepts (Table 2). The development of the concept matrix was instrumental for bringing up insights from published research to answer the research question "*Which concerns related to the implementation of cloud-based ERP systems have been addressed in previous research literature?"* The results of the analysis are presented in Section 3.

Table 1. List of selected articles

#	**Reference list comprising the selected articles**
1	Al-Johani, A. A., & Youssef, A. E. (2013). A framework for ERP systems in SME based on cloud computing technology. *International Journal on Cloud Computing: Services and Architecture*, 3(3), pp. 1–14.
2	Das, S., & Dayal, M. (2016). Exploring determinants of cloud-based enterprise resource planning (ERP) selection and adoption: a qualitative study in the Indian education sector. *Journal of Information Technology Case and Application Research*, 18(1), pp. 11–36.
3	Duan, J., Faker, P., Fesak, A., & Stuart, T. (2013). Benefits and drawbacks of cloud-based versus traditional ERP systems. *Proceedings of the 2012–13 course on Advanced Resource Planning*.
4	Elragal, A., & El Kommos, M. (2012). In-house versus in-cloud ERP systems: a comparative study. *Journal of Enterprise Resource Planning Studies*, vol. 2012, pp. 1–13.
5	Gupta, S., & Misra, S. C. (2016). Moderating effect of compliance, network, and security on the critical success factors in the implementation of cloud ERP. *IEEE Transactions on Cloud Computing*, 4(4), pp. 440–451.
6	Gupta, S., Misra, S. C., Kock, N., & Roubaud, D. (2018). Organizational, technological and extrinsic factors in the implementation of cloud ERP in SMEs. *Journal of Organizational Change Management*, 31(1), pp. 83–102.
7	Gupta, S., Misra, S. C., Singh, A., Kumar, V., & Kumar, U. (2017). Identification of challenges and their ranking in the implementation of cloud ERP. *International Journal of Quality & Reliability Management*, 34(7), pp. 1056–1072.
8	Johansson, B., Alajbegovic, A., Alexopoulos, V., & Desalermos, A. (2015). Cloud ERP adoption opportunities and concerns: the role of organizational size. *48th Hawaii International Conference on System Sciences*, pp. 4211–4219.

#	Reference list comprising the selected articles
9	Johansson, B., & Ruivo, P. (2013). Exploring factors for adopting ERP as SaaS. *Procedia Technology*, 9, pp. 94–99.
10	Kranz, J. J., Hanelt, A., & Kolbe, L. M. (2016). Understanding the influence of absorptive capacity and ambidexterity on the process of business model change – the case of on-premise and cloud-computing software. *Information Systems Journal*, 26(5), pp. 477–517.
11	Loebbecke, C., Thomas, B., & Ullrich, T. (2012). Assessing cloud readiness at Continental AG. *MIS Quarterly Executive*, 11(1), pp. 11–23.
12	López, C., & Ishizaka, A. (2017). GAHPSort: a new group multi-criteria decision method for sorting a large number of the cloud-based ERP solutions. *Computers in Industry*, 92, pp. 12–24.
13	McCrea, B. (2011). Putting the spotlight on ERP. *Logistics Management*, 50(6), pp. 32–35.
14	Meghana, H. L., Mathew, A. O., & Rodrigues, L. L. (2018). Prioritizing the factors affecting cloud ERP adoption – an analytic hierarchy process approach. *International Journal of Emerging Markets*, 13(6), pp. 1559–1577.
15	Mijac, M., Picek, R., & Stapic, Z. (2013). Cloud ERP system customization challenges. *Central European Conference on Information and Intelligent Systems*, pp. 132–140.
16	Peng, G. C. A., & Gala, C. (2014). Cloud ERP: a new dilemma to modern organisations? *Journal of Computer Information Systems*, 54(4), pp. 22–30.
17	Saeed, I., Juell-Skielse, G., & Uppström, E. (2012). Cloud enterprise resource planning adoption: motives & barriers. *Advances in Enterprise Information Systems*, II, pp. 429–434.
18	Seethamraju, R. (2015). Adoption of software as a service (SaaS) enterprise resource planning (ERP) systems in small and medium sized enterprises (SMEs). *Information Systems Frontiers*, 17(3), pp. 475–492.
19	Weng, F., & Hung, M. C. (2014). Competition and challenge on adopting cloud ERP. *International Journal of Innovation, Management and Technology*, 5(4), pp. 309–313.

3. Results

The analysis of the selected articles reveals several concerns related to the implementation of cloud-based ERPs. Specifically, the identified concerns are associated with both *transition management* and *operations* supported by cloud ERPs. Transitioning concerns include the introduction of new ERP work arrangements, the migration of legacy data, and the assurance of compliance with extant rules and regulations for security. The concerns related to operations include the continuous alignment between ERP functionality and business processes, the ongoing integration between ERPs and the rest of the organization's application portfolio, and the establishment of adequate reliability levels. In the following subsections, we present these concerns in detail.

3.1 Concerns related to transition management

Introduction of new ERP work arrangements. Similar to conventional ERP solutions, the adoption of cloud-based ERPs leads to organizational changes [11]. Workers must adjust some of their routines to handle data differently. This can be especially challenging for large organizations that have to bring onboard numerous employees from different business units, investing significant resources and time to train everybody. Furthermore, the IT Department's resistance to the changes induced by cloud ERPs (e.g., related to working with external service providers) tends to be an issue for large businesses but not for small- and medium-sized enterprises (SMEs) [8],[10].

Migration of legacy data. The implementation of cloud-based ERP systems can be challenged when there is a need to migrate data from existing repositories to the cloud ERP database. The rules and the data structures of cloud ERP solutions can be very different from those of the systems that are already in use on the premises [18]. The migration

from traditional ERP solutions to cloud-based ERP systems can be especially demanding for large organizations with complex systems, making migration very expensive and time consuming [10],[18].

Assurance of compliance with extant rules and regulations for security. Security is a key concern for organizations deciding to adopt cloud-based services [10], [19]-[21]. In cloud-based ERPs, all organizational information, such as financial data and customer details, needs to be stored with a third-party supplier; thus, data security can be threatened if encryption and other related mechanisms are not properly implemented. It can be challenging for cloud ERP suppliers to build user trust, and their data protection measures should be explained [19]. For many businesses, it is difficult to decide to rely on suppliers for secure storage, implementation of security policies, and application of access control rules [9],[12],[18],[22]. Furthermore, regulations in many countries are not in favor of cloud solutions for enterprise data storage [23] or impose stringent compliance requirements [19]. Consequently, organizations are increasingly apprehensive about cloud ERP data storage arrangements. Additionally, cultural aspects can considerably influence company stances regarding data security. For instance, companies in Western Europe can be particularly reluctant to use cloud software because of concerns regarding data security [24]. Overall, many enterprises are uncomfortable with losing control over the storage and the management of their own data by adopting cloud ERPs [23]. Ensuring compliance with extant rules and regulations for data security is one of the most common concerns.

3.2 Concerns related to operations

Continuous alignment between ERP functionality and business processes. Cloud-based ERPs are usually not as comprehensive in terms of functionality as traditional on-site ERP systems. Unsurprisingly, business units with standardized processes across industries (e.g., human resources, purchase management, accounting) were the first to demand cloud ERP services [24]. Business units that perform less standardized work tend to be less interested as it can be difficult to find a cloud-based solution to fit all the needs of an implementing organization [8],[25],[26]. Furthermore, organizations frequently need to adapt their ERPs over time, adjusting to changing needs. Thus, alignment should be continuously ensured via system adaptability [21]. This is especially challenging for organizations that need functionalities that are not required by many other firms. Cloud ERP service providers rarely add functionalities that only benefit a few of the companies using their cloud software [27]. Consequently, organizations implementing cloud ERPs may need customized cloud-based ERP services [19].

Ongoing integration between ERPs and the rest of the organization's application portfolio. Many cloud-based ERP systems have noticeable limitations in integrating with existing application portfolios [8]. Overall, organizations that implement cloud ERPs depend on cloud ERP providers' ability to solve integration issues [23]. This can create problems, especially regarding business-critical systems or processes [12],[28]-[29]. Furthermore, integration can be difficult for organizations with complex legacy systems [10]. Therefore, ease of integration is one of the key factors influencing cloud ERP adoption [21]. The introduction of service-oriented architecture can support the orchestration of cross-functional business processes and the integration between ERP and non-ERP components of the information infrastructure [9].

Instituting adequate reliability levels. When a company chooses a cloud-based ERP system, reliability is crucial [20]. Delays or failures can create serious problems [14], so ensuring system availability is necessary [21],[23]. This means that a predictable, stable, and reliable network connection is required [19],[30]. Organizations that need round-the-clock access to their ERPs express significant concerns about the timeliness and the quality of cloud provider support services [27]. Overall, it is important for ERP users to ensure that their systems have reliable response times [19].

The concept matrix presented in Table 2 provides an overview of the findings and shows how the identified concerns (listed in columns) are associated with the analyzed articles (listed in rows). Organizations of different sizes have different capabilities and resources, so their concerns may differ. Although not all the articles that we analyzed specify the sizes of the studied organizations, several articles provide insights specific to different sizes of organizations, especially making the distinction between large companies and SMEs. To trace potential differences, we decided to map the concerns according to organizational sizes by using the relevant information available in 10 out of the 19 selected papers. These mappings are presented in Tables 3a and 3b.

Table 2. Concept matrix for all selected articles

Article # (full references provided in Table 1) (Appendix A provides the key aims and insights)	Transitioning Concerns			Operating Concerns		
	Introduction of new ERP work arrangements	Migration of legacy data	Assurance of compliance with security regulations	Alignment between ERP functionality and processes	Integration between ERPs and application portfolios	Instituting adequate reliability levels
1			X	X	X	X
2			X	X		X
3	X		X	X	X	X
4	X		X			
5	X		X	X	X	
6			X	X		X
7	X	X	X	X	X	X
8	X	X	X	X	X	X
9			X	X		X
10			X	X		X
11			X	X	X	
12	X			X		
13			X			X
14			X	X	X	X
15	X				X	
16	X		X		X	
17			X	X	X	X
18	X		X		X	X
19			X	X	X	

Table 3a. Concept matrix based on organizational size* – Small and Medium Organizations

Article # (full references provided in Table 1) (Appendix A provides the key aims and insights)	Small and Medium Organizations					
	Transitioning Concerns			Operating Concerns		
	Introduction of new ERP work arrangements	Migration of legacy data	Assurance of compliance with security regulations	Alignment between ERP functionality and processes	Integration between ERPs and application portfolios	Instituting adequate reliability levels
1			X	X	X	X
2			X	X		X
3						
5	X		X	X	X	
6			X	X		X

Article # (full references provided in Table 1) (Appendix A provides the key aims and insights)	Small and Medium Organizations					
	Transitioning Concerns			Operating Concerns		
	Introduction of new ERP work arrangements	Migration of legacy data	Assurance of compliance with security regulations	Alignment between ERP functionality and processes	Integration between ERPs and application portfolios	Instituting adequate reliability levels
7			X	X	X	X
8			X			X
11						
14						
18	X		X		X	X

*Only 10 out of the 19 selected papers contain organizational size-specific information; these 10 papers are included in this table.

Table 3b. Concept matrix based on organizational size* – Large Organizations

Article # (full references provided in Table 1) (Appendix A provides the key aims and insights)	Large Organizations					
	Transitioning Concerns			Operating Concerns		
	Introduction of new ERP work arrangements	Migration of legacy data	Assurance of compliance with security regulations	Alignment between ERP functionality and processes	Integration between ERPs and application portfolios	Instituting adequate reliability levels
1						
2						
3	X		X	X	X	
5						
6						
7	X	X	X	X	X	X
8	X	X	X	X	X	X
11			X	X	X	
14			X	X	X	X
18						

*Only 10 out of the 19 selected papers contain organizational size-specific information; these 10 papers are included in this table.

4. Discussion and implications

The concerns identified through our literature review are sociotechnical in nature and point to the need to ensure continuity with the past and sustainability in the future by embedding cloud ERPs in the information infrastructures that are already in place. Infrastructural embeddedness entails being "sunk" into other structures, social arrangements, and technologies [31]. Specifically, implementing cloud ERPs involves becoming part of the installed base of applications and data, work processes, and governance arrangements [31]-[33]. The installed base serves as the foundation for

business development and can be both enabling and constraining. The new cloud-based ERPs need to fit and make use of existing arrangements and at the same time, extend and transform them.

When implementing cloud ERPs, the old and the new need to be linked together, becoming interoperable in one way or another. Therefore, the old (the installed base) heavily influences how the new can be designed, and the overall infrastructure is developed through extending and improving the installed base [34]. The installed base may create path dependencies and lock-in mechanisms [35]. Vendor lock-in has been identified as a possible barrier to implementing cloud solutions, and the relationship between the vendor and the consumer of a cloud solution is important in the consumer's decision to move to the cloud [36]. Furthermore, as cloud-based ERP solutions are built on a different service model than the traditional ERP systems, they have consequences for the established control structures within an organization. For example, the IT Department has traditionally controlled the systems and the related infrastructure. When implementing cloud-based ERP solutions, the control is shifted to external suppliers. It follows that the IT Department will need to adapt and introduce new ways of organizing and training the staff in new skills [37]. Overall, the implementation of cloud ERPs entails positioning and fitting them in the overall information infrastructure, which consists of multiple sociotechnical components, including data and applications, work processes, and governance arrangements [32]. Ensuring embeddedness (i.e., becoming sunk) in work processes, data and applications, and governance arrangements involves specific activities during both the transition period (introducing new ERP work arrangements, migrating legacy data, and ensuring compliance with extant rules and regulations) and the subsequent day-to-day operations (through the continuous alignment between ERP functionality and business processes, the ongoing integration between ERPs and the rest of the organization's application portfolio, and the establishment of adequate reliability levels). Figure 3 presents the synthesis of our findings in a framework for ERP implementation, which focuses on infrastructural embeddedness. The cloud ERP should be embedded in the information infrastructure through the activities of transitioning (noted in the inner circle) and of day-to-day operations (noted on the sides of the triangle).

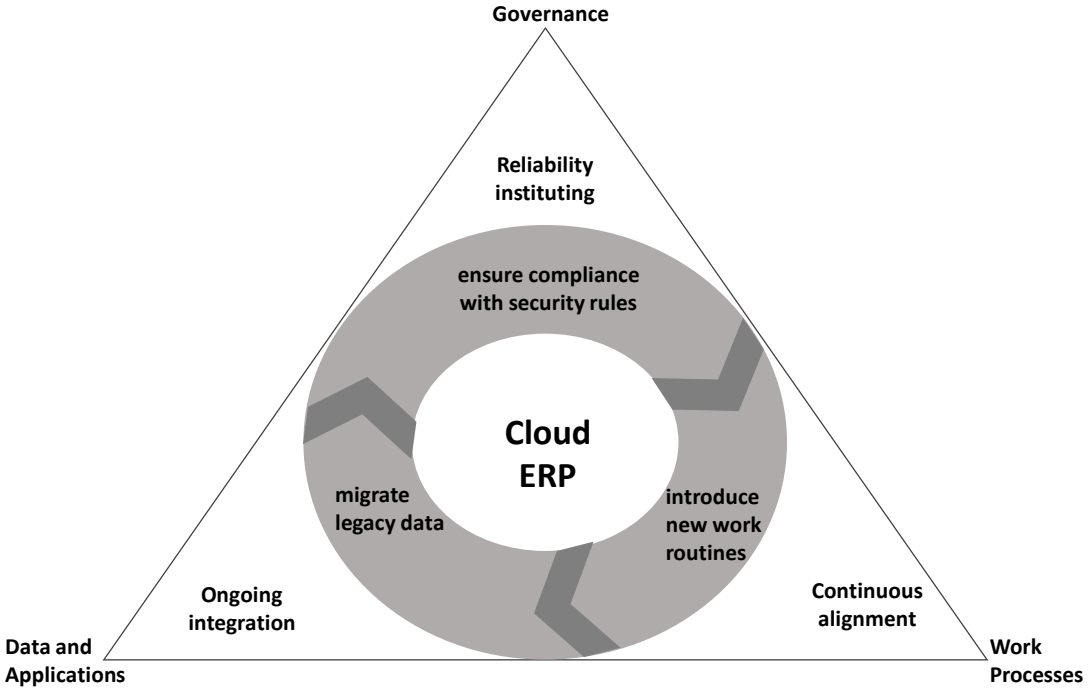

Fig. 3. Implementing cloud ERPs: the challenge of infrastructural embeddedness

The framework presented in Figure 3 is common for all organizations, irrespective of size. Nevertheless, some of its aspects are more challenging for large organizations because they tend to have more extensive and complex existing information infrastructures than smaller companies [38]. For instance, in Tables 3a and 3b, which present the specific concerns of large enterprises and SMEs, data migration only appears as a specific concern for the former. This is probably because many SMEs decide to implement cloud ERPs without having legacy ERPs in place (i.e., they introduce ERPs for the first time). Furthermore, SMEs tend to have more informal structures than larger companies and consequently can move to cloud ERPs more swiftly [39].

The size-specific concept matrix (Tables 3a and 3b) illustrates a gap in the literature regarding cloud-based ERP implementation relative to organizational size. In their study, Johansson and colleagues [10] identify that SMEs and large businesses may have different needs in implementation and mention that scant research compares them, as confirmed by our matrix. We suggest that more research is needed toward this direction, especially in exploring the challenges of large organizations where there is less experience because vendors mostly target SMEs that can now obtain ERP functionality at a low cost due to limited implementation overhead and simplicity. Nevertheless, large companies also recognize and appreciate the advantages of cloud ERPs, such as IT efficiency and business agility [10].

Unsurprisingly, most of the identified concerns can be traced back to the challenges related to adopting cloud computing and introducing ERPs [23]. For instance, previous research provides evidence that the security issue is one of the main obstacles to utilizing cloud computing services for business-critical applications [40]-[41]. In this review, ensuring compliance with security regulations is the most prominent concern and is mentioned in almost all the reviewed articles. There are multiple reasons for being apprehensive about security. On one hand, there are strategic reasons for safeguarding core business information; on the other hand, regulatory requirements are becoming increasingly strict. Organizations are particularly worried about international and national regulations, as well as laws for data storage when moving business-critical systems to the cloud [42]. It is important that they assess the quality of different cloud service providers before making a decision on choosing their provider. Some service providers may lack contract competency, and the combination of poorly developed contracts and little evidence of security makes it difficult to ensure compliance with security regulations when introducing cloud services [24]. A quick look at the size-specific concept matrix in Tables 3a and 3b reveals that this concern is discussed for smaller and larger organizations, irrespective of organizational size. The legal issues related to data security when considering cloud ERP solutions can be particularly challenging for small enterprises that mostly lack organized legal departments. With a cloud ERP solution, it is difficult to know where the data are located, and which legislation would apply to these data. In a supply chain in the cloud, the SaaS provider may be located in China, while the platform or infrastructure provider could be based in Germany. What then are the rules, and who is responsible if conflicts occur?

Another area of concern that is frequently found in the literature is related to introducing new ERP work arrangements. Although cloud ERPs can be quickly launched, they still require significant time for organizational adaptations, including new roles for the IT Department. Many small organizations have no existing ERPs in place, and cloud solutions offer them the opportunity to introduce capabilities that were previously inconceivable. These organizations also need to initiate new work arrangements for their newly introduced ERPs. More research is needed to investigate the needs of small companies, probably also distinguishing among different industries and maturity levels of the pre-existing information infrastructures.

5. Conclusion

Evidence suggests that organizations that want to reduce the complexity of IS implementation and use tend to positively consider cloud solutions as alternatives to on-premise systems [43]. Nevertheless, organizations want to control their core business processes and are frequently skeptical about moving complex and business-critical systems, such as their ERPs, to the cloud, opting to introduce the cloud concept through simpler and less critical applications (e.g., office support tools). However, it is important to think strategically and consider what solution creates the best business value [11]. This is especially challenging for organizations that have already complex on-premise systems and traditional platforms in place. In this paper, we have identified several recurring cloud ERP implementation concerns beyond

strategic aspirations. By synthesizing a corpus of selected research articles on cloud ERP implementation, we offer a sound base for researchers and practitioners interested in the introduction of cloud ERPs in organizations. Our contribution is threefold. First, we identify some recurring cloud ERP implementation concerns, pointing to the work involved in introducing such systems in organizations that already have information infrastructures in place. Second, we map the identified concerns to different sizes of organizations, foregrounding the implications of size. Third, we integrate the findings in a concise framework, covering the multiple aspects of infrastructural embeddedness for cloud-based ERPs.

In our literature review, we have found surprisingly few empirical papers that focus on the implementation of cloud-based ERP solutions and sociotechnical concerns in this regard. One reason might be that cloud-based ERP solutions are still not widespread. Furthermore, as noted, several of the reviewed articles do not explicitly state the sizes of the organizations under study. It is important for research to be properly contextualized to be useful for further development, and we urge researchers to report as much contextual information as possible (e.g., organizational size, industry, years in operation). To advance our knowledge on the implementation of cloud ERP solutions, we need more empirical studies that show the issues addressed by organizations of different sizes.

References

[1] M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, *et al.*, "A view of cloud computing," *Communications of the ACM,* vol. *53*, pp. *50-58*, 2010.

[2] R. Buyya, C. S. Yeo, S. Venugopal, J. Broberg, and I. Brandic, "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility," *Future Generation Computer Systems,* vol. *25*, pp. *599-616*, 2009.

[3] W. Venters and E. A. Whitley, "A critical review of cloud computing: researching desires and realities," *Journal of Information Technology,* vol. *27*, pp. *179-197*, 2012.

[4] M. L. Markus and C. Tanis, "The enterprise systems experience-from adoption to success," *Framing the Domains of IT Research: Glimpsing the Future through the Past,* vol. *173*, pp. *207-173*, 2000.

[5] H. A. Akkermans and K. Van Helden, "Vicious and virtuous cycles in ERP implementation: a case study of interrelations between critical success factors," *European Journal of Information Systems,* vol. *11*, pp. *35-46*, 2002.

[6] E. Hustad and D. H. Olsen, "ERP implementation in an SME: a failure case," in *Information Systems for Small and Medium-sized Enterprises: State of the Art of IS Research in SMEs*, J. Devos, H. van Landeghem, D. Deschoolmeester, Eds., New York, US: Springer, 2014, sec. *III*, pp. *213-228*.

[7] M. Haddara, "ERP systems selection in multinational enterprises: a practical guide," *International Journal of Information Systems and Project Management,* vol. *6*, pp. *43-57*, 2018.

[8] J. Duan, P. Faker, A. Fesak, and T. Stuart, "Benefits and drawbacks of cloud-based versus traditional ERP systems," in *Proceedings of the 2012-13 Course on Advanced Resource Planning,* 2013.

[9] A. A. Al-Johani and A. E. Youssef, "A framework for ERP systems in SME based on cloud computing technology," *International Journal on Cloud Computing: Services and Architecture,* vol. *3*, pp. *1-14*, 2013.

[10] B. Johansson, A. Alajbegovic, V. Alexopoulo, and A. Desalermos, "Cloud ERP adoption opportunities and concerns: the role of organizational size," in *Proceedings of the 48th Hawaii International Conference on Systems Sciences (HICSS),* 2015, pp. *4211-4219*.

[11] A. Elragal and M. El Kommos, "In-house versus in-cloud ERP systems: a comparative study," *Journal of Enterprise Resource Planning Studies,* vol. *2012*, pp. *1-13*, 2012.

[12] G. C. A. Peng and C. Gala, "Cloud ERP: a new dilemma to modern organisations?" *Journal of Computer Information Systems,* vol. *54*, pp. *22-30*, 2014.

[13] S. Schneider and A. Sunyaev, "Determinant factors of cloud-sourcing decisions: reflecting on the IT outsourcing literature in the era of cloud computing," *Journal of Information Technology,* vol. *31*, pp. *1-31*, 2016.

[14] R. Seethamraju, "Adoption of software as a service (SaaS) enterprise resource planning (ERP) systems in small and medium sized enterprises (SMEs)," *Information Systems Frontiers,* vol. *17*, pp. *475-492*, 2015.

[15] G. Gallardo, J. Hernantes, and N. Serrano, "Designing SaaS for enterprise adoption based on task, company, and value-chain context," *IEEE Internet Computing,* vol. *22*, pp. *37-45*, 2018.

[16] B. Kitchenham, "Procedures for performing systematic reviews," *Keele University Technical Report, UK,* vol. *TR/SE-0401*, pp. *1-26*, 2004.

[17] J. Webster and R. T. Watson, "Analyzing the past to prepare for the future: writing a literature review," *MIS Quarterly,* vol. *26*, pp. *xiii-xxiii,* 2002.

[18] S. Gupta, S. C. Misra, A. Singh, V. Kumar, and U. Kumar, "Identification of challenges and their ranking in the implementation of cloud ERP: A comparative study for SMEs and large organizations," *International Journal of Quality and Reliability Management,* vol. *34*, pp. *1056-1072*, 2017.

[19] S. Gupta, S. C. Misra, N. Kock, and D. Roubaud, "Organizational, technological and extrinsic factors in the implementation of cloud ERP in SMEs," *Journal of Organizational Change Management,* vol. *31*, pp. *83-102*, 2018.

[20] B. McCrea, "Putting the spotlight on ERP," *Logistics Management,* vol. *50*, pp. *32-35*, 2011.

[21] H. L. Meghana, A. O. Mathew, and L. L. R. Rodrigues, "Prioritizing the factors affecting cloud ERP adoption–an analytic hierarchy process approach," *International Journal of Emerging Markets,* vol. 13, pp. 1559-1577, 2018.

[22] C. Loebbecke, B. Thomas, and T. Ullrich, "Assessing cloud readiness at Continental AG," *MIS Quarterly Executive,* vol. *11*, pp. *11-23*, 2012.

[23] I. Saeed, G. Juell-Skielse, and E. Uppström, "Cloud enterprise resource planning adoption: motives & barriers," *Advances in Enterprise Information Systems II,* pp. *429-434*, 2012.

[24] J. J. Kranz, A. Hanelt, and L. M. Kolbe, "Understanding the influence of absorptive capacity and ambidexterity on the process of business model change–the case of on-premise and cloud-computing software," *Information Systems Journal,* vol. 26, pp. *477-517*, 2016.

[25] F. Weng and M.-C. Hung, "Competition and challenge on adopting cloud ERP," *International Journal of Innovation, Management and Technology,* vol. *5*, pp. *309-313*, 2014.

[26] C. López and A. Ishizaka, "GAHPSort: A new group multi-criteria decision method for sorting a large number of the cloud-based ERP solutions," *Computers in Industry,* vol. *92*, pp. *12-24*, 2017.

[27] S. Das and M. Dayal, "Exploring determinants of cloud-based enterprise resource planning (ERP) selection and adoption: A qualitative study in the Indian education sector," *Journal of Information Technology Case and Application Research,* vol. *18*, pp. *11-36*, 2016.

[28] M. Mijac, R. Picek, and Z. Stapic, "Cloud ERP system customization challenges," in *Proceedings of Central European Conference on Information and Intelligent Systems,* 2013, pp. *132-140*.

[29] S. Gupta and S. C. Misra, "Moderating effect of compliance, network, and security on the critical success factors in the implementation of cloud ERP," *IEEE Transactions on Cloud Computing,* vol. *4*, pp. *440-451*, 2016.

[30] B. Johansson and P. Ruivo, "Exploring factors for adopting ERP as SaaS," *Procedia Technology,* vol. *9*, pp. *94-99*, 2013.

[31] S. L. Star and K. Ruhleder, "Steps toward an ecology of infrastructure: design and access for large information spaces," *Information Systems Research,* vol. *7*, pp. *111-134*, 1996.

[32] O. Hanseth and K. Lyytinen, "Design theory for dynamic complexity in information infrastructures: the case of building internet," *Journal of Information Technology,* vol. *25*, pp. *1-19*, March 2010.

[33] M. Aanestad, M. Grisot, O. Hanseth, and P. Vassilakopoulou, "Information infrastructures and the challenge of the installed base," in *Information Infrastructures within European Health Care*, M. Aanestad, M. Grisot, O. Hanseth, P. Vassilakopoulou, Eds., Cham, Switzerland: Springer, ch. *3*, sec. *I*, 2017, pp. *25-33*.

[34] C. U. Ciborra and O. Hanseth, "From tool to Gestell: Agendas for managing the information infrastructure," *Information Technology & People,* vol. *11*, pp. *305-327*, 1998.

[35] C. Shapiro and H. R. Varian, *Information Rules: A Strategic Guide to the Network Economy*, Brighton, Massachusetts, US: Harvard Business Press, 1998.

[36] P. K. Wamuyu, "Use of cloud computing services in micro and small enterprises: a fit perspective," *International Journal of Information Systems and Project Management,* vol. *5*, pp. *59-81*, 2017.

[37] J. Vithayathil, "Will cloud computing make the Information Technology (IT) department obsolete?" *Information Systems Journal,* vol. *28*, pp. *634-649*, 2018.

[38] E. Hustad and L. Staverløkk, "Implementing a Service-Oriented Architecture: A Technochange Approach," in *Information Systems Development: Reflections, Challenges and New Directions*, R. Pooley, J. Coady, C. Schneider, H. Linger, C. Barry & M. Lang, Eds., New York, US: Springer, 2013, ch. *42*, pp. *527-538*.

[39] C. M. Chan, S. Y. Teoh, A. Yeow, and G. Pan, "Agility in responding to disruptive digital innovation: Case study of an SME," *Information Systems Journal*, vol. *29*, pp. *436-455*, 2019.

[40] N. Kshetri, "Privacy and security issues in cloud computing: The role of institutions and institutional evolution," *Telecommunications Policy,* vol. *37*, pp. *372-386*, 2013.

[41] R. El-Gazzar, E. Hustad, and D. H. Olsen, "Understanding cloud computing adoption issues: a Delphi study approach," *Journal of Systems and Software,* vol. *118*, pp. *64-84*, 2016.

[42] S. Marston, Z. Li, S. Bandyopadhyay, J. Zhang, and A. Ghalsasi, "Cloud computing—The business perspective," *Decision support systems,* vol. *51*, pp. *176-189*, 2011.

[43] M. Stieninger, D. Nedbal, W. Wetzlinger, G. Wagner, and M. Erskine, "Factors influencing the organizational adoption of cloud computing: a survey among cloud workers," *International Journal of Information Systems and Project Management,* vol. *6*, pp. *5-23*, 2018.

Appendix A. List of selected articles – overview of key aims and insights

#	Title	Year	Author(s)	Key Aims	Insights
1	A framework for ERP systems in SME based on cloud computing technology	2013	Al-Johani, A. A., & Youssef, A. E.	Identify benefits and drawbacks of cloud ERPs through a comprehensive comparison of ERPs before and after moving to the cloud. Propose a framework for cloud ERPs tailored to SME needs, and test it in an actual case.	Although several challenges and drawbacks are associated with cloud ERPs, the overall benefits for SMEs are more significant. The proposed framework can be applied to facilitate SMEs' transfer of their ERPs to the cloud, realizing solution integration and industry functionality at a relatively low cost.
2	Exploring determinants of cloud-based enterprise resource planning (ERP) selection and adoption: a qualitative study in the Indian education sector	2016	Das, S., & Dayal, M.	Explore the drivers for cloud ERP selection and adoption through a framework that integrates three technology adoption theories (diffusion of innovations, task-technology fit, and extended technology acceptance model), and test the framework in three cases.	The results suggest that vendors should focus on providing secure, standardized, long-term, convenient, and high-quality services, balancing between customization-related additional costs and business value. Adopting organizations should determine organizational fit and train their employees to minimize resistance.
3	Benefits and drawbacks of cloud-based versus traditional ERP systems	2013	Duan, J., Faker, P., Fesak, A., & Stuart, T.	Identify and classify the benefits and the drawbacks of cloud-based versus traditional ERPs. Analyze whether the benefits and the drawbacks of cloud-based ERPs are more relevant for SMEs than for large enterprises.	Lower costs, scalability, access to specialized technology, and disaster recovery facilities are important for SMEs. At the same time, the known drawbacks of cloud-based ERPs are less important to SMEs. For some SMEs, extensive customization and integration may be irrelevant. Similarly, loss of IT skills and competencies, the IT Department's resistance to change, and certain security risks may not be major issues for SMEs.
4	In-house versus in-cloud ERP systems: a comparative study	2012	Elragal, A., & El Kommos, M.	Provide a framework for comparison between traditional and cloud-based ERP implementation.	The results show that cloud ERPs are faster to implement, easier to use, scalable, and cost less. However, traditional ERPs allow more control; thus, many organizations deem them more secure.
5	Moderating effect of compliance, network, and security on the critical success factors in the implementation of cloud ERPs	2016	Gupta, S., & Misra, S. C.	Explore correlations in key success factors (organizational, human, and technological) in the implementation of cloud ERPs.	Structural equation modeling is used to establish whether there are moderating effects of compliance, network, and security on the success factors for cloud ERP implementation. There is no significant effect on people and technological success factors. Only the organizational success factors are found to be moderated.
6	Organizational, technological and extrinsic factors in the implementation of cloud ERP in SMEs	2018	Gupta, S., Misra, S. C., Kock, N., & Roubaud, D.	Investigate the relationship between SMEs and cloud service providers and identify crucial factors that lead to successful implementation of cloud ERPs.	The findings include organizational and technical factors for successful implementation of cloud ERPs in SMEs, as well as the extrinsic factors that may influence cloud service providers' performance. The resource dependency theory is used to explain SME concerns.
7	Identification of challenges and their ranking in the implementation of cloud ERP: a comparative study for SMEs and large organizations	2017	Gupta, S., Misra, S. C., Singh, A., Kumar, V., & Kumar, U.	Identify critical challenges in the implementation of cloud ERPs.	A number of challenges are ranked, showing also how small, medium, and large businesses differ.

#	Title	Year	Author(s)	Key Aims	Insights
8	Cloud ERP adoption opportunities and concerns: the role of organizational size	2015	Johansson, B., Alajbegovic, A., Alexopoulos, V., & Desalermos, A.	Identify and classify opportunities and concerns that are often associated with cloud ERPs with respect to organizational size.	Small- and medium-sized businesses can reap significant benefits and have no major concerns. Large companies have greater concerns related to complexity and specific requirements.
9	Exploring factors for adopting ERP as SaaS	2013	Johansson, B., & Ruivo, P.	Map the value proposition for ERPs delivered as SaaS. Explore perceived benefits and concerns regarding cloud ERP adoption.	The 10 key factors identified are costs, security, availability, usability, implementation, ubiquity, flexibility, compatibility, analytics, and best practices. The main concerns include costs, data security, and system availability.
10	Understanding the influence of absorptive capacity and ambidexterity on the process of business model change – the case of on-premise and cloud-computing software	2016	Kranz, J. J., Hanelt, A., & Kolbe, L. M.	Explore the business model changes by studying the technological trajectory of ERP software that shifts from on-premise to on-demand software services.	A theoretical model built on the concepts of absorptive capacity and organizational ambidexterity is proposed. The factors that determine how and why incumbents change business models to provide cloud ERP services are identified. Some insights on ERPs switching from on-premise to on-demand services are offered.
11	Assessing cloud readiness at Continental AG	2012	Loebbecke, C., Thomas, B., & Ullrich, T.	Use a field-tested method to evaluate the studied organization's maturity for cloud services.	Five guidelines for businesses to switch to cloud services are presented. The suggested approach can resolve compliance and security issues.
12	GAHPSort: a new group multi-criteria decision method for sorting a large number of the cloud-based ERP solutions	2017	López, C., & Ishizaka, A.	Support companies in choosing cloud-based ERP systems through a decision support tool validated in a real case.	The paper highlights the differences between traditional and cloud-based ERP and proposes how to proceed in the selection process.
13	Putting the spotlight on ERP	2011	McCrea, B.	Investigate the supply chain software space to find how ERP systems are used, covering both cloud-based and on-premise ERPs.	The study identifies several benefits for and barriers to ERP systems, along with the status toward cloud computing and a detailed mapping of applications in use or planned.
14	Prioritizing the factors affecting cloud ERP adoption – an analytic hierarchy process approach	2018	Meghana, H. L., Mathew, A. O., & Rodrigues, L. L.	Rank different factors influencing cloud ERP adoption in multinational companies.	The five most important factors are data accessibility, availability, user friendliness, scalability, and data backup and recovery, while vendor trustworthiness and data retention are ranked relatively low.
15	Cloud ERP system customization challenges	2013	Mijac, M., Picek, R., & Stapic, Z.	Provide an overview of customization challenges.	The study identifies 12 challenges and problems with the customization of cloud-based ERP systems.
16	Cloud ERP: a new dilemma to modern organisations?	2014	Peng, G. C. A., & Gala, C.	Explore benefits and barriers associated with the adoption of cloud-based ERPs.	The study identifies 15 benefits and 18 critical barriers.
17	Cloud enterprise resource planning adoption: motives & barriers	2012	Saeed, I., Juell-Skielse, G., & Uppström, E.	Build a unified framework of motives for and barriers to cloud ERP adoption.	Most of the motives and the barriers found can be traced back to ERP outsourcing and/or cloud computing. The motives and the barriers are strategic, operational, and technical.
18	Adoption of software as a service (SaaS) enterprise resource planning (ERP) systems in small and medium sized enterprises	2015	Seethamraju, R.	Explore specific factors and challenges in the adoption of cloud ERP systems in SMEs.	Cloud ERP systems are considered suitable for SMEs. They can support visibility and standardized processes, as well as support and improve performance.
19	Competition and challenge on adopting cloud ERP	2014	Weng, F., & Hung, M. C.	Provide a framework that facilitates organizations' assessment of whether ERP cloud services are right for them.	The important factors that should be considered are listed. The four main concerns are related to data security, business profit, internet accessibility, and total cost.

Biographical notes

Eli Hustad is Professor at the Department of Information Systems, University of Agder. She holds a Ph.D. from the University of Oslo, Department of Informatics, Norway. Her main research interest are implementation and adoption of enterprise systems, knowledge management and business analytics. She serves as a Senior Editor for the Journal of Information Technology and People. She has presented her research at several international conferences and published her work in journals such as Information Systems Journal, Information Management Systems, Journal of Systems and Software, and Journal of Integrated Design & Process Science.

Emeli Høvik Jørgensen has a Master of Science in Information Systems. Her specialization and master thesis focused on implementation of ERP systems as cloud solutions. She is currently working within the Oil & Energy sector. Her work focuses on access management, digitalization, Robotics Process Automation and cloud solutions.

Vegard Uri Sørheller has a Master of Science in Information Systems. His specialization and master thesis focused on implementation of ERP systems as cloud solutions. He is currently working as a Business & Integration Analyst in a leading Technology Consultancy Company.

Polyxeni Vassilakopoulou is Associate Professor at the Department of Information Systems, University of Agder. She studied industrial engineering (M.Eng) at the Technical University of Crete, operations research at Columbia University (M.Sc). and received her Ph.D. from the National Technical University of Athens. Her research interests relate to information systems for complex settings with a dual focus on systems' design and systems' appropriation and use. She serves as a Co-Editor for the Scandinavian Journal of Information Systems. She has published in journals including Information Systems Journal, Computer Supported Collaborative Work and the International Journal of Medical Informatics. Before joining academia, she worked in management consulting for over a decade leading large-scale projects mostly within banking.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

The pivotal factors of IT projects' success – Insights for the case of organizations from the Federation of Bosnia and Herzegovina

Muamer Bezdrob
American University in Bosnia and Herzegovina, Faculty of Economics
Trg solidarnosti 10, 71000 Sarajevo
Bosnia and Herzegovina
mbezdrob@aubih.edu

Sabina Brkić
American University in Bosnia and Herzegovina, Faculty of Economics
Trg solidarnosti 10, 71000 Sarajevo
Bosnia and Herzegovina
sabc1122@aubih.edu

Manfred Gram
American University in Bosnia and Herzegovina, Faculty of Economics
Trg solidarnosti 10, 71000 Sarajevo
Bosnia and Herzegovina
mdgm1122@aubih.edu

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

M. Bezdrob, S. Brkić, M. Gram, "The pivotal factors of IT projects' success – Insights for the case of organizations from the Federation of Bosnia and Herzegovina", *International Journal of Information Systems and Project Management*, vol. 8, no. 1, pp. 23-41, 2020.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

The pivotal factors of IT projects' success – Insights for the case of organizations from the Federation of Bosnia and Herzegovina

Muamer Bezdrob
American University in Bosnia and Herzegovina, Faculty of Economics
Trg solidarnosti 10, 71000 Sarajevo, Bosnia and Herzegovina
mbezdrob@aubih.edu

Sabina Brkić
American University in Bosnia and Herzegovina, Faculty of Economics
Trg solidarnosti 10, 71000 Sarajevo, Bosnia and Herzegovina
sabc1122@aubih.edu

Manfred Gram
American University in Bosnia and Herzegovina, Faculty of Economics
Trg solidarnosti 10, 71000 Sarajevo, Bosnia and Herzegovina
mdgm1122@aubih.edu

Abstract:
This research aims to investigate the circumstances and possible reasons for a very high and rather unexpected success rate of Information Technology (IT) projects implemented in the Federation of Bosnia and Herzegovina (F BiH). For that purpose, the existing literature was reviewed thoroughly, and appropriate research design was formulated. In order to answer the research questions posed, a questionnaire was developed and sent to 400 companies in the F BiH that meet the defined business profile, yielding 62 valid responses. For the purpose of data analysis, a multivariate analysis of variance (MANOVA) was employed. The obtained results show that keeping the project size small significantly increases the odds for achieving IT project success, regardless of the organizational maturity level in project management. In addition, the higher the organizational maturity level in project management, the higher IT projects success ratio. Results also revealed that the differences between IT projects' success ratio of different groups of organizations are primarily induced by the time and costs project constraints, but not with the project scope.

Keywords:
project management; IT projects; PM success rate; PM success factors; The Federation of Bosnia and Herzegovina.

DOI: 10.12821/ijispm080102

Manuscript received: 18 February 2019
Manuscript accepted: 9 September 2019

1. Introduction

Managers and academics alike agree that the company's efficiency and growth stem from its successful implementation of IT projects, which provide various IT solutions that are critical for businesses success. Apart from the common project's challenges, IT projects are further tangled by specifics and constant changes of a business and its needs, as well as by unprecedented technology evolvement. All of this makes IT project management a distinct and very complex branch of the discipline of project management. Even though there has been a significant improvement in IT project management, the problem of the high failure rate of IT projects still stands.

The Standish Group International report of 2015 [1], although representing the best results over the last eight years, still shows 19% of all IT projects as failed, while the astonishing 45% are "challenged" – projects that are late, over budget, and/or under the scope, and 36% were successful. Results that are more desirable are shown in the 2018 IT Success Rate Survey of Ambler [2], presenting in total a failure rate of 8%, with 38% of challenged projects, and 49% successfully completed. These numbers include significant improvements that occurred over the last years in both the general project management and IT project management [3], [4], but despite the progress achieved, there is still a fairly high failure rate of IT projects [5].

The results of a recent survey conducted among companies from the Federation of Bosnia and Herzegovina differ significantly from those presented in the literature related to this topic. These results show a very high and rather unexpected success rate of the implemented IT projects [6]. More specifically, only 20% of closed IT projects were reported as failed and/or challenged, measured by the three main project constraints – time, cost and scope. Such an unusual finding may indicate surprisingly good managerial performance, some specific projects' characteristics, or a combination of these two elements.

In order to explore such findings in more detail, this study aims to analyze the circumstances and possible reasons for the rather high and unexpected IT projects' success rate. Thus, the main research question of the study is as follows:

RQ: Which IT projects' characteristics and characteristics of the organizations that implement those projects influence the unexpectedly high level of IT projects success in the Federation of Bosnia and Herzegovina.

To further investigate this issue, relevant research was designed, and appropriate research model was proposed. The research model was subsequently tested using the data gathered through the above-mentioned survey.

The next section of this study presents a thorough literature review of the theoretical background relevant to the research. The section that follows provides a description of the research methodology, the data analysis methods used, and the research results obtained. Interpretation and discussion of the results, followed by research limitations, concludes this section. The final section of this study contains concluding remarks about the research and the list of main research findings.

2. Literature review

The ever-increasing competition and fast-changing business environments create challenges for organizations to continuously adapt to new conditions. In order to stay competitive, as laid out by PricewaterhouseCoopers [7], organizations have to move from doing business as usual to pursuing project management as part of their competitive strategy. However, numerous research results point out that IT project failures and projects running over budget and time amount to almost half in numbers, sometimes even higher [1], [2], whereas the project failures often jeopardize the very existence of the companies that have implemented them [8]. The missing awareness of the financial impacts of failed projects is illustrated by a survey conducted by Ernst&Young [9], stating that 56% of the responding companies consider the opportunity costs of failed projects as simply being the direct costs of the failed projects, totalling not more than 5% of the annual sales. Although this is considered as underestimated, the alarming figure is that the opportunity losses are unknown for 34% of respondents. At the same time, this survey shows that IT-related projects are, with more than 30%, by far the most frequent of all projects that were implemented.

2.1 Project success – The definition and influential factors

There is no commonly accepted definition of project success. Stare [10] lists numerous reasons for a project to succeed or fail, such as project schedule definition, the number of changes during the project implementation, or adequacy of project control, just to name a few. Since differing in value, size, or complexity, projects do have different attributes which affect their performance and outcomes [11]. The study of Alqahtani and associates [11] identifies three major streams of performance criteria that accords with other research outcomes: the project manager´s characteristics (skills, competencies, etc.), organizational factors (structure, strategy, culture types, etc.), and the project management culture (project management methodology, project review and learning, etc.). In addition, some researches show a positive relationship between project management culture and project success [11], [12].

In terms of having a deeper understanding of project success, recent developments in the respective literature indicate that project success is a multi-dimensional and networked construct [13]. It is influenced by project cost, time, and scope, but also by interactions of personal competences and quality of teamwork. The perception of project success differs by individual type of person, by nationality, or by project type. Therefore, the project success continues to be to a great extent "in the eyes of the beholder" [13]. Also, the *PMBOK® Guide* [14] recognizes stakeholder satisfaction as an additional measure of project success.

The measurement of project success creates challenges to efficiency and effectiveness at different levels within an organization – at the entity level, team level, and individual level. The degree of a project´s success is influenced by numerous factors, and the literature shows that two components of project success are frequently referred to: project success factors and project success criteria [11], [13]. The first are the elements of a project that increase the likelihood of success, so-called independent variables, while the latter are measures to assess the success of a project, called the dependent variables [13]. Project performance and the outcome can be evaluated by using various performance indicators, such as project cost, quality, business satisfaction, or customer satisfaction [15]. However, time, cost and quality are the three major dimensions of a project to evaluate [16]. Similar ranking of main project success criteria is also suggested by the study of Pankratz and Basten [17]. To gain even deeper insight in meeting quality requirements, Pankratz and Basten further separated the quality criterion into two parts - conformance and the actual realization between: a) specified functional requirements, and b) specified non-functional requirements.

An interesting view of the variety of project success measures and their correlation is taken by Serrador and Turner [18] by clearly differentiating between project efficiency and the overall project success as such. Whereas the first is related to meeting the traditional triangle of cost, time and scope goals, the latter refers to meeting broader business and enterprise goals, which are defined by key stakeholders. The results of the analysis performed by Serrador and Turner [18] show a positive correlation between the iron triangle of project efficiency and the overall project success. Since scope is sometimes considered as closer related to project success than to project efficiency, an additional, modified, analysis was completed by removing scope. Even in this case there is still a clear correlation between conformity of time and budget constraints and overall project success [18]. These two factors, time and budget, are also correlated, while time overruns seem to be bigger than budget overruns [19].

Finally, a very important issue of choosing between the two approaches to project management in regard to the projects' success should be addressed. Even though there exist certain differences in the projects' success perception between the two approaches to project management, the project success criteria in projects using agile-based approaches do not significantly differ from projects following a waterfall model [20].

2.2 Project size and complexity

One of the first tasks in any formal project management methodology is to determine the size of the project, because, in general, project size corresponds to the extent of the application of formal project management methodology. Usually, the project size is designated by three typical terms – small, medium, and large, but the parameters that identify the size designation vary a lot. However, most commonly, project size is determined by the number of project team members, the components of the final product, or the project costs

To distinguish between project complexity and size is rather difficult, because project complexity is sometimes the result of project size [21]. Project complexity is widely discussed in literature and can be impacted by a variety of factors. There is not a single obvious definition of project complexity anymore, but rather choices of many. When linking complexity to project budget, Ernst&Young [9] illustrate that the average project budgets (and costs) of Western-European countries are considerably higher than those of CEE countries. At the same time, the projects are on average significantly more complex in bigger Western-European countries, which points to the direct and positive correlation between projects' costs and complexity.

Jørgensen [22] presents a study based on a data set that is dominated by small-scale software projects. According to this study, larger projects are identified to be on average more complex than smaller ones, and the failure rate increases with the increase in the size of a project. Even though the project size measurement based on the bid price may not be an accurate proxy of the actual project size, especially where a very low bid price was offered in order to get reference clients, the overall bid price gives sufficiently accurate indication of the project size [22].

Both project size and complexity are negatively related to the overall project success. Hurskainen [19] emphasizes the relationship between project size and duration and project success. Namely, numerous research studies indicate that, when project size or duration increase, the probability of project failure also rises [1]. This indicates a strong negative correlation between size and duration and project success. In addition, the reason of increased project failure is often tied to different project risks. The project risk level depends on the systems' size, scope, components and level of complexity [23]. Numerous research results show that the bigger the project size the higher risk of project failure [19], [24]-[27]. Thus, increasing the project size and complexity introduces greater risks to the project, which negatively impacts project schedules and budgets, and, consequently the overall project success [21].

2.3 Project management maturity

Project management maturity is considered as a means to assess an organization´s project management competences, whereas the basic assumption suggests that the higher the organization´s maturity level, the higher the chances of successfully completing its projects [28]. Since any effort to increase an organization´s project management maturity level is connected with costs, that begs the question of an ideal maturity level. Whilst the Lukač [29] study shows a positive correlation between organization size and project management maturity, in their study Albrecht and Spang [28] examine the maturity level which suits the organization´s needs and, at the same time, represents an optimal cost-benefit ratio. It is not necessary for every organization to operate at the highest maturity level. Rather, the ideal level is determined by the magnitude of an organization´s project business, the complexity of projects, and the project´s stakeholders and their interaction with each other [28].

A research performed by PricewaterhouseCoopers [7] shows the positive correlation between the project management maturity level and project performance. The survey results indicate three main areas where mature organizations favor highly formalized project management processes: scope management, quality management, and cost management. Using established project management methodologies increases the chance to meet project objectives in the key performance indicators of budget, schedule, scope, quality, and business benefits [7].

The project organizational culture and top management´s attitude also show a strong impact on project performance [10]. Even though some studies show that simply having a specific project management certification does not make a difference in overall project success [30], organizations investing in proven project management practices achieve better financial performance due to successfully completed projects [4]. The strong influence of project success on the business success of an organization is particularly evident in case of information system projects [31]. The PMI's report states that for the first time in five years more projects are meeting their original goals and are completed within budget, which indicates that the higher an organization´s project management maturity the more likely it is to achieve its goals [4]. PwC [7] also noted a significant rise in project management maturity over the last years, which goes along with more practitioners becoming certified in project management. Another key finding that PwC [7] reports is that maturity level is directly correlated with organizational success.

Yazici [32] illustrates in his research the relationship between project management maturity and organizational competitiveness, showing that a higher project management maturity is perceived to contribute to an organization´s savings, improvement of competitiveness and increase of market share. The results of various studies indicate the need for improvement of the PM skills of the project managers [33].

According to a 2014 Wrike study [34], only 56% of IT project managers hold an official certificate, which indicates that project managers may be lacking formal education in the project management area [33]. According to a 2014 PM Solutions study [35], only 49% of the organizations surveyed have a project management training in place [33]. It is especially important for organizations to put more attention to their ability for effectively pursuing IT projects [36]. This can be done either by recruiting professional project managers or strengthening the knowledge of current staff by way of formalized trainings and certification such as Project Manager Professional (PMP)®.

The recent efforts of the U.S. government in incentivizing the PMP are very important for the global project management community. In December 2016, former US President Barack Obama signed the "Program Management Improvement and Accountability Act" (PMIAA) into law, which creates an increased awareness of the need for experienced and certified project management professionals across America [37]. This bill impacts all areas of the US federal government except the Department of Defense [38]. Any government agency that is required to have a CFO are mandated to appoint a Program Management Improvement Officer. According to Alexander [38], this amplifies and elevates the project management profession as a whole, and shines a spotlight on the imperative role which project management professionals play in both the government and private sector.

2.4 Status of project management capacity and IT sector in Bosnia and Herzegovina

Bosnia and Herzegovina (BiH), a Southeast Europe country, is a small, transitional economy, which with its GDP per capita of 5,149 US$ and population of 3.5 million belongs to the group of developing countries. BiH is considered as the least competitive economy in the region for its lack of a single economic space, poor institutional support for business, and slow technological infrastructure development [39]. The country and its economy was severely devastated during the war from 1992 to 1995, but in the first decade after the war, BiH recorded substantial economic recovery with an average GDP growth rate of 16.76% [40]. Unfortunately, fast postwar economy growth was decelerated by the complex and inefficient public administration and very unstable political climate.

Besides the agriculture and energy sectors, the most promising industry sectors in BiH are IT and telecommunications sectors [41]. Even though BiH lags behind other countries from the wider region in ICT adoption [39], the IT sector, with a 201% income growth and 1419% employment growth during the five years period, from the year 2012 to the year 2016, is one the fastest growing industry sectors in BiH [42]. The largest user of IT solutions and services is the public sector, followed by the financial and telecommunications sectors.

The main method of providing IT solutions is through project-based endeavors, which points to the critical importance of project management competences for both the users and solution providers. A study on the project management capacity of Western Balkan countries has shown that the project management capacity in Bosnia and Herzegovina is rather limited, but still above the regional average. Furthermore, there was a pronounced interest for improving project management capacity in both industry and academia [43]. This is corroborated with the fact that the PMI Bosnia and Herzegovina Chapter was established in 2017, since when the number of certified project management practitioners was increased by more than twofold.

So far, the research work on project management and its success factors in Bosnia and Herzegovina is quite rare. Although the situation in many transition economies has dramatically changed since 1989, the development process in transition economies has shown much heterogeneity [44]. Yanwen [45] suggests that implementing project management into developing countries must be seen in connection with the general political, economic, social and technological conditions. In addition, the strategy for introducing project management in developing countries must be aligned with the culture, the characteristics of the society and the set-up of the economic, political and administrative system of the particular country [46]. Such strategic approach is optimal for developing countries, since these country specific factors still hamper the advance of software project management [47]. Despite all differences, Moohebat and associates [48]

highlight in their research on implementing ERP software that comparing the critical success factors in the two groups of developing and developed countries almost have similar patterns.

This similarity is supported by a recent research pursued in the former Yugoslav Republic of Macedonia, which suggests a positive correlation between project management approach and IT project success [49]. According to a research on IT project planning practices, also conducted with Macedonian SMEs, 86.7% firms have confirmed having planning practices in place [50]. Some other research work from the wider region also points to positive correlation between IT project implementation success and use of sound project management practices [51], [52]. Therefore, and despite all differences between developed and developing countries, there is a strong need and increasing importance of having adequate project management processes in place.

2.5 IT projects success – Study hypotheses

Although there is an uptick in the reported success rates of IT projects of 36%, research findings still point to IT project failures of 19%, and IT projects running over budget and time amounting to 45% [1]. A number of other studies point to the similar, rather low success rate of IT projects [8], [53], [54]. However, some research findings point to quite different outcomes. Namely, companies that are very experienced in managing IT projects have had around two thirds of all IT projects implemented almost on time, on budget and within the scope [25].

In spite of the wide variety of project success factors, one of the most important project management practices is project costs control. A research by Gładysz and associates [55] suggests that larger organizations are more likely to complete IT projects within the budget than smaller organizations. Another finding of this study shows that organizations running several IT projects in parallel are more likely to stay within the budget than organizations which always concentrate on one single project [55]. On the other hand, it is very interesting that cost control, as a success factor, ranks fifth in construction industry, while in IT industry it is ranked only eleventh [56].

This study aims to better understand the overall project success under the conditions of a still underdeveloped market such as that of the Federation of Bosnia and Herzegovina. Special attention is given to the project budget, as a proxy for project size and complexity, as well as to the companies' project management maturity level. The results of a recent study show that great majority of the closed projects (more than 80%) were on budget and time, and with no or only minor changes in scope (almost 80%). This study also reveals that one third of the implemented IT projects had rather small budgets [6], which indicates both a smaller project size on average and lower project complexity. This finding leads to the first hypothesis of the study:

H1: Organizations that implement small-size projects, measured by the average project budget, have a higher IT projects success ratio, regardless of the achieved project management maturity level.

The remaining two thirds of the closed IT projects had medium-to-large size budgets. To successfully manage such projects, companies are assumed to have a fairly high overall level of project management maturity. These facts intuitively point to the implication that both the project characteristics and sound managerial practices influence the project implementation success. The second hypothesis of this research study is therefore:

H2: Organizations that have achieved a high level of project management maturity have a higher IT projects success ratio for medium-to-large size IT projects, measured by the average project budget.

These two hypotheses define the research design and the corresponding research model, which are described in the following section.

3. Data and methodology

To test the hypothesized research model, a survey questionnaire was developed and sent to 400 organizations in the Federation of Bosnia and Herzegovina, which were randomly chosen from within the whole population. All selected organizations comply with the following profile:

- employing 10 or more people (in any year during the period from 2012 to 2016),
- established in 2010 or earlier,
- capable of implementing at least small-scale IT projects.

A total of 84 responses (21.0%) to the survey were received, out of which 62 belonged to the organizations that have implemented at least one IT project within the observed time-period, so they were considered as valid (15.5%). The total number of projects implemented by the organizations surveyed, which includes successful, unsuccessful and cancelled projects, over the last 5 years, is 846.

About one third (33.87%) of all organizations surveyed have had more than 10 years of experience in project management, while only one fifth (19.35%) of them have less than two years of experience. Regarding the average budget of closed IT projects, which can be considered as a project complexity indicator, all closed projects are equally distributed between small-size (budget less than 50K BAM – 33.9%), mid-size (budget between 50K BAM and 100K BAM – 33.9%), and large-size projects (budget greater than 100K BAM – 32.3%).

3.1 Research design and measures

The main concern of this study is the success rate of IT projects implementation, and comparison of the success rate between different groups of organizations. More specifically, the accompanying research examines whether the differences in the project success rate between different groups of organizations as a whole are statistically significant. In accordance with the two research hypotheses posed, the groups of organizations were formed based on the implemented projects size and organizations' project management maturity level. These groups differentiate between three types of organizations: a) those that have implemented only small-size IT projects, b) those that have implemented larger IT projects and are immature in project management, and c) those that have implemented larger IT projects and are mature in project management. Since the first research hypothesis relates only to those organizations that have implemented small-sized IT projects, regardless of the organizations' maturity level, there was no need to differentiate them based on the achieved project management maturity level. In order to conduct an appropriate testing, the MANOVA was employed, where the differences in IT projects success ratio between three groups of organizations were examined.

The corresponding research design is presented in Figure 1. The dependent latent variable, *"Project Success Rate"* (*PSR*), is measured by two indicators – "*Time and Cost Conformity*" (Y_1) and "*Scope Conformity*" (Y_2), which are listed and described in the next section. As it can be seen from Figure 1, there are three sets of project success rate measures, which are designated with PSR_{Gi} ($i = 1, 2, 3$). Each measure-set (PSR_{Gi}) relates to the single data-cell of the research design vector, where the vector dimension is defined by the independent variable *"PM Maturity & Project Size"* (*G*). The independent variable *G* designates different groups of organizations (described in details later in the text), formed on the basis of *project size–project management maturity* criterion. Both dependent (*PSR*) and independent (*G*) variables were measured using data from the survey, while the measurement spans a five-year period from the year 2012 to the year 2016.

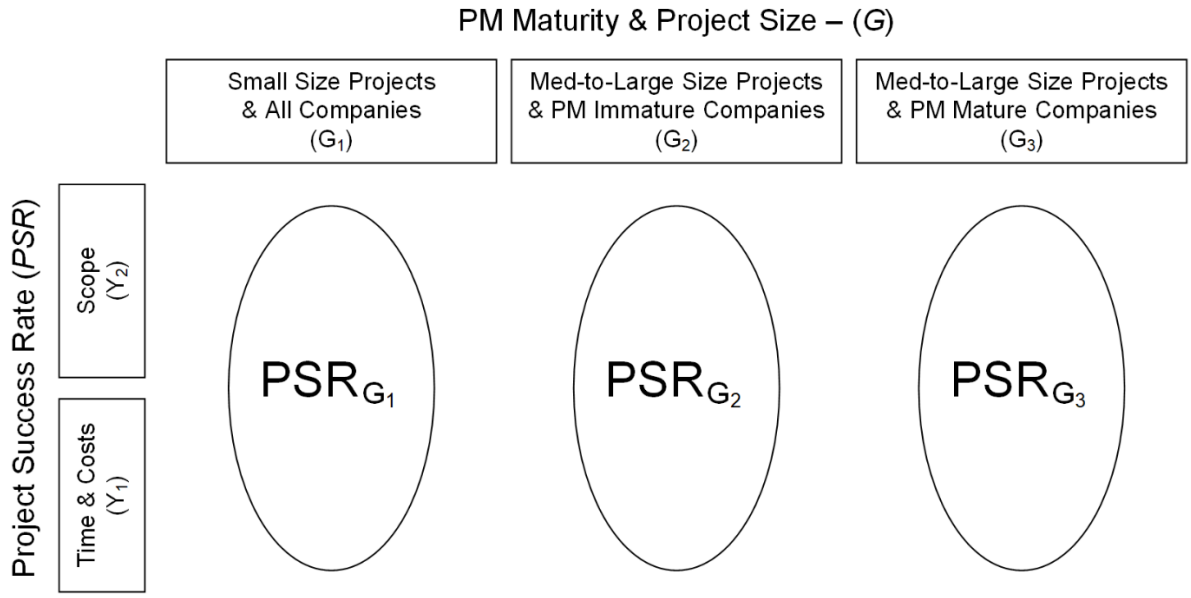

Figure 1. Layout of the research design

Dependent variables

Traditionally, project success is measured by the main project constraints – time, cost and scope. For that purpose, two five-degree rating scales were defined. The first scale corresponds to the project success level in regard to time and costs, and the second scale in regard to project scope conformity (Table 1).

Table 1. Project success level rating scales

Level	Value (SV)	Criterion for time (*T*) and costs (*C*)	Criterion for scope (*S*)
L1	*10.0*	Both time (*T*) and costs (*C*) are within the plan	No changes in planned scope
L2	*5.0*	Both time and costs are up to 10% over the plan ($0\% \leq T \leq 10\%$ and $0\% \leq C \leq 10\%$)	Minor changes in planned scope ($0\% \leq S \leq 10\%$)
L3	*2.0*	Either time or costs are above 10% over the plan, but each of them is below or equal to 50% over the plan ($T > 10\%$ or $C > 10\%$) and ($T \leq 50\%$ and $C \leq 50\%$)	Moderate changes in planned scope ($10\% < S \leq 50\%$)
L4	*0.5*	Either time or costs are above 50% over the plan, but each of them is below or equal to 150% over the plan ($T > 50\%$ or $C > 50\%$) and ($T \leq 150\%$ and $C \leq 150\%$)	Significant changes in planned scope ($50\% < S \leq 75\%$)
L5	*0.0*	Either time or costs are above 150% over the plan ($T > 150\%$ or $C > 150\%$)	Complete changes in planned scope ($S > 75\%$)

In order to quantify the overall project success level, an arbitrary threshold and scoring value is assigned to each level of the proposed scales (columns "*Value*" and "*Criterion*" from Table 1). These values are chosen experientially and in accordance with some empirical findings from the existing literature (e.g. [54]). In addition, scoring values approximate the exponential function, since it best estimates the perceived value of the project's success level.

For each IT project closed during the measurement period (from the year 2012 to the year 2016) survey responders have assessed the corresponding success level (*L1* to *L5*), both for the scope and time and costs constraints. Based on this assessment and the chosen scoring values, a very simple two-indicator measure for the dependent latent variable – *Project Success Rate* (*PSR*), was adopted. Those two indicators are as follows:

- "*Time & Costs Conformity*" (Y_1) – measuring conformity with planned project schedule and costs:

$$Y_1 = \frac{1}{N_p}\sum_{i=1}^{N_p} SV_i^{T\&C} \quad (1)$$

Where:

N_p – number of closed projects in period from the year 2012 to the year 2016.

$SV_i^{T\&C}$ – scoring value for *i*-th closed project in regard to time and costs ($i = 1 \ldots N_p$).

- "*Scope Conformity*" (Y_2) – measuring conformity with planned project scope:

$$Y_2 = \frac{1}{N_p}\sum_{i=1}^{N_p} SV_i^{S} \quad (2)$$

Where:

N_p – number of closed projects in period from the year 2012 to the year 2016.

SV_i^{S} – scoring value for *i*-th closed project in regard to scope ($i = 1 \ldots N_p$).

Independent variables

As it can be seen from Figure 1, the research design must ensure comparison between three groups of organizations:

- Group 1 – organizations that declared that all their IT projects, closed during the measurement period, had a small project budget on average (budget less than 50K BAM),
- Group 2 – organizations that are immature in project management, and that declared that all their IT projects, closed during the measurement period, had a medium to large project budget on average (budget greater than 50K BAM),
- Group 3 – organizations that are mature in project management, and that declared that all their IT projects, closed during the measurement period, had a medium to large project budget on average (budget greater than 50K BAM).

Obviously, this is a simple case of a single three-level independent variable – *"PM Maturity & Project Size"* (*G*), which differentiates these three types of organizations. The organizations which declared that their closed IT projects, during the measurement period (from the year 2012 to the year 2016), had, on average, budgets less than 50K BAM, were allocated to the *Group 1* (G_1). All other organizations were further allocated to the remaining two groups based on their

maturity level in project management – organizations that are mature in project management were allocated to the *Group 3* (G_3), and those that are not, were allocated to the *Group 2* (G_2).

A number of different indicators were used to determine the maturity level in project management – number of implemented projects during the measurement period (separating threshold was set at five projects), formal certifications in project management, corresponding organizational structure (*P*roject *M*anagement *O*ffice), and number of years applying the project management techniques. Combining these indicators, organizations are allocated to *Group 2* (immature in project management) or *Group 3* (mature in project management).

3.2 Results

Table 2 contains the means and standard deviations of all model dependent variables for all three groups of independent variable *G*. Same data are graphically presented in Figure 2. To test the differences between the defined groups of organizations, MANOVA was employed in order to examine a set of two indicators, which represents the organizations' IT projects implementation success rate.

Table 2. Descriptive statistics of indicator variables for groups of *G*

Indicator	Group of *G*	N	Mean	Std. Deviation
Y_1	Group 1	21	8.02	2.42
Time & Cost Conformity	Group 2	18	5.68	2.87
	Group 3	23	7.74	2.17
	Total	*62*	*7.24*	*2.63*
Y_2	Group 1	21	8.04	2.33
Scope Conformity	Group 2	18	6.99	2.46
	Group 3	23	7.05	2.84
	Total	*62*	*7.37*	*2.57*

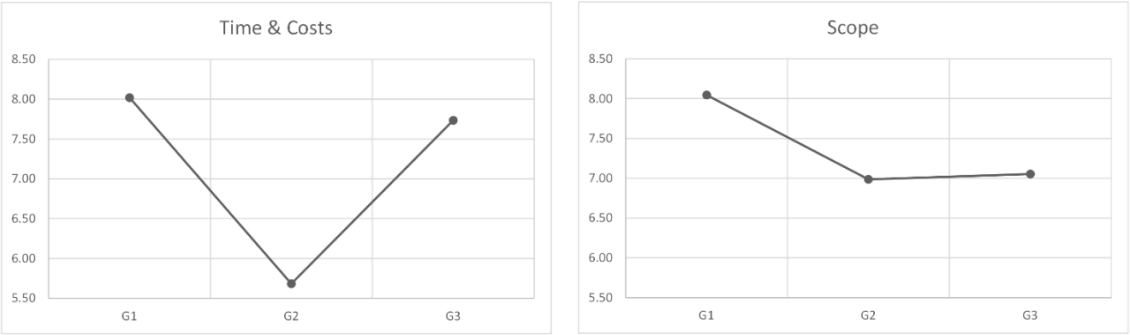

Figure 2. Graphical display of indicator variables for groups of *G*

Assumptions

The most important assumptions for MANOVA – independence, multivariate normality and homogeneity of covariance matrices, were evaluated through the IBM® SPSS Statistics®. Independence of observations is provided as much as possible by a random selection of the responding organizations.

There were no missing data and no outliers in the sample, so in relation to this assumption no action of any type was taken. However, both indicator variables showed modest deviation from normal distribution (skew < 1, kurtosis < 1).

Since the MANOVA analysis is robust to modest violations of normality [57], it can be considered that the findings may not be severely affected by the normality deviation. This violation can be further compensated by decreasing the *p-value* while testing the significance of MANOVA statistics [58].

The assumption of the homogeneity of variance-covariance matrices among all groups was checked using Box's test. The assumption of homogeneity of variance-covariance matrices was met, since Box's test results [M = 6.934, $F(6, 66436) = 1.098$, $p = 0.361$] were not statistically significant at $p < 0.001$, meaning that there was no difference between the two groups on all variables collectively.

The assumption of univariate homogeneity was assessed by the Levene's test. As can be seen from the test results (Table 3), this assumption was met for both indicator variables ($p > 0.05$).

Table 3. Levene's test of equality of error variances

Dependent Variable	F	df_1	df_2	Sig.
Y_1 – *Time & Cost Conformity*	0.829	2	59	0.442
Y_2 – *Scope Conformity*	0.998	2	59	0.375

Finally, the correlation between two indicator variables is below the threshold value of 0.9 ($r = 0.498$, $p < 0.001$), which means that multicollinearity does not exist, so this assumption was also met.

The MANOVA model estimation

After all of the assumptions were checked, the next step in MANOVA procedure was to assess whether there exist significant differences for all IT projects success rate variables (indicators) across the three groups of organizations, first all variables together and then each of them individually [59].

In order to compensate for the normality deviation, the family-wise error rate was taken as $\alpha = 0.025$, both for the MANOVA test and the follow-up ANOVA tests for main effects. All four most commonly used multivariate tests are statistically significant at $p < 0.025$, indicating that the set of IT projects success rate variables has a significant difference between three types of organizations (Table 4).

Table 4. Multivariate tests for group differences in IT projects success rate

Test	Value	F	df_1	df_2	Sig.	Power[1]
Pillai's Trace	0.185	3.000	4	118	0.021	0.691
Wilks' Lambda	0.820	3.029	4	116	0.020	0.696
Hotelling's T^2	0.214	3.055	4	114	0.020	0.700
Roy's Largest Root	0.185	5.463	2	59	0.007	0.745

[1] – *Computed using $\alpha = 0.025$*

Univariate ANOVA tests for both indicator variables show that only indicator Y_1 (*Time & Costs Conformity*) has a significant main effect ($p < 0.025$), while indicator Y_2 (*Scope Conformity*) has a non-significant main effect (Table 5).

Table 5. Univariate tests for group differences in IT projects success rate

Source	Variable	Σ of sq.	*df*	Mean sq.	*F*	Sig.	η^2	Power
Model	Y_1 – *Time & Cost Conformity*	62.075	2	31.038	5.077	0.009	0.147	0.801
	Y_2 – *Scope Conformity*	14.519	2	7.260	1.100	0.339	0.036	0.234
Error	Y_1 – *Time & Cost Conformity*	360.673	59	6.113				
	Y_2 – *Scope Conformity*	389.219	59	6.597				

Since there exists a significant main effect, a further analysis of post hoc comparisons for each indicator was conducted. For that purpose, two post hoc comparison methods, LSD and Bonferroni, were applied to both indicators across three groups of organizations (Table 6).

Table 6. Post hoc comparison for individual indicators of IT projects success rate

Indicator Variable	Group (A)	Group (B)	Mean Diff. (A – B)	*Std. Err.*	Sig.*	Sig.**
Y_1 – *Time & Cost Conformity*	G_1	G_2	2.338	0.794	**0.005**	**0.014**
		G_3	0.285	0.746	0.704	1.000
	G_2	G_1	-2.338	0.794	**0.005**	**0.014**
		G_3	-2.052	0.778	**0.011**	**0.032**
	G_3	G_1	-0.285	0.746	0.704	1.000
		G_2	2.052	0.778	**0.011**	**0.032**
Y_2 – *Scope Conformity*	G_1	G_2	1.059	0.825	0.204	0.613
		G_3	0.991	0.775	0.206	0.618
	G_2	G_1	-1.059	0.825	0.204	0.613
		G_3	-0.068	0.808	0.934	1.000
	G_3	G_1	-0.991	0.775	0.206	0.618
		G_2	0.068	0.808	0.934	1.000

* - LSD adjustments for multiple comparisons; ** - Bonferroni adjustments for multiple comparisons

The LSD and Bonferroni tests shows the same pattern of results (Table 6). The post hoc comparison results show that the difference between groups of organizations is statistically significant for indicator Y_1 (*Time & Costs Conformity*), while being non-significant for indicator Y_2 (*Scope Conformity*).

Interpretation of the results

Since all assumptions for MANOVA have been met or there are appropriate corrections for their violation, the results obtained by the analysis can be considered as reliable. Thus, some deeper understanding of the relationship between IT projects success ratio and organizational and project characteristics may be inferred. Of course, all of that under the market conditions of the Federation of Bosnia and Herzegovina.

The multivariate effect of the between-subject factor (*PM Maturity & Project Size*) on the IT projects success ratio, which is measured with two indicators, was statistically significant [Wilks' $\lambda = 0.820$, $F(4, 116) = 3.029$, $p = 0.02$]. This finding means that there exists a difference in combined IT projects success ratio indicators between the three groups of organizations. The follow up ANOVA analysis showed that there was a significant main effect for indicator Y_1 [$F(2, 59) = 5.077$, $p = 0.009$], and non-significant for indicator Y_2 [$F(2, 59) = 1.1$, $p = 0.339$].

Results from multivariate and univariate tests show that the difference in IT projects success rate between the three groups of organizations is primarily induced by the difference in indicator Y_1 (*Time & Costs Conformity*), and some underlying combination of the two indicators. A further post hoc comparison for each indicator was conducted to break down this interaction.

The post hoc comparison results (Table 6 and Figure 2) revealed that the difference between *Group 1* and *Group 3* is non-significant for both indicators. On the other hand, the difference between *Group 1* and *Group 2* is positive and statistically significant for indicator Y_1 (*Time & Costs Conformity*), while being non-significant for indicator Y_2 (*Scope Conformity*). This finding, along with the significant multivariate interaction effect, fully supports the first hypothesis of this study. The same stands for difference between *Group 3* and *Group 2*, which, along with the significant multivariate interaction effect, fully supports the second hypothesis of this study.

3.3 Discussion

The results of data analysis indicate that organizations in BiH that either keep their IT projects small and simple, or are very experienced in managing IT projects, both achieve a higher project success ratio. This goes along with the general economic conditions in BiH as a transitional and developing country [39], where the average project budgets are considerably lower than in developed countries [9], while the IT sector is one of the fastest growing industry sectors [42]. The results are therefore interpreted as supportive of both research hypotheses, which goes in favor of the main study assertion about the factors that significantly impact IT projects' success ratio. Therefore, given the importance of projects in modern business, investing the necessary organizational resources in improving the project management processes, tools and skills is a matter of carefully building and maintaining the organizational competitive advantage. In other words, project management excellence has become an ultimate competitive weapon in today's highly competitive business environment [60].

Two particularly interesting findings regarding the project size and complexity are revealed by the data analysis. First, keeping the project size small significantly increases the odds for the IT project success, irrespective of the organizational maturity level in project management. On the other side, the higher the organizational maturity level in project management the higher its IT projects success ratio. These two findings combined provide a very practical insight into the process of achieving project management excellence. Namely, organizations that are not experienced in project management should strictly control the size and complexity of the IT projects launched, while simultaneously investing in improving formal project management skills and gathering the necessary experience through a number of small-size IT projects. Once they achieve an appropriate maturity level in project management, they can pursue bigger and more complex IT projects. This line of reasoning is highly aligned to the fact that a strong interest for improving project management capacity exists in BiH in both industry and academia [43].

All these findings and insights are in concordance with the existing theory and practice of project management (e.g. [1], [7], [21], [22], [25], [31], [32] and [61]), which is of particular importance given the fact that the most significant research work on project management has been done by scholars and professionals from the most developed countries. Namely, the study findings provide a further support for the validity and applicability of such theoretical and practical propositions under the economic and market circumstances of the developing countries. Furthermore, the small size of the overall IT market in Bosnia and Herzegovina [62] indicates that the most common IT projects are of a small or, possibly, medium size. That fact, combined with the study findings, provide a further explanation of high success rate of the implemented IT projects in the F BiH.

Finally, the study results showed that the differences between IT projects' success ratio of the three groups of organizations are primarily indicated by the time and costs project constraints. The difference regarding the project

scope was not found to be statistically significant (Table 6). Such a finding can be interpreted in two ways. First, project scope can be treated as a distinguishing trait of the project and not as an indicator of project management efficiency [18]. Furthermore, scope is quite often considered as a project constraint that is functionally dependent on the other three constraints – time, costs, and quality [63]. Therefore, project scope should not or could not be treated as a project success indicator along with time and costs.

On the other hand, this finding may point to a shortcoming in research design. More specifically, it is possible that the measurement of project scope constraint was not defined properly, which prevented the necessary distinguishing between different projects' efficiency levels. However, it must be noted that such outcome could also be caused by inadequate data sample (see "Limitations of the Research" sub-section). Whatever the case may be, these results point toward the necessity of further research of the link between the IT projects' success ratio and project scope. For example, one way to improve the research design for future studies is to separate the criterion scope (or quality) between functional and non-functional requirements, as suggested by Pankratz and Basten [17]. That would also be the main recommendation for the future research on the topic. Results of that research along with the results of this study will be useful for both academia and management practitioners – the former to get a deeper insight into the ever-interesting issue of IT projects' success, and the latter to better manage their IT projects.

Limitations of the research

There are several limitations that apply to this research, both design and technical. In order to keep the research design simple, the IT projects' success was only measured by the projects' time and costs constraints, and by the projects' scope constraint. Hence, one recommendation for the future research would be to seek out new indicators which would improve the measurement of the dependent latent variable (*Project Success Rate*). In addition, the study focuses on project efficiency measures only, so the measurement of the dependent latent variable should be expanded by the indicators of business and enterprise goals [18].

Regarding the technical limitations, the data analysis was conducted on a single sample whose size is just adequate for this research design. Consequently, no confirmation of the findings was done. Besides, the data were collected from a single country, so the obtained results could be generalized only for the population from which the sample was drawn. Future studies may remedy the above noted limitations by applying this (or similar) research design to different datasets.

Finally, it must be noted that MANOVA is primarily intended for experimental research. Nevertheless, this quasi-experimental approach (survey research) is quite common in empirical research. The main problem here is that an unambiguous cause and effect relationship cannot be established, since the researcher does not have full control over the research environment. For this research, this issue comes down to whether the increase in project management maturity is a cause or effect of the increase in IT projects' success ratio. However, strong support in theory that a higher project management maturity is positively related to a favorable project outcome (see the Literature Review section) justifies the assumed causal order.

4. Conclusion

Running counter to the literature found on the topic of IT projects success, a great majority of closed IT projects in the F BiH were on budget and time, and with no or very small changes in the project scope. Consequently, this study aims to get a deeper understanding of the relationship between organizational and project characteristics and success ratio of implemented IT projects, under the conditions of an underdeveloped market, such as the market of the F BiH.

In order to get a deeper insight into the phenomena, a comparison of the success rate between different groups of surveyed organizations was made. These groups are formed based on the implemented projects size and organizations' project management maturity level. To conduct an appropriate data analysis, the MANOVA was used.

The research results showed that organizations which implement small-size projects, measured by the average project budget, have a higher IT projects success ratio, regardless of their project management maturity level. Furthermore, the results also showed that organizations which have achieved a high level of project management maturity have a higher IT projects success ratio for medium-to-large size IT projects, measured by the average project budget. These two research findings combined explain such (unexpectedly) high success ratio of implemented IT projects in the F BiH. Finally, the research results unveil that the differences between IT projects' success ratio of the three groups of organizations was primarily induced by the time and costs project constraints.

A practical insight into the process of achieving project management excellence, which arises from the main research findings, is that organizations inexperienced in project management should focus on controlling the size and complexity of their IT projects, while simultaneously improving formal project management skills and gathering the necessary experience by implementing a number of small-size IT projects. Upon reaching an adequate project management maturity level, they should pursue larger and more complex IT projects.

The main implication of this research is a deeper insight into the possible reasons for a very high and rather unexpected success rate of IT projects implemented in F BiH, as well as a better understanding of the importance of organizational and project characteristics for the IT projects' success. In addition, as a more distant research outcome, the study showed that the existing theoretical propositions and sound practices of modern project management are fully applicable to the economic and technological conditions of Bosnia and Herzegovina as a developing country.

References

[1] The Standish Group International (2015). *The Chaos Report 2015* [Online]. Available: https://www.standishgroup.com/sample_research_files/CHAOSReport2015-Final.pdf.

[2] S. W. Ambler (2018). *2018 IT Success Rate Survey Results* [Online]. Available: http://www.ambysoft.com/surveys/success2018.html.

[3] C. Millhollan and M. Kaarst-Brown, "Lessons for IT Project Manager Efficacy: A Review of the Literature Associated with Project Success," *Project Management Journal*, vol. 47, no. 5, pp. 89–106, 2016.

[4] Project Management Institute, *PMI´s Pulse of the Profession.* Newtown Square, PA: Project Management Institute, 2017.

[5] Y. K. Dwivedi, D. Wastell, S. Laumer, H. Z. Henriksen, M. D. Myers, D. Bunker, A. Elbanna, M. N. Ravishankar and S. C. Srivastava, "Research on Information Systems Failures and Successes: Status Update and Future Directions," *Information Systems Frontiers*, vol. 17, no. 1, pp. 143-157, 2015.

[6] M. Bezdrob, S. Brkić, D. Bajramović, M. Gram and D. Burić, "'Black Swans' in IT Projects – Myth or Reality," in *9th International Conference* "*An Enterprise Odyssey – Managing Change to Achieve Quality Development*", University of Zagreb, Zagreb, Croatia, 2018.

[7] PricewaterhouseCoopers (2012). *Insights and Trends: Current Portfolio, Programme, and Project Management Practices* [Online]. Available: https://www.pwc.com.tr/en/publications/.

[8] S. I. Hajeer, "Critical Risk Factors for Information System (IS) Projects – (IS) Projects between Sink and Swim," *International Journal of Computer Science Engineering and Technology*, vol. 2, no. 6, pp. 1270-1279, 2012.

[9] Ernst&Young (2006). *Survey of Project Management Practices* [Online]. Available: https://www.pmsz.hu/.

[10] A. Stare, "The Impact of the Organizational Structure and Project Organizational Culture on Project Performance in Slovenian Enterprises," *Management*, vol. 16, no. 2, pp. 1-22, 2011.

[11] E. F. Alqahtani, E. Chinyio, S. Mushatat and D. Oloke, "Factors Effecting Performance of Projects: A Conceptual Framework," *International Journal of Scientific & Engineering Research*, vol. 6, no. 4, pp. 670-676, 2015.

[12] D. Bryde, "Perceptions of the Impact of Project Sponsorship Practices on Project Success," *International Journal of Project Management*, vol. 26, no. 8, pp. 800-809, 2008.

[13] R. Müller and K. Jugdev, "Critical Success Factors in Projects: Pinto, Slevin, and Prescott – The Elucidation of Project Success," *International Journal of Managing Projects in Business*, vol. 5, no. 4, pp. 757-775, 2012.

[14] Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK® guide)*, 5th ed. Newtown Square, PA: Project Management Institute, 2013.

[15] S. O. Cheung, H. C. H. Suen and K. K. W. Cheung, „PPMS: A Web-based Construction Project Performance Monitoring System," *Automation in Construction*, vol. 13, no. 3, pp. 361-376, 2004.

[16] A. Enshassi, S. Mohamed and S. Abushaban, "Factors Affecting the Performance of Construction Projects in the Gaza Strip," *Journal of Civil Engineering and Management*, vol. 15, no. 3, pp. 269-280, 2009.

[17] O. Pankratz and D. Basten, "Ladder to success – eliciting project managers´ perceptions of IS project success criteria," *International Journal of Information Systems and Project Management*, vol. 2, no. 2, pp. 5-24, 2014.

[18] P. Serrador and R. Turner, "The Relationship Between Project Success and Project Efficiency," *Project Management Journal*, vol. 46, no. 1, pp. 30-39, 2015.

[19] M. Hurskainen, "Analyzing IT Project Success – An Empirical Approach to Critical Success Factors," M.S. thesis, School of Business, Financial Management, Lappeenranta University of Technology, Finland, 2014.

[20] L. Siddique and B. A. Hussein, "A qualitative study of success criteria in Norwegian agile software projects from suppliers´ perspective," *International Journal of Information Systems and Project Management*, vol. 4, no. 2, pp. 63-79, 2016.

[21] N. L. Martin, J. M. Pearson and K. A. Furumo, "IS Project Management: Size, Practices and the Project Management Office," *Journal of Computer Information Systems*, vol. 47, no. 4, pp. 52-60, 2007.

[22] M. Jørgensen, "Failure Factors of Small Software Projects at a Global Outsourcing Marketplace," *Journal of Systems and Software*, vol. 92, no. 1, pp. 157-169, 2014.

[23] K. C. Laudon and J. P. Laudon, *Management Information Systems: Managing the Digital Firm*, 13th ed. Harlow, England: Pearson Education, 2014.

[24] T. C. Jones, *Estimating software costs*. New York: McGraw-Hill, 1998.

[25] C. Sauer, A. Gemino and B. H. Reich, "The Impact of Size and Volatility on it Project Performance: Studying the Factors Influencing Project Risk," *Communications of the ACM*, vol. 50, no. 11, pp. 79-84, 2007.

[26] House of Commons – PASC, *Government and IT – "a Recipe for Rip-offs": Time for a New Approach*, Volume I. London: The Stationery Office, 2011.

[27] J. Fishenden and M. Thompson, "Digital Government, Open Architecture, and Innovation: Why Public Sector IT Will Never Be the Same Again," *Journal of Public Administration Research and Theory*, vol. 23, no. 4, pp. 977-1004, 2012.

[28] J. C. Albrecht and K. Spang, „Project Complexity as an Influence Factor on the Balance of Costs and Benefits in Project Management Maturity Modelling," *Procedia – Social and Behavioral Sciences*, vol. 119, pp. 162-171, 2014.

[29] K. Lukač, "Software Project Management at Republic of Croatia," *Ekonomski Pregled*, vol. 53, no. 1-2, pp. 164-190, 2002.

[30] J. W. Robertson, "The Relationship between Project Management Professional Certification and Project Health," PhD. dissertation, Department of Leadership, Research, and Foundations, University of Colorado, Colorado Springs, USA, 2015.

[31] J. Varajão, "The many facts of information systems (+projects) success," *International Journal of Information Systems and Project Management*, vol. 6, no. 4, pp. 5-13, 2018.

[32] H. J. Yazici, "The Role of Project Management Maturity and Organizational Culture in Perceived Performance," *Project Management Journal*, vol. 40, no. 3, pp. 14–33, 2009.

[33] R. Burger (2016, September 26). *20 Surprising Project Management Statistics* [Online]. Available: https://blog.capterra.com/surprising-project-management-statistics/.

[34] Wrike Team (2014, February 12). *Top 5 Project Management Myths BUSTED (Infographic)* [Online]. Available: https://www.wrike.com/blog/top-5-project-management-myths-busted-new-infographic/.

[35] Project Management Solutions (2014, April 10). *The State of the Project Management Office (PMO) 2014* [Online]. Available: https://www.pmsolutions.com/resources/view/the-state-of-the-project-management-office-pmo-2014/.

[36] R. Sánchez-Morcilio and F. Quiles-Torres, "Trends in Information Technology Project Management," *Issues in Information Systems*, vol. 17, no. 3, pp. 187-198, 2016.

[37] R. Burger (2017, November 14). *The 5 Biggest Project Management Trends Shaping 2018* [Online]. Available: https://blog.capterra.com/the-5-biggest-project-management-trends-shaping-2018/.

[38] M. Alexander (2018, January 18), *What is the Program Management Improvement and Accountability Act?* [Online]. Available: https://www.cio.com/article/3158676.

[39] World Economic Forum, *The Global Competitiveness Report 2018*. Geneva: World Economic Forum, 2018.

[40] The World Bank (2019). *Data*. [Online]. Available: https://data.worldbank.org/country/bosnia-and-herzegovina.

[41] US Department of State (2017). *Us Country Commercial Guides: Bosnia and Herzegovina* [Online]. Available: https://ba.usembassy.gov/wp-content/uploads/sites/270/2017/08/ Bosnia-CCG-2017.pdf.

[42] Official Gazette of BiH 42/17, *The Policy of Information Society Development in BiH*. Sarajevo: JP NIO Službeni list Bosne i Hercegovine, 2017.

[43] T. Lukić. *Regional Project Management Capacity Assessment*. Belgrade: USAID Competitiveness Project, 2010.

[44] W. Bartlett, M. Čičić and B. Ćulahović, "Institutions, Innovation and Knowledge Transfer in Bosnia and Herzegovina," *The Journal of Knowledge Economy & Knowledge Management*, vol. 7, no. 1, pp. 199-224, 2012.

[45] W. Yanwen, "The Study on Complex Project Management in Developing Countries," *Physics Procedia*, vol. 25, pp. 1547–1552, 2012.

[46] L. C. Stuckenbruck and A. Zomorrodian, "Project Management: The Promise for Developing Countries," *International Journal of Project Management*, vol. 5, no. 3, pp. 167–175, 1987.

[47] M. K. Shaikh and K. Ahsan, "Software Project Management in Developing Countries: Landscape, Literature Review Framework and Opportunities," *Research Journal of Recent Sciences*, vol. 4, no. 1, pp. 118-128, 2015.

[48] M. R. Moohebat, A. Asemi and M. D. Jazi, "A Comparative Study of Critical Success Factors (CSFs) in Implementation of ERP in Developed and Developing Countries," *International Journal of Advancements in Computing Technology*, vol. 2, no. 5, pp. 99-110, 2010.

[49] N. Kaleshovska, S. Josimovski, L. Pulevska-Ivanovska, K. Postolov and Z. Janevski, "The Contribution of Scrum in Managing Successful Software Development Projects," *Economic Development*, vol. 17, no. 1/2, pp. 175-194, 2015.

[50] F. Tasevska, T. Damij and N. Damij, "Project Planning Practices Based on Enterprise Resource Planning Systems in Small and Medium Enterprises — A Case Study from the Republic of Macedonia," *International Journal of Project Management*, vol. 32, no. 3, pp. 529-539, 2014.

[51] B. Johansson and F. Sudzina, "Actual vs. Planned ERP Systems Implementation Costs in European SMEs," in *3rd European Conference on Information Management and Evaluation - ECIME 2009*, Gothenburg, Sweden, 2009.

[52] T. Jukić, M. Vintar and J. Benčina, "Ex-ante Evaluation: Towards an Assessment Model of its Impact on the Success of e-Government Projects," *Information Polity: The International Journal of Government & Democracy in the Information Age*, vol. 18, no. 4, pp. 343-361, 2013.

[53] K. Conboy, "Project Failure en masse: A Study of Loose Budgetary Control in ISD Projects," *European Journal of Information Systems*, vol. 19, no. 3, pp. 273- 287, 2010.

[54] B. Flyvbjerg and A. Budzier, "Why Your IT Project May Be Riskier Than You Think," *Harvard Business Review*, vol. 89, no. 9, pp. 1-4, 2011.

[55] B. Gładysz, D. Kuchta, K. Frączkowski and A. Pawlicki, "Factors which Influence Keeping within a Project Budget in IT Projects," *Finanse, Rynki Finansowe, Ubezpieczenia*, vol. 1, no. 74, pp. 511-522, 2015.

[56] J. Varajão, C. Dominguez, P. Ribeiro and A. Paiva, "Critical Success Aspects in Project Management: Similarities and Differences Between the Construction and Software Industry," *Technical Gazette*, vol. 21, no. 3, pp. 583-589, 2014.

[57] B. G. Tabachnick and L. S. Fidell, *Using Multivariate Statistics*, 5th ed. London: Pearson Education Inc., 2007.

[58] J. P. Verma, *Repeated Measures Design for Empirical Researchers*. Hoboken: John Wiley & Sons, Inc., 2016.

[59] J. F. Hair, W. C. Black, B. J. Babin and R. E. Anderson, *Multivariate Data Analysis*, 7th ed. Upper Saddle River: Prentice Hall, 2009.

[60] H. Kerzner, *Project Management: Best Practices: Achieving Global Excellence*, 2nd ed. Hoboken: John Wiley & Sons, Inc., 2010.

[61] M. Pejić Bach, J. Zoroja and A. Čeljo, "An extension of the technology acceptance model for business intelligence systems: project management maturity perspective," *International Journal of Information Systems and Project Management*, vol. 5, no. 2, pp. 5-21, 2017.

[62] LRC – Business Intelligence System. (2019). *IT Industry Profile 2015 - 2017* [Online]. Available: https://lrc.boniteti.ba/faces/users/layoutHome.xhtml.

[63] J. P. Lewis, *Project Planning, Scheduling, and Control: A Hand-on Guide to Binging Projects in On Time and On Budget*, 3rd ed. New York: McGraw-Hill, 2001.

Biographical notes

Muamer Bezdrob
Ph.D. in Management and Business, is a cofounder and director of PING ltd. Sarajevo, a project-oriented company that designs, develops and implements complex information systems. He is also assistant professor at the American University in Bosnia and Herzegovina, where he lectures on strategic management and project management courses. His current research interests focus mainly on management development in general and on project management. His other research interests include organizational innovation and performance.

Sabina Brkić
Ph.D. in Management, is Head of Financial and Risk Controlling department in HETA Asset Resolution ltd. Sarajevo. For more than ten years she worked in different financial institutions, from a leasing company to small and large banks and currently in a "bad bank" company. She has been involved in implementation of many projects from implementation of complex information systems to projects that relate to sale of large portfolios and share deal. Her current research interest is soft-hard data fusion expert systems for risk modeling.

Manfred Gram
Ph.D. in Management, has more than 30 years of executive management experience in international Banking and Industry, with a focus on risk management, restructuring, work out and wind down, but was usually also responsible for finance and operations. He has held various positions at Management Board level. During his assignment in Bosnia and Herzegovina his focus was the strategic management and completing the complex project of taking over the portfolios of distressed assets from systemic relevant banks, the process of establishing a wind down entity, and its transformation towards a fully functional wind down organization in BiH.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

The documentation of design decisions in engineering projects: A study in infrastructure development

Tara Kinneging
Witteveen+Bos N.V.
PO box 233, 7400 AE Deventer
The Netherlands
tara.kinneging@witteveenbos.com

Robin de Graaf
Faculty of Engineering Technology, Department of Construction Management & Engineering,
University of Twente
PO box 217, 7500 AE Enschede
The Netherlands
r.s.degraaf@utwente.nl

Sander Siebelink
Faculty of Engineering Technology, Department of Construction Management & Engineering,
University of Twente
PO box 217, 7500 AE Enschede
The Netherlands
s.siebelink@utwente.nl

Tim van Dijck
Witteveen+Bos N.V.
PO box 233, 7400 AE Deventer
The Netherlands
tim.van.dijck@witteveenbos.com

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

T. Kinneging, R. de Graaf, S. Siebelink, T. van Dijck, "The documentation of design decisions in engineering projects: A study in infrastructure development", *International Journal of Information Systems and Project Management*, vol. 8, no. 1, pp. 44-64, 2020.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

The documentation of design decisions in engineering projects: A study in infrastructure development

Tara Kinneging
Witteveen+Bos N.V.
PO box 233, 7400 AE Deventer
The Netherlands
tara.kinneging@witteveenbos.com

Robin de Graaf
Faculty of Engineering Technology, Department of Construction Management & Engineering,
University of Twente
PO box 217, 7500 AE Enschede
The Netherlands
r.s.degraaf@utwente.nl

Sander Siebelink
Faculty of Engineering Technology, Department of Construction Management & Engineering,
University of Twente
PO box 217, 7500 AE Enschede
The Netherlands
s.siebelink@utwente.nl

Tim van Dijck
Witteveen+Bos N.V.
PO box 233, 7400 AE Deventer
The Netherlands
tim.van.dijck@witteveenbos.com

Abstract:
In most design projects, the documentation of design decisions is considered important. Among others, documentation of design decisions contributes to the traceability of decisions that shape a project's development process, helps deal with changes in the project and prevents the recurrence of old discussions. Yet, little attention is given to documenting design decisions in the engineering literature. In this study, a theoretical framework for the key elements of this documentation process was developed. Four infrastructure projects were studied and compared to this framework by means of pattern matching. This method compares theoretical and empirical patterns and determines whether they match or do not match. The findings demonstrate that accessibility of documentation for all involved project parties and the division of documentation tasks are in accordance with the literature. However, the documentation of design decisions and their rationale is not done as completely as is recommended in theory. Literature states that the documentation of interrelations and context of decisions should be described thoroughly, but that is barely done in practice. In addition, the findings show that neither immediate documentation nor periodical monitoring of documentation is applied. Based on these findings, this research proposes a strategy for improving the documentation of design decisions.

Keywords:
design decision; civil engineering; documentation strategy; infrastructure; project management; information systems.

DOI: 10.12821/ijispm080103

Manuscript received: 5 May 2019
Manuscript accepted: 11 September 2019

1. Introduction

The documentation of design decisions in complex projects is of great importance as it, among others, improves the ability to trace decisions, provides more insight in which decisions have been decisive in the project development, and prevents the occurrence of old discussions.

Civil engineering projects often have a long duration and are dynamic in nature [1]. A project consists of multiple phases that have to be completed for the design of new infrastructure, or for redesign or modification of existing infrastructure. The execution of different phases requires the involvement of different specialized parties. Information is not only transferred between different involved parties, but also from one phase to another. Documentation is of great importance as it is the main means to transfer information from party to party and from phase to phase. However, problems concerning the documentation of design decisions have been identified at these transitions [1]. For example, a clear baseline for the project is not always established, as the documentation provided during these transitions is often incomplete or missing in many projects [2]. Moreover, the quality of input-documentation appears to be a problem, even for a phase itself. Project disciplines do not receive the information they require, or the documentation is provided too late [3]. Finally, design decisions are not always communicated with those involved in the project organization [1],[4]. Hence, being dependent on the documented information of others, different teams cannot continue their work activities or have to make assumptions which may turn out to be wrong [5],[6].

Approaches and formats differ per organization or team, which makes tracing information a tedious and time-consuming task and prone to errors [2],[7]. In addition, a high level of effort is also required for managing and controlling changes in project scope and requirements [8]. It is hard for stakeholders, or for members of the project organization, to determine which design decisions have been made earlier in the process, and how these affect or are affected by, the changed parameters [3]. Moreover, a lack of procedures sometimes results in ambiguities about people's responsibilities for both making and documenting design decisions [6]. This not only results in miscommunication between the different involved parties but also between individuals of the same team. Finally, discussions in projects are repeated multiple times as no documentation can be provided based on which the discussion could be closed [1]. To solve these problems, the development of a strategy for the documentation of design decisions in civil engineering projects is relevant.

The documentation of design decisions is required to provide both the project organization and different stakeholders with a reference throughout the project [7]. Documentation allows clients, project members and stakeholders to keep track of project changes and ensures a good traceability [1],[9]. By doing so, knowledge and practices from previous phases could be reused, and reoccurring discussions can be prevented [8],[10]. This increased efficiency enables a timely completion of the different project tasks [11]. Moreover, documentation of design decisions could also be beneficial for communicating within the project organization as well as for allowing an understandable representation of the design for different stakeholders [3].

The objective of this study is to develop recommendations in the form of a strategy for the documentation of design decisions in civil engineering projects by investigating current practices. A literature review has been done, current practices have been studied in four projects, and a concept strategy has been developed. The findings of this study can help determine how to deal with the process of documentation to improve the traceability of design decisions.

In this study, the two research questions are: what are important elements for the documentation of design decisions in civil engineering infrastructure projects? And how can these elements be implemented in civil engineering infrastructure projects to improve the documentation of design decisions?

Section 2 presents the theoretical framework that has been developed based on previous research on design decisions, documentation and information management. Section 3 presents the methodology used to achieve the research objective. Section 4 focuses on the analysis and explanation of the findings of the case studies and Section 5 describes the recommendations of this research, followed by the conclusions and limitations (Sections 6 and 7).

2. Theoretical background

To determine the elements for the documentation of design decisions, a literature study has been carried out. Literature on documenting design decisions in civil engineering has been reviewed. However, current research on documentation of design decisions in civil engineering projects appeared to be scarce. Therefore, literature in other disciplines was reviewed as well. In literature, why-, what-, who-, when-, where- and how aspects of documentation could be distinguished. In this section, we present a review of the literature.

2.1 Literature study

What

Literature addresses the specifics of what should be documented concerning design decisions. First, the design decision itself should be included explicitly in documentation because it describes the specific consideration made [12],[13],[14],[15]. In addition, not only a design decision itself but also the rationale behind the decision should be documented [6],[7],[16]. The rationale comprises the justification and process that has led to a design decision [17],[18]. This rationale is required to determine why a decision has been made, even after a long period of time or if the decision-maker has left the project [19]. Literature also suggests to additionally document the dependencies and interrelations between design decisions [20],[21]. This will provide project members with more insight in the cohesion of the entire system [22]. To further extend this system overview, Babar & Gorton [23] and de Lange et al. [24] propose to document a decision's context as well. The design objects and systems that are affected by a design decision are thus included explicitly in the documentation. The context will provide clarity on different project teams' involvement for a decision, guiding the communication and reflection between them [25].

Who

A documentation strategy is not complete without assigning responsibilities for both documentation and monitoring tasks [7]. To ensure a continuous and structured documentation of design decisions, the responsibility for this should be given to a specific person [1],[11]. Defining clear responsibilities prevents discussion on who is responsible for performing specific documentation tasks. This clarity will also improve the communication about design decisions, as it is clear for project members who should be contacted concerning a specific decision [26]. Furthermore, the responsibility for monitoring and checking the documentation should also be assigned clearly, to ensure verification on the existence and quality of documentation [2]. To prevent errors and inconsistencies, only project members responsible for documenting a specific decision are given rights to do so, similar for the rights to check and approve the documentation which should only be given to those who have these responsibilities [27],[28].

When

To ensure adequate documentation of design decisions, agreements on the moment of documentation should be made. It is stressed in literature that design decisions should be documented continuously during the project, preferably immediately after making decisions [10],[29],[30]. As Lee & Kruchten [31], Weinreich et al. [32], Tyree & Akerman [33] and Babar et al. [34] point out, immediate documentation is required to prevent the loss of information and knowledge. In addition, this documentation should then be evaluated and reviewed periodically [13]. The periodical review will ensure that documentation tasks are executed, and additionally the quality is monitored [35]. Farnham & Aslaksen [2] also suggest reviewing previous documentation at the start of a new project phase to provide the project members with a clear baseline. This baseline provides insight in what documentation is present and what information still needs to be retrieved.

Where

Literature states additional requirements for the documentation conditions concerning the location of documentation. As many parties are involved in civil engineering projects, the transfer of information should be considered [4]. Easily sharing documentation is considered very important in a project organization [1],[36]. However, in order to safeguard sufficient traceability and smooth transition of documentation across phases and people, good accessibility of the

documentation is essential [4],[35],[37]. Involved project parties should therefore be provided with good access to the latest documentation at all times [6],[38],[39]. Often a web interface or software application is recommended as storage and retrieval location for documentation, sometimes complemented by a repository or database [10],[40]. Within such an environment, the use of a pre-defined template or query could present structured and uniform documentation and improves retrieval, but it also supports the user in documenting decisions [2],[35],[37].

How

The first four aspects of documentation describe the content and conditions, but theory also addresses the format in which the documentation could be captured. Anumba et al. [10], Mena et al. [37] and Kruchten [41] suggest documenting design decisions and their dependencies in the form of an ontology. This is a network in which all properties and relations of design decisions are documented [24],[42],[43]. Another possibility to visualize the decisions is to connect them to their context. This could be visualized by placing design decisions in conceptual drawings or models [6],[44]. By doing so, a decision is shown directly connected to the objects in the design that it affects [27].

Implementing a strategy for the documentation of design decisions

Existing literature focused on civil engineering points out that difficulties might be encountered when implementing a strategy for the documentation of design decisions. Documentation requires time and effort of the project members, while benefits often cannot be perceived immediately [1],[2],[6]. Furthermore, a new approach might require training for the project members, however proper guidance is currently often not guaranteed [1],[37]. Additional difficulties occur because of the project-oriented, short-term and task-focused work culture of the civil engineering sector [6],[35]. The level of collaboration is generally low, while the number of involved parties is high [2]. On top of that, Van der Meer et al. [6] add that the documentation provided by the client at the start of the project is often uncertain and incomplete.

2.2 General overview

This literature review combines theory of the civil engineering discipline and of other disciplines. Therefore, it provides new input that is required to solve long-existing problems concerning the documentation of design decisions in civil engineering projects. First of all, it is important to not only document design decisions, but also their rationale, interrelations and context. This will provide a justification of why a decision has been made, but also shows the decision in relation to other decisions and its context. Because of this, project members will have more insight in the cohesion of the entire system. The responsibilities for both documenting and monitoring this documentation should be given to a specific person, so that all design elements are accounted for. Uniform documentation should be ensured by using a documentation environment in which the user can document in a pre-defined template. Civil engineering projects have many involved project parties, thus good accessibility to documentation for all parties is very important. To ensure continuous and complete documentation, design decisions should be documented immediately and this should be monitored by periodical reviews. At the start of each project phase, an assessment of previous documentation should be done to provide a baseline of all available information.

2.3 Theoretical framework

By means of this literature study, a theoretical framework has been developed that was used as a reference for both data collection and analysis. The theoretical framework is summarized in Table 1. As literature did not offer one conclusive framework for the documentation of design decisions, the framework has been developed with separate elements from different sectors. As coherence was not present in literature, case study research should be used to determine if cohesion between the elements of the theoretical framework could be found in practice. The relevance and existence of these elements in current practices should also be determined in the case studies. At last, the case study research should provide a better understanding of the different elements of the theoretical framework.

Table 1. Theoretical framework

Framework	Theoretical patterns	Sources
What	There should be documentation of design decisions and their interrelations, context and the rationale behind decisions	[6], [7], [12], [13], [14], [15], [16], [20], [21], [23], [24]
Who	There should be clear responsibilities assigned for the documentation	[1], [2], [7], [11]
	There should be clear responsibilities assigned for monitoring the documentation	[2]
When	There should be immediate documentation of design decisions, rationale, interrelations and context which should be ensured by periodical monitoring	[10], [29], [30], [31], [32], [33], [34], [35]
	There should be an assessment of all available documentation performed at the start of a new project phase	[2]
Where	There should be a documentation environment in which the user should document in a pre-defined template	[2], [4], [6]. [10], [35], [37], [38]
	There should be good accessibility of the documentation for all involved project parties	[2], [4], [35], [37]
How	There should be a visualization of the design decisions and interrelations in their context	[6], [10], [27], [37], [41], [44]

3. Method

A theoretical framework has been established by performing a literature review. To be able to develop a strategy for the documentation of design decisions, this framework has been compared to current practices at project level. To establish a clear description of current practices, in which the contextual conditions play an important role, case study research was used [45],[46]. This type of research strategy has been chosen considering the three conditions for using a case study. First, the research question addressing the elements of documentation of design decisions is of exploratory nature, as the goal is to investigate current practices and to develop propositions in the form of a strategy. Furthermore, the projects studied are contemporary and the researchers have no control over the events [46].

This study on the documentation of design decisions has been performed in four civil engineering road infrastructure projects. Data were collected from these projects by means of interviews and document analysis. To ensure data triangulation, both these sources were used for cross verification of the collected data. The case studies have been compared to the theoretical framework by means of pattern matching. Patterns of similarities and differences have been modelled based on this reflection. Pattern matching was used in this research as it is recommended as strategy for qualitative analysis for case studies, as it will provide critical understanding of the subject [46],[47],[48]. This in-depth understanding was needed to define the improvements that are necessary in current practices. This enabled answering the second research question addressing the implementation of the documentation elements. This question is of prescriptive nature and based on the case study findings, recommendations in the form of a concept strategy are proposed. In this strategy, different elements concerning the documentation process are integrated. Also the manner in which those elements should be applied in practice is discussed.

3.1 Case studies

Four projects in the Netherlands were studied. The projects all focus on road infrastructure, more specifically national highways. The projects have been selected following the principle of *ceteris paribus*, in which multiple variables affecting a dependent variable are remained constant as much as possible. The cases were selected in such a way that the discipline, client, use of Systems Engineering (SE) and project objectives and sizes are as similar as possible. This enables an in-depth view on different practices concerning documentation of design decisions in projects with similar contexts and conditions. In all projects, Rijkswaterstaat (RWS) was the client and therefore SE was mandated because

RWS prescribes SE in all its engineering projects [49]. RWS is the executive body of the Dutch Ministry of Infrastructure and Water Management, and is responsible for water management and the construction and maintenance of public works, including waterways and roads. These four cases together provide a clear insight in the current practices of the documentation of design decisions in different stages of development in road infrastructure. For Dutch public road infrastructure, project organizations are obliged to follow the phases as described in the MIRT phasing and Transport Infrastructure Planning Act [50],[51]. MIRT is the multiple year program for infrastructure-, spatial planning- and transport projects of the Dutch government, provinces and municipalities. The Transport Infrastructure Planning Act describes the obligatory procedure for the development of road infrastructure. The projects are:

- Project A: extension of a station and widening of a highway, requiring the construction of two tunnels for the road. The phases studied were the Plan Development Phase, the Development and Contracting Phase, and the Realization Phase;
- Project B: widening of a highway and separation of traffic flows. This project was studied in the Development and Contracting Phase;
- Project C: widening of a highway, construction of a switch lane and development of a sunken road construction. This project was studied in the Plan Development Phase, and the Development and Contracting Phase;
- Project D: widening of a highway, with the ambition to develop a smart and sustainable road through extensive innovation. This project was studied in the Plan Development Phase.

This research focused on the involved project members of both the client and an engineering consulting firm that supported the client. Some of these project members have been involved in the projects in all phases, while others have only contributed to a specific phase, or part of a phase.

3.2 Data collection

During the case studies, current practices concerning the documentation of design decisions were compared with the theoretical framework that is described in Section 2. To collect data, interviews were conducted amongst team members of the four projects, supported by a documentation analysis. The theoretical framework was used as an outline for the interview format so that descriptive data on current practices were gathered for identical elements. These elements describe the what, who, when, where and how characteristics concerning the documentation of design decisions in the case studies. All participants were interviewed following a structured outline, but with addition of some probing questions if more information was required. Examples of the questions used are “was there a standardized procedure for the documentation of design decisions?” and “what are the major limitations of the current method for the documentation of design decisions?” The interviews were conducted in a one-on-one setting of participant and researcher and had a duration of one hour. Data have been collected from in total 29 participants; six for project A, six for project B, eight for project C and nine for project D. These participants have been selected for interviews based on their roles and responsibilities. Among others, technical managers of both the client and engineering consulting firm were interviewed for all projects. Furthermore, both people focusing on SE activities and those responsible for the design products have been interviewed. Several designers, technical advisors and design leaders representing different disciplines of both client and engineering consulting firm completed the list of interviewees.

3.3 Data analysis

The qualitative, descriptive data of the case studies consist of a documentation analysis and interview transcripts. Empirical patterns were formulated for each of the previously defined elements [45]. This condensed set of data was confronted with the theoretical framework by means of pattern matching. This method compares theoretical and empirical patterns and determines whether they match or do not match [29],[46],[47],[52]. The theoretical framework serves as the ‘theoretically ideal pattern’, the collected set of data is the ‘observed pattern’. The theoretical pattern thus describes how the documentation of design decisions should be done according to literature, while the observed pattern provides insight in how it is actually done in practice.

The confrontation either results in matches, partly matches or mismatches between the expected and observed patterns. These matches are assigned values on a three-point scale, a minus (-) indicating that the patterns do not match entirely, a zero (o) indicating a slight overlap and a plus (+) indicating a complete match. For each of the elements of the framework, the matches and mismatches were evaluated and explained, which provides an enhanced interpretation of the data.

The pattern matching analysis has been performed cross-case to compare the different projects and their confrontations with the theoretical framework [46]. Based on these findings, and explanations for the findings, recommendations for improving documentation of design decisions were proposed. These recommendations were formulated in the form of a concept strategy.

4. Results: case studies

This section summarizes the background of the four case study projects from which the empirical patterns are derived. These patterns resemble the elements as used for the theoretical patterns. Analysis of the results explains the differences and resemblances between theory and practice.

4.1 Case study results

Pattern matching was used to confront the theoretical framework and current practices [48]. Table 2 shows the summarized results of the pattern match between theoretical and empirical patterns for all projects. The confrontation was scored per element and is indicated by a three-point scale (-/o/+). By adding up the scores of all projects, the elements were ranked from best match to worst match. The explanations of the initial scores were used to determine the ranking if the combined score was equal for multiple patterns. Background data on matches for each separate project can be found in Appendix A, Tables 1, 2, 3 and 4.

Table 2. Summarized results of the pattern match for all projects

Element	Description	Project A	Project B	Project C	Project D	Rank
What	There should be documentation of design decisions and their interrelations, context and the rationale behind decisions	o	-	o	o	**5**
Who	There should be clear responsibilities assigned for the documentation	+	-	o	+	**3**
	There should be clear responsibilities assigned for monitoring the documentation	+	-	+	+	**1**
When	There should be immediate documentation of design decisions, rationale, interrelations and context which should be ensured by periodical monitoring	-	-	o	o	**8**
	There should be an assessment of all available documentation performed at the start of a new project phase	-	o	-	+	**7**
Where	There should be a documentation environment in which the user should document in a pre-defined template	o	-	+	+	**3**
	There should be good accessibility of the documentation for all involved project parties	+	-	+	+	**1**
How	There should be a visualization of the design decisions and interrelations in their context	-	o	o	o	**5**

- patterns do not match, o patterns match partly and + patterns match. The ranking indicates the correspondence of the pattern with literature, from best matches (1) to worst matches (8). Some patterns (1), (3) and (5) have a similar correspondence with literature and are thus ranked similarly.

4.2 Ranking the results

As the pattern match (Table 2) indicates, large differences between the results of the different projects emerge. Project D seems to score best on most of the patterns, and project B never performs up to the theoretical standard. The results were ranked from high to low, in correspondence with literature. Considering this ranking, the following most important conclusions can be drawn:

- Both good accessibility of documentation is considered (see Table 2-'Where'- ranking 1) and clear responsibilities for monitoring documentation are assigned in three projects (see Table 2-'Who'- ranking 1). Only in project B, no match between theory and practice could be observed for both these patterns. Two projects (A and D) are in keeping with theory concerning the division of responsibilities for documenting itself, and one is partly (C), see Table 2-'Who'-ranking 3. The use of a documentation environment with pre-defined template is applied in projects C and D and for a part of the aspects of the documentation process in project A (see Table 2-'Where'-ranking 3).
- Project B is the only project that does not document any of the aspects as suggested in literature (see Table 2-'What'-ranking 5). For the visualization of design decisions and interrelations in their context, project A is the only project without any correspondence with theory (see Table 2-'How'-ranking 5);
- Only in project D, a match between theory and practice could be observed concerning the documentation assessment. The other projects are only partly (B) or not in keeping with literature, see Table 2-'When'-ranking 7. Immediate documentation and periodical monitoring were performed in some situations in projects C and D, but none of the projects showed practices comparable to theory (see Table 2-'When'-ranking 8).

Based on the data, we could explain the findings. It appeared that good accessibility of documentation is currently considered in practice as long as clients require the use of a specific environment that contributes to traceability and structure in handling large SE projects (cases A, C, D). The analysis also indicates that assigning responsibilities for both documenting and monitoring this documentation is done because it is considered as common practice to handle the projects' complexity. A pre-defined template for documenting design decisions is used to improve the quality of documentation sometimes, but users are given much freedom in completing it. The findings also show that the client plays an important role because documentation appeared to be more complete when the client puts emphasis and focus on documentation. The documentation of design decisions and rationale is considered in current practices, but the context of and interrelations between design decisions are not documented. The design decisions have been visualized in their context in some projects (cases B, C, D), however this could be further improved by additionally developing a visualization of the interrelations. The largest differences between current practices and literature are identified regarding performing a documentation assessment. It appeared that assessing previous documentation, which is provided by the client, is considered difficult because of the difference in power position between the client and the engineering consulting firm. As the client procures the project assignment, the engineering consulting firm is considered to meet the client's requirements and report regularly on their progress. Even though they are able to assess the documentation of the client, they cannot demand effort of the client to improve or complement the documentation if this is not sufficient. Furthermore, a difference between literature and current practices is observed in performing periodical monitoring and immediate documentation. Currently, hardly any strict procedures for the moment of documentation are applied resulting in postponement of these tasks due to time-pressure.

4.3 Additional findings

In the interviews performed during the case studies, additional data were collected that were not used in the pattern matching analysis. These data provided a better understanding of the specific approaches that are already used or are absent in current practices. First of all, the project members stressed that guidelines for when a design decision needs to be documented are required because these are not present yet. Besides stressing the need for adequate documentation, the findings show that discussing the documentation during meetings is still needed to ensure that everyone becomes

familiar with the contents: documentation alone is not enough. Furthermore, project members indicated that often, based on experience, an overview of design decisions that will need to be made in a project phase could be developed already at the start of that phase. This enables a better overview of the design decisions and dependencies in terms of project schedule, and provides structure for those responsible. In addition to documenting, this structure could be used for planning and dividing the periodical monitoring tasks.

5. Towards a strategy for the documentation process

This section describes the recommendations. These have the form of a concept strategy, which is based on the findings of the cases. The concept strategy aims to improve the documentation process of design decisions in the civil engineering infrastructure sector. The proposed concept strategy describes what should be documented, who is responsible, when it should be documented, where it should be documented and how it should be documented. The pattern match of each case shows an overview of the similarities and differences between theoretical and empirical patterns. The case studies thus provide insight in the elements already covered in current practices, and those which could still be improved. Also, the findings indicate the relevance of and cohesion between these elements in practice.

This paragraph describes the specifications of the concept strategy, of which the visualization is shown in Figure 1. The extensive descriptions of the elements in the different levels are based on the data collected in the case studies. The different strategy levels are visually presented in Figure 2.

Because of the extent of the improvements following from the case studies, it is considered difficult to implement this in a project organization at once. Therefore, recommendations are described in the form of a concept strategy in which the elements are assigned to different levels that should be implemented subsequently. The base level describes the current practices at the engineering consulting firm being good accessibility of documentation and division of responsibilities. In the first level, the documentation of design decisions and their justification, the use of a pre-defined template, immediate documentation and periodical monitoring are explained and suggestions for their implementation are provided. The second level addresses the documentation of interrelations and context of design decisions, and possibilities for visualizing these aspects. The third level considers an assessment of all available documentation at the start of a new project phase. The levels should be implemented subsequently in that specific order. In each level, the depth of the documentation increases as the required elements have a higher complexity. The subsequent levels improve the documentation by adding relations and visualizations, but in order to do so the basic documentation level has to be acquired. The third level requires much insight of project members, to which execution of the previous levels contributes.

5.1 Current practices

The three elements that are generally included already in current practices, good accessibility (see Table 2; where; ranking 1) and responsibilities for both documenting and monitoring this documentation (see Table 2; who; ranking 1 and 3), are addressed in the base level. The concept strategy stresses the importance of a shared documentation environment. Furthermore, it describes the possibility of applying different user restrictions based on involvement in specific activities and project phases. Second, the importance of assigning responsibilities for monitoring documentation is stressed. As the results indicated, performing the monitoring is considered necessary. Third, also the distribution of responsibilities for documenting itself is described. The concept strategy suggests a distribution of responsibilities for different documentation activities that were identified in the case studies.

5.2 Level 1

First addressed in this level is the documentation of design decisions and rationale, because these elements are already partly implemented (see Table 2-‘What’-ranking 5), however also because these elements form the foundation required for the implementation of all other strategy elements. As documenting all design decisions is considered not desirable, indications for when a design decision needs to be documented are described. Furthermore, at the start, all known design decisions that will have to be made during the project have to be documented already. Secondly, the pre-defined

template in which these design decisions and rationale should be documented is addressed. The specifics of this template are suggested, based on the documentation elements described in the concept strategy. Finally, immediate documentation and periodical monitoring will have to be acquired in this level even though its performance is a large step from current practices (see Table 2-'When'-ranking 8). The concept strategy distinguishes documentation during design activities and during meetings.

5.3 Level 2

Defining the interrelations and documenting these requires a better understanding of the project system by the user than is required for a design decision itself. Because of this, relations are introduced in the second level of the strategy. Justification of the relation is required as the findings demonstrated it is often unclear why decisions are related and how one affects another. Similar steps are included for defining and documenting the context of a design decision. Second, these new aspects of documentation should be visualized. The settings for these visualizations are to be accounted for by the software manager, so the description focuses on the implications for the project members and how the visualizations could be used in practice.

5.4 Level 3

The assessment of all available documentation at the start of a new project phase is addressed. This is included in the last level as findings indicate that performing this effectively could only be achieved if the assessors have a good understanding of what documentation should be available and what quality this should have. It is important that all design activities are postponed until the assessment is finished.

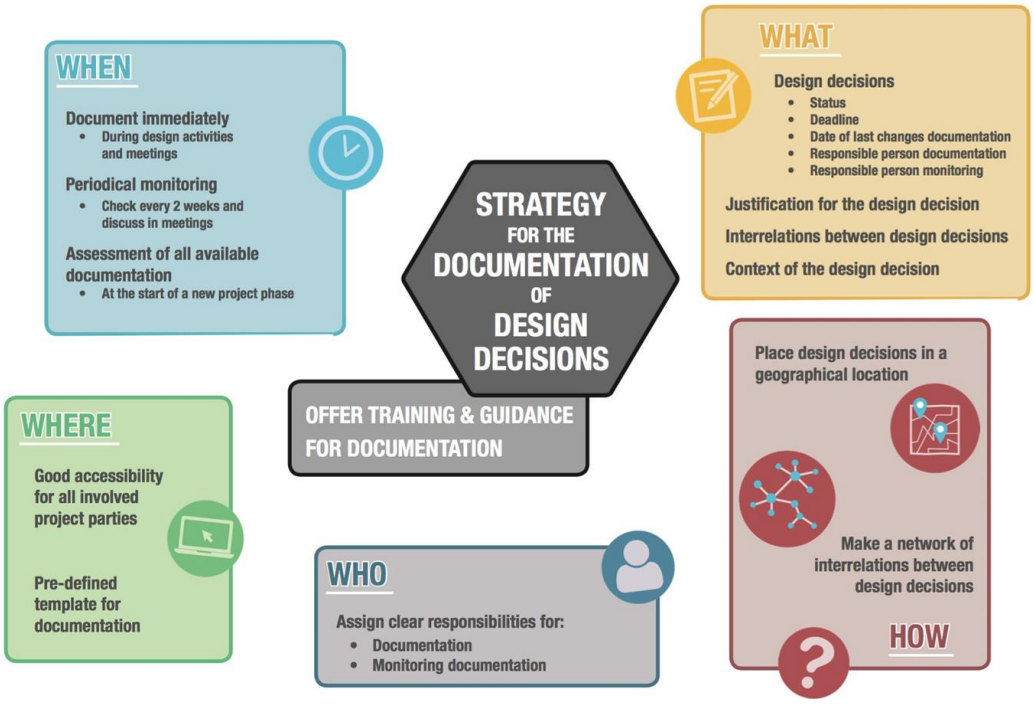

Figure 1. The concept strategy, showing all elements

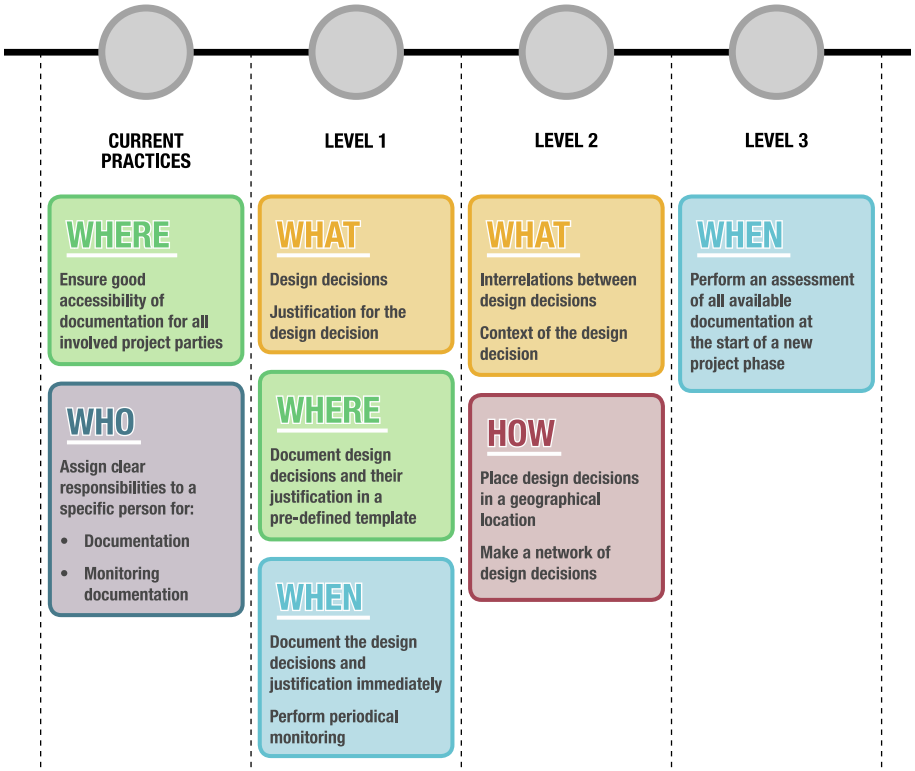

Figure 2. The strategy levels of the concept strategy

6. Conclusion

The documentation of design decisions is important as it provides insight in which decisions have been significant during the development of a project. However, in several studies, problems concerning the documentation of design decisions are mentioned, especially at the transitions between project phases or between different involved parties. For example, project members do not receive the required information, or it is provided too late, delaying work activities. Furthermore, approaches and formats to capture and manage information differ per organization or team, which makes tracing information a tedious and time-consuming task. Moreover, discussions in projects are repeated multiple times as no documentation can be provided based on which the discussion could be closed. Although these documentation problems are acknowledged in several disciplines, little attention is paid in literature to these problems in the context of civil engineering.

To identify the important elements of the documentation of design decisions in a civil engineering context, this research was conducted. It aimed to develop recommendations for improving the documentation process in civil engineering road infrastructure. These recommendations were proposed in the form of a documentation strategy. Coherence was not present in literature, so the case studies were used to determine if cohesion between the elements of the theoretical framework could be found in practice.

The relevance and existence of these elements in the case studies contributed to theory building on the documentation of design decisions and also helped formulate practical recommendations. Since the case study approach only allowed for theoretical generalization, we encourage other researchers to test and expand the theory in other contexts.

The findings demonstrate that good accessibility of documentation for all involved project parties is already considered in current civil engineering practices. This is mainly because of the requests made by the client for the use of a specific environment that contributes to ensuring structure and traceability in large SE projects. Furthermore, the division of responsibilities in practice for both documenting and monitoring this documentation are in keeping with theory. Project members explained these results by indicating that assigning these responsibilities was required to be able to the handle the projects' complexity.

The documentation environments used in practice do provide pre-defined templates to document design decisions, but these templates leave more freedom to the user than those described in literature. Design decisions are documented in some of the projects studied, but often incomplete and without rationale that explains why the decision was made. These aspects were most complete in the project that started most recently. Project members who also participated in some of the other case study projects, indicated that they learned from previous experiences of those projects. Interrelations between design decisions and a decision's context, as described in literature, are missing in current documentation processes in practice. The suggestions that were provided in literature for visualizing the decisions in their context are observed in practice, but this could be complemented by additionally developing a visualization of the interrelations.

Assessing all previous documentation at the start of a new project phase is only done in the project that started most recently. Based on previous experience, this project team persisted in performing this assessment to prevent redoing activities. Other projects indicated that the assessment is considered difficult in practice because of high time pressure and the difference in power position of the client and engineering consulting firm. The moment of documentation is not in keeping with theory, as documenting is not done immediately. Also, no periodical monitoring is performed in practice that could ensure this immediate documentation.

Recommendations for the documentation of design decisions

To ensure successful application of the recommendations, barriers that could obstruct the implementation should be deducted or studied further. Tight project schedules form a threat to a successful implementation of the strategy. For example, performing the assessment of documentation would be obstructed, as deadlines require the design activities to commence already. Future research should study the influence of such an assessment on the project performance, so that the reclassification of time could be argued. Furthermore, the attitude of the designers in a civil engineering infrastructure project is considered a possible barrier. They might perceive the documentation process described in the strategy as an administrative burden, which distracts them from their design tasks, and thus obstructs them from performing it. Therefore, the added value and benefits of documenting design decisions also for them should be proven in practice. This will have a more positive effect on their incentives to document than requiring so from a managerial position.

7. Limitations and further work

This research has some limitations that should be pointed out. First, we compared current practices relative to a normative theoretical framework, but did not relate the documentation process to performance in terms of budget, client satisfaction or compliance to the schedule. It was not the intention to study the relation between the degree of documentation and project outcomes. The intention was to identify potential improvements in the documentation of design decisions and to develop a strategy for that. Nevertheless, it is a recommendation for future research to study the relation between the degree of documentation of design decisions and project outcomes.

Second, the projects used for the case studies were all large road infrastructure projects in the Netherlands in which the same engineering consulting firm and client were involved. Moreover, only four projects were studied. This reduces the generalizability of the findings for different types of projects and other organizations involved. Therefore, it is suggested to further study a broader variety of projects to improve and further refine our proposed documentation strategy.

Finally, related to the issue of generalizability, we suggest to address implementation of the strategy with attention and caution. Although we have validated our proposed strategy for documenting design decisions with several experts, it still is the first time that a documentation strategy has been developed for civil engineering infrastructure projects. The strategy should be further tailored to, and validated with, the specific situation and context where it is supposed to be implemented. Most likely, the context of other situations is different compared to the context in which we carried out the research.

Acknowledgments

The authors thank the project members and experts for their contribution to the research.

References

[1] S. T. A. van den Houdt and J. L. M. Vrancken, "Rolling out Systems Engineering in the Dutch Civil Construction Industry. Identifying and Managing the Factors leading to Succesful Implementation," *retrieved from repository.tudelft.nl*, pp. 1-9, 2013.

[2] R. Farnham and E. W. Aslaksen, "Applying Systems Engineering to infrastructure projects," in *INCOSE Spring Conference*, Nottingham, UK, 2009.

[3] L. Luo, Z. Liu, and M. Xie, "Comprehensive information management model of construction projects based on System Engineering methodology," in *International Conference on Construction and Real Estate Management*, Guangzhou, China, 2017.

[4] B. Elliot, "Overcoming barriers to transferring systems engineering practices into the rail sector," *Systems Engineering*, vol. 15, no. 2, pp. 203-212, 2012.

[5] S. Bathallath, Å. Smedberg, and H. Kjellin, "Managing project interdependencies in IT/IS project portfolios: a review of managerial issues," *International Journal of Information Systems and Project Management*, vol. 4, no. 1, pp. 133-145, 2015.

[6] J. van der Meer, A. Hartmann, A. van der Horst, and G. Dewulf, "Challenges of using systems engineering for design decisions in large infrastructure tenders," *Engineering Project Organization Journal*, vol. 5, no. 4, pp. 133-145, 2015.

[7] J. M. Chachere and J. R. Haymaker, "Framework for measuring the rationale clarity of AEC design decisions," *Journal of Architectural Engineering*, vol. 17, no. 3, pp. 86-96, 2011.

[8] R. S. de Graaf, R. M. Vromen, and J. Boes, "Applying systems engineering in the civil engineering industry: an analysis of systems engineering projects of a Dutch water board," *Civil Engineering and Environmental Systems*, vol. 34, no. 2, pp. 144-161, 2017.

[9] R. S. de Graaf, J. T. Voordijk, and L. van den Heuvel, "Implementing Systems Engineering in Civil Engineering Consulting Firm: An Evaluation," *Systems Engineering*, vol. 19, no. 1, pp. 44-58, 2016.

[10] C. J. Anumba, R. R. A. Issa, J. Pan, and I. Mutis, "Ontology-based information and knowledge management in construction," *Construction Innovation*, vol. 8, no. 3, pp. 218-239, 2008.

[11] P. Pirzadeh and H. Lingard, "Understanding the Dynamics of Construction Decision Making and the Impact on Work Health and Safety," *Journal of Management in Engineering*, vol. 33, no. 5, pp. 1-11, 2017.

[12] R. Capilla, F. Nava, and J. C. Duenas, "Modeling and documenting the evolution of architectural design decisions," in *International Conference on Software Engineering*, Minneapolis, US, 2007.

[13] H. Deng, Y. Wang, and J. Deng, "Study on decision information management and application during complex engineering system development," in *International Conference on Comprehensive Product Realization*, Beijing, China, 2007.

[14] M. Küster, "Architecture-centric modeling of design decisions for validation and traceability," in *Software Architecture*, vol. 7957, K. Drira, Ed. (LNCS: Springer, Berlin, Heidelberg, 2013, pp. 184-191.

[15] O. Zimmermann, J. Koehler, F. Leymann, R. Polley, and N. Schuster, "Managing Architectural Decision Models with Dependency Relations, Integrity Constraints, and Production Rules," *Journal of Systems and Software*, vol. 82, no. 8, pp. 1249-1267, 2009.

[16] A. Jansen, J. S. van der Ven, P. Avgeriou, and D. K. Hammer, "Tool support for architectural decisions," in *The Working IEEE/IFIP Conference on Software Architecture*, Mumbai, India, 2007, no. 4-4: IEEE.

[17] M. Bhat, K. Shumaiev, and F. Matthes, "Towards a framework for managing architectural design decisions," in *11th European Conference on Software Architecture: Companion Proceedings*, Canterbury, UK, 2017, pp. 48-51.

[18] J. S. van der Ven, A. G. J. Jansen, J. A. G. Nijhuis, and J. Bosch, "Design Decisions: The Bridge between Rationale and Architecture," in *Rationale Management in Software Engineering*, A. Dutoit, R. McCall, I. Mistrik, and B. Paech, Eds.: Springer Berlin Heidelberg, 2006, pp. 329-348.

[19] U. Zdun and R. Capilla, "Sustainable Architectural Design Decisions," *IEEE Software*, vol. 30, no. 6, pp. 46-53, 2013.

[20] P. D. Borches Juzgado, "A3 Architecture overviews. A tool for effective communication in product evolution," Design, Production and Management, Faculty of Engineering Technology, University of Twente, Enschede, 2010.

[21] G. Pahl, W. Beitz, J. Feldhusen, and K.-H. Grote, *Engineering design: A systematic approach*. Springer-Verlag London, 2007.

[22] A. MacCalman, H. Kwak, M. McDonald, and S. Upton, "Capturing experimental design insights in support of the model-based System Engineering approach," *Procedia Computer Science*, vol. 44, pp. 315-324, 2015.

[23] M. A. Babar and I. Gorton, "A tool for managing software architecture knowledge," in *Sharing and Reusing Architectural Knowledge - Architecture, Rationale, and Design Intent*, Minneapolis, USA, 2007: IEEE.

[24] J. de Lange, E. J. Oude Luttikhuis, and E. Lutters, "Networked Design Decisions in Balanced Life Cycles," *Procedia CIRP*, vol. 21, pp. 230-235, 2014.

[25] T.-M. Hesse, A. Kuehlwein, and T. Roehm, "DecDoc: A tool for documenting decisions collaboratively and incrementally," in *1st International Workshop on Decision Making in Software ARCHitecture*, Venice, Italy, 2016: IEEE.

[26] H. Dogan, M. J. Henshaw, and G. Ragsdell, "The risk of information management without knowledge management," *Journal of Information & Knowledge Management*, vol. 10, no. 4, pp. 393-408, 2011.

[27] A. Tang, M. A. Babar, I. Gorton, and J. Han, "A survey of the use and documentation of architecture design rationale," in *5th Working IEEE/IFIP Conference on Software Architecture*, Pittsburgh, USA, 2005: IEEE.

[28] R. Weinreich and G. Buchgeher, "Integrating requirements and design decisions in architecture representation," in *Software Architecture*, vol. 6285, M. A. Babar and I. Gorton, Eds. (LNCS: Springer, Berlin, Heidelberg, 2010, pp. 86-101.

[29] R. D. Galliers and D. E. Leidner, *Strategic information management: challenges and strategies in managing information systems*, 3th ed. Oxford, UK: Butterworth-Heinemann, 2014.

[30] U. van Heesch, V.-P. Eloranta, P. Avgeriou, K. Koskimies, and N. Harrison, "Decision-centric architecture reviews," *IEEE Software*, vol. 31, no. 1, pp. 69-76, 2014.

[31] L. Lee and P. Kruchten, "A tool to visualize architectural design decisions," in *Quality of Software Architectures. Models and Architectures*, vol. 5281, S. Becker, F. Plasil, and R. Reussner, Eds. (LNCS: Springer, Berlin, Heidelberg, 2008, pp. 43-54.

[32] R. Weinreich, I. Groher, and C. Miesbauer, "An expert survey on kinds, influence factors and documentation of design decisions in practice," *Future Generation Computer Systems*, vol. 47, pp. 145-160, 2015.

[33] J. Tyree and A. Akerman, "Architecture decisions: Demystifying architecture," *IEEE Software*, vol. 22, no. 2, pp. 19-27, 2005.

[34] M. A. Babar, I. Gorton, and B. Kitchenham, "A framework for supporting architecture knowledge and rationale management," in *Rationale Management in Software Engineering*, A. H. Dutoit, R. McCall, I. Mistrík, and B. Paech, Eds.: Springer, Berlin, Heidelberg, 2006, pp. 237-254.

[35] M. F. Noordin, L. A. Burhanuddin, and A. Kanaa, "The current state of information management and knowledge management in the Malaysian construction industry," *Australian Journal of Basic and Applied Sciences*, vol. 6, no. 6, pp. 138-145, 2012.

[36] R. Maier and T. Hädrich, "Knowledge management systems," in *Encyclopedia of Knowledge Management*, D. G. Schwartz, Ed.: Springer Berlin Heidelberg, 2005, pp. 442-450.

[37] Á. Mena, F. López, J. M. Framiñan, F. Flores, and J. M. Gallego, "XPDRL project: Improving the project documentation quality in the Spanish architectural, engineering and construction sector," *Automation in Construction*, vol. 19, no. 2, pp. 270-282, 2010.

[38] A. Jansen, J. Bosch, and P. Avgeriou, "Documenting after the fact: Recovering architectural design decisions," *Journal of Systems and Software*, vol. 81, no. 4, pp. 536-557, 2008.

[39] J. Varajão, "The many facets of information systems (+projects) success," *International Journal of Information Systems and Project Management*, vol. 6, no. 4, pp. 5-13, 2018.

[40] C. S. Greeven and S. P. Williams, "Enterprise collaboration systems: addressing adoption challenges and the shaping of sociotechnical systems," *International Journal of Information Systems and Project Management*, vol. 5, no. 1, pp. 5-23, 2017.

[41] P. Kruchten, "An ontology of architectural design decisions in software-intensive systems," in *2nd Groningen Workshop on Software Variability Management*, Groningen, The Netherlands, 2004, pp. 54-61.

[42] Z. Ming *et al.*, "Ontology-based representation of design decision hierarchies," *Computing and Information in Engineering*, vol. 18, no. 1, pp. 1-12, 2016.

[43] E. J. Oude Luttikhuis, J. de Lange, E. Lutters, and R. ten Klooster, "Evolving Product Information in aligning Product Development Decisions across Disciplines," *Procedia CIRP*, vol. 29, pp. 573-578, 2015.

[44] F. F. Brussel and G. M. Bonnema, "Interactive A3 Architecture Overviews," *Procedia Computer Science*, vol. 44, pp. 204-213, 2015.

[45] M. B. Miles, A. M. Huberman, and J. Saldana, *Qualitative Data Analysis: A Methods Sourcebook*. Thousand Oaks, USA: SAGE, 2013.

[46] R. K. Yin, *Case Study Research: Design and Methods - Second Edition* (Applied Social Research Methods). London, UK: SAGE, 1994.

[47] G. Cao, S. Clarke, and B. Lehaney, "The need for a systemic approach to change management: a case study," *Systemic Practice and Action Research*, vol. 17, no. 2, pp. 103-126, 2004.

[48] T. Hak and J. Dul, "Pattern matching," in *Encyclopedia of Case Study Research*, A. J. Mills, G. Durepos, and E. Wiebe, Eds. Thousand Oaks, USA: SAGE, 2009.

[49] Rijkswaterstaat, "Procesbeschrijving Systems Engineering voor RWS Projecten. Version 2.1.3," 2017.

[50] Ministry of Infrastructure and Water Management, “Spelregels van het Meerjarenprogramma Infrastructuur, Ruimte en Transport (MIRT),” 2016.

[51] *Tracéwet*, 2017.

[52] D. T. Campbell, "Degrees of freedom and the case study," *Comparative Political Studies,* vol. 8, no. 2, pp. 178-193, 1975.

Appendix A. Background data on matches for each separate case study project

Table 1. Pattern match Project A

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
What	There should be documentation of design decisions and their interrelations, context and the rationale behind decisions	There is limited explicit documentation of design decisions and rationale is only implicitly documented. No interrelations or context of design decisions are documented	o	Design decisions and rationale are documented implicitly in specific reports as this was requested by client. There were no requirements set for explicit documentation in a digital online documentation environment, so due to time pressure and short-term deadlines this was not done to a large extent. Interrelations are regarded as logical derivatives of design activities, thus were not documented specifically
Who	There should be clear responsibilities assigned for the documentation	Responsibilities for documentation are assigned to specific people	+	Responsibilities were assigned to prevent elements of the project not being accounted for. However, this responsibility was for the documentation in the final reports
	There should be clear responsibilities assigned for monitoring the documentation	Responsibilities for monitoring the documentation are assigned to specific people	+	Responsibilities were assigned to prevent elements of the project not being accounted for. However, this responsibility was for monitoring the documentation in the final reports
When	There should be immediate documentation of design decisions, rationale, interrelations and context which should be ensured by periodical monitoring	Documentation is not done immediately and no periodical procedure for monitoring was used	-	Designers perceive the immediate documentation as administration without obvious benefits, so they are not willing to change to that new manner of working even though management would prefer it. No hard rules for moment of documentation are set
	There should be an assessment of all available documentation performed at the start of a new project phase	No assessment of all available documentation was performed at the start of a new project phase	-	An assessment of all documentation has not been performed as the engineering consulting firm is considered not to be in the position to set requirements for the client at that moment
Where	There should be a documentation environment in which the user should document in a pre-defined template	The design decisions are documented in a digital online documentation environment in a template, and in free form in meeting minutes and reports	o	Administrators of the digital online documentation environment decided to specify several fields in the template to ensure uniform documentation. However, user is free to leave parts of template open. In reports, users could document in his own manner as this is considered most easy for them
	There should be good accessibility of the documentation for all involved project parties	The digital online documentation environment ensures good accessibility of the documentation for all project parties	+	The digital online documentation environment is considered as standard in the industry for management large SE projects, so its use was prescribed by the client
How	There should be a visualization of the design decisions and interrelations in their context	Design decisions are not placed in context but only documented as derivative of meetings or implicitly in text, interrelations are not documented at all	-	Textual documentation was considered sufficient to determine to which element of the design the decisions belong

Table 2. Pattern match Project B

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
What	There should be documentation of design decisions and their interrelations, context and the rationale behind decisions	There is only implicit documentation of design decisions and rationale is missing. No interrelations or context of design decisions are documented	-	The project team was not focused on traceability of information in the early phases of the project and thus did not document extensively. Interrelations and context are regarded as logical derivatives of design activities, thus were not documented specifically
Who	There should be clear responsibilities assigned for the documentation	Responsibilities for documentation are not clearly assigned to specific people	-	Because documentation was considered less important in design phases no responsibilities were assigned. In the contract development, actions do have responsible persons but these are not focused on documentation
	There should be clear responsibilities assigned for monitoring the documentation	No responsibilities are assigned for monitoring the documentation	-	In the contract development, focus is on delivering specifics contract and thus not on documentation and monitoring
When	There should be immediate documentation of design decisions, rationale, interrelations and context which should be ensured by periodical monitoring	Documentation is not done immediately and no periodical procedure for monitoring was used	-	Designers do not think the benefits of immediate documentation outweigh the effort and time it takes. No hard rules for moment of documentation are set
	There should be an assessment of all available documentation performed at the start of a new project phase	Standard RWS procedures are used for assessment of some documentation at the start of a new project phase	o	The RWS procedures (gates and KAd[1]), focusing on the most important design documents, are considered sufficient for assessing necessary documentation according to management
Where	There should be a documentation environment in which the user should document in a pre-defined template	The design decisions are documented implicitly and in free form in memos and meeting minutes	-	In memos and meeting minutes, users could document in his own manner as this is considered most easy for them
	There should be good accessibility of the documentation for all involved project parties	Not all required documentation could be traced by project members	-	As traceability of information was not considered in early project phases, this documentation is missing or hard to trace by current project members
How	There should be a visualization of the design decisions and interrelations in their context	A selection of design decisions is captured in posters of objects in context, interrelations are not documented at all	o	To structure the project and gain overview, posters are made for each object in which the most important decisions are discussed

[1] KAd (Kwaliteitsborging Aanbestedingsdossier) is the formal review performed by a dedicated team of Rijkswaterstaat to ensure the quality of the tender documentation.

Table 3. Pattern match Project C

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
What	There should be documentation of design decisions and their interrelations, context and the rationale behind decisions	There is documentation of design decisions and rationale. No interrelations or context of design decisions are documented	o	The traceability of design decisions and rationale was not considered in the design project phases, so documentation is done at a later moment as justification of the design was required by client. Interrelations and context are regarded as logical derivatives of design activities, thus were not documented specifically
Who	There should be clear responsibilities assigned for the documentation	Responsibilities for documentation are assigned to specific people for a large part	o	Responsibilities were assigned to prevent elements of the project not being accounted for. However, some elements do not have a specific responsible person for documentation because of lack of discipline
	There should be clear responsibilities assigned for monitoring the documentation	Responsibilities for monitoring the documentation are assigned to specific people	+	Responsibilities were assigned to prevent elements of the project not being accounted for. However, this responsibility was generally for monitoring the documentation in the final reports as the documentation was not fully explicit
When	There should be immediate documentation of design decisions, rationale, interrelations and context which should be ensured by periodical monitoring	Documentation is not done immediately, but documentation is monitored by discussion in design meetings	o	In two-weekly design meetings, design decisions have to be discussed and are at least documented then, documentation is not done immediately because of lack of discipline and time
	There should be an assessment of all available documentation performed at the start of a new project phase	No assessment of all available documentation was performed at the start of a new project phase	-	An assessment of all documentation has not been performed as the engineering consulting firm is considered not to be in the position to set requirements for the client at that moment and feels they should be able to trust the client in this
Where	There should be a documentation environment in which the user should document in a pre-defined template	The design decisions and rationale are documented in a pre-defined template of lines of reasoning	+	For the lines of reasoning a template was discussed to ensure that all elements were documented at the same level. However, the exact completion of the templates was different for each discipline as else it would require too complex alignment
	There should be good accessibility of the documentation for all involved project parties	Procedure for storage documentation ensures good accessibility for all project parties	+	Communication between different project parties was considered very important, so focus was put on good accessibility of all documentation
How	There should be a visualization of the design decisions and interrelations in their context	Design decisions are connected to the contextual geographical location, interrelations are not documented at all	o	Design decisions are connected to the location in design drawings to create insight in the context of the decision

Table 4. Pattern match Project D

Framework	Theoretical patterns	Empirical patterns	Match	Explanation
What	There should be documentation of design decisions and their interrelations, context and the rationale behind decisions	There is documentation of design decisions, rationale and context. No interrelations of design decisions are documented	o	Design decisions, rationale and context are documented explicitly as traceability was in the project focus from the beginning due to the level of innovation required in the project. Interrelations are regarded as logical derivatives of design activities, thus were not documented specifically
Who	There should be clear responsibilities assigned for the documentation	Responsibilities for documentation are assigned to specific people	+	Responsibilities were assigned to prevent elements of the project not being accounted for. The explicitness of documentation improved assigning responsibilities
	There should be clear responsibilities assigned for monitoring the documentation	Responsibilities for monitoring the documentation are assigned to specific people	+	Responsibilities were assigned to prevent elements of the project not being accounted for. The explicitness of documentation improved assigning responsibilities
When	There should be immediate documentation of design decisions, rationale, interrelations and context which should be ensured by periodical monitoring	Documentation is done immediately during meetings, during design activities it is not. No periodical procedure for monitoring was used	o	Meetings are directly documented in a digital online documentation environment to prevent additional documentation activities afterwards. For other documentation, designers perceive the immediate documentation as administration without obvious benefits, so they are not willing to change to that new manner of working even though management would prefer it. No hard rules for moment of documentation are set
	There should be an assessment of all available documentation performed at the start of a new project phase	An assessment of all available documentation was performed at the start of a new project phase	+	Management instructed that the design could not start until all required documentation was collected and assessed, to prevent unnecessarily redoing activities
Where	There should be a documentation environment in which the user should document in a pre-defined template	The design decisions are documented in a digital online documentation environment in a template	+	Administrator of the digital online documentation environment decided to specify several fields in template to ensure uniform documentation. However, user is free to leave parts of template open
	There should be good accessibility of the documentation for all involved project parties	The digital online documentation environment ensures good accessibility of the documentation for all project parties	+	The digital online documentation environment is considered as standard in the industry for management large SE projects, so its use was prescribed by the client
How	There should be a visualization of the design decisions and interrelations in their context	Design decisions are connected to the contextual geographical location, interrelations are not documented at all	o	Design decisions are connected to objects in the digital online documentation environment which are visualized in the GIS viewer[1] to create insight in the context of the decision

[1] GIS (Geographical Information System) is an information system in which (geographical) data is captured, stored, analyzed and displayed.

Biographical notes

Tara Kinneging
Tara Kinneging is project engineer at the engineering consulting firm Witteveen+Bos in the Netherlands. Her project activities focus on system integration and the application of Systems Engineering in multiple phases of infrastructure development and renovation. Tara obtained her MSc degree in Civil Engineering and Management at the University of Twente, with a specialization in Construction Management and Engineering.

Robin de Graaf
Robin de Graaf is Assistant Professor at the Department of Construction Management and Engineering at the University of Twente in the Netherlands. His teaching, research and projects focus on the design management of construction projects in general, and on Systems Engineering and Value Management in particular. Robin has an MSc in Civil Engineering & Management and a PhD in Strategic Urban Planning.

Sander Siebelink
Sander Siebelink is PhD candidate at the Department of Construction Management and Engineering at the University of Twente in the Netherlands. He earned a master's degree in Civil Engineering and Management and a Professional Doctorate in Engineering from the University of Twente. His PhD research focusses on Building Information Modelling (BIM) maturity and the organizational (in)capabilities to change to BIM.

Tim van Dijck
Tim van Dijck is system integrator at the engineering consulting firm Witteveen+Bos in the Netherlands. His project activities focus on project- and design management of infrastructure projects with Systems Engineering as guideline. Tim obtained his MSc degree in Civil Engineering and Management at the University of Twente, with a specialization in Intelligent Transport Systems.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

W4RM: A prescriptive framework based on a wiki to support collaborative risk management in information technology projects

Rogerio Alves Soares
Nove de Julho University, Graduate School of Management
Rua Deputado Salvador Julianelli, s/n, Prédio D - 1º andar, São Paulo – SP, 01156-080
Brazil
rogas2002@gmail.com

Marcirio Silveira Chaves
Pontifícia Universidade Católica do Rio Grande do Sul, PUCRS, Business School
Av. Ipiranga, 6681 - Prédio 50 – 11º andar, Porto Alegre – RS, 90619-900
Brazil
marcirio.chaves@pucrs.br

Cristiane Drebes Pedron
Nove de Julho University, Graduate School of Management and DBA & Master in Project Management
Rua Deputado Salvador Julianelli, s/n, Prédio D - 1º andar, São Paulo – SP, 01156-080
Brazil
cdpedron@gmail.com

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

R. Soares, M. Chaves, C. Pedron, "W4RM: A prescriptive framework based on a wiki to support collaborative risk management in information technology projects", *International Journal of Information Systems and Project Management*, vol. 8, no. 1, pp. 67-83, 2020.

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

W4RM: A prescriptive framework based on a wiki to support collaborative risk management in information technology projects

Rogério Alves Soares
Nove de Julho University, Graduate School of Management
Rua Deputado Salvador Julianelli, s/n, Prédio D - 1º andar, São Paulo – SP, 01156-080, Brazil
rogas2002@gmail.com

Marcirio Silveira Chaves
Pontifícia Universidade Católica do Rio Grande do Sul, PUCRS, Business School
Av. Ipiranga, 6681 - Prédio 50 – 11º andar, Porto Alegre – RS, 90619-900, Brazil
marcirio.chaves@pucrs.br

Cristiane Drebes Pedron
Nove de Julho University, Graduate School of Management and DBA & Master in Project Management
Rua Deputado Salvador Julianelli, s/n, Prédio D - 1º andar, São Paulo – SP, 01156-080, Brazil
cdpedron@gmail.com

Abstract:
Despite the positive influence of risk management in Information Technology (IT) project results, many project managers are not managing risks or are managing them partially. To enhance risk management, collaborative project management has gained attention in recent years with the introduction of Web 2.0 tools. Project managers have used such tools to facilitate open communication and distribution of activities. This research introduces a prescriptive framework (W4RM – Wiki for Risk Management) based on a wiki to support collaborative risk management in IT projects. An exploratory focus group was set up and a series of interviews with practitioners was conducted to explore how a wiki can support risk management in IT projects. Findings show that project managers are facing difficulties managing risks and are the only ones responsible for identifying, registering and monitoring risks. By implementing a collaborative tool, managers can disseminate a collaboration culture and participate in risk management processes. This sense of collaboration may be used to keep the community identifying new risks, relating these risks to one or more projects, and facilitating continuous risk management. Practitioners can also adopt W4RM as a tool to support communication regarding risks status to be established for internal team stakeholders.

Keywords:
project management; project risk management; information technology; web 2.0; wiki.

DOI: 10.12821/ijispm080104

Manuscript received: 2 July 2018
Manuscript accepted: 3 June 2019

1. Introduction

Software, as a tool to manage a project, is widely used by companies. The proper use of these tools, associated with a methodology, can influence project results positively [1]. Web 2.0 tools ease communication and collaboration between people, creating networks of direct communication for all users in the same community, allowing the flow of ideas and knowledge with efficient generation, dissemination, sharing and refining of information [2, 3]. Although the use of the internet and emails have been the major means of communication between teams, the use of applications and Web 2.0 tools have emerged in the last few years and present a new opportunity to manage Information Technology (IT) projects successfully [4, 5].

One of these Web 2.0 tools is the wiki, which is being adopted by companies to be used in different segments, enabling interactivity and communication between internal and external teams [6]. In Project Management (PM), wikis have been used as a tool to organize project information and help project managers create and share information with project teams and stakeholders [7-9]. Wikis are a useful tool that can be adopted by project managers for knowledge dissemination and project documentation [3].

Not only project managers, but also all project stakeholders are being helped by wiki usage in such different activities as document system development, managing document versions and report activities [10]. Considering that wikis bring with them a change of paradigm (collaboration, active participation by the project team, transparency and co-responsibility) to deal with risks, this research proposes the use of wiki pages to manage risks in IT projects. Wikis confront the users with unused ways of working with IT systems [3]. Although proposed solutions that make use of sophisticated methods without ensuring applicability might be useless in practice, researchers mention problems in risk management that *can* be supported by a wiki tool, but a framework for this proposal is absent in the literature.

Some of these problems include risk identification, when not all of the team is involved [11]; risk communication, when stakeholders lack information regarding risks [12]; and risk control, when the team is not informed of risk status and not updated with new information, or new risks [13]. To deal with these issues, this study intends to find answers to the following research question: How can a wiki support risk management in IT projects? To answer this question, this research will: 1) Verify risk management gaps reported in the literature and show how wiki pages can help with that; 2) Propose a framework based on a wiki to support risk management; and 3) Validate with experts the proposed framework and viability of implementation for risk management processes.

This paper is organized as follow. Section 2, the background of difficulties in project management is outlined and how the main wiki characteristics may help on that. In section 3 we present research methodology. The results are presented in section 4. Section 5 contains theoretical and practical contributions of this paper. Finally in section 6, we present our conclusions.

2. Background

2.1 Risk management in IT projects

IT projects are exposed to a greater number of risks due to their technological dependence. Monitoring and mitigating risks related to technology dependency can contribute to project success [14]. Although there are different definitions of risk management in projects, common aspects emerge among them, such as the description of main activities emphasizing the execution of these activities for successful risk management. References such as, Project Management Institute [15], Kerzner [16] and Office of Government Commerce [17], have their own list of activities that they present as important to be done. Some activities like risk identification, risk analysis and risk control, are present in all definitions as major activities.

Analyzing risk management and PM guides has allowed the identification of common steps in managing risks, such as: ***Identification*** - despite different names and terminology, all guides define a step to perform this action; ***Assessment*** - this step is also identified in all guides, but in different ways. Some of them suggest carrying out assessment in one step

and others in two steps; ***Response Strategy*** - the guides propose response strategies according to project strategy, budget, priorities and prioritization of risks; ***Communication*** - the guides suggest effective communication by establishing recurrence and periodicity for the internal team and stakeholders; and ***Control*** - this phase is presented in all guides, yet in some, beginning after a response strategy has been created and communicated.

Several studies have positively related risk management and project success [18-21], but this relation is not consensual among researchers. While some of them point out that a relationship between risk management and project success could not be found [22], others report that despite project managers agreeing that risk management can have a positive influence on project success, they do not apply risk management to their projects [23]. Although this nonconsensual evidence of the positive relation between risk management and project success, risk management is a critical activity that should be stimulated by project managers and done by everyone involved in the project.

The risk management process will require the action of project members during the entire project cycle, not only remediating occurred events, but preventively acting to fix negative events before they occur [24]. A continuous and iterative process needs to be performed at regular intervals to analyze, plan, track and fix risk events and consequences [13]. In order for a project team to achieve a successful coordination of all these activities, it is essential that project managers pay attention to risk management and create a recurrent agenda with all the team [25]. The coordination required regards not only the internal team, but additional stakeholders as well [26]. Complex and innovative projects are influenced by inputs from other teams and external partners [25]. Therefore, planning the right coordination practice is important, due to the influence on information sharing between teams and the generation of outcomes [25].

An additional challenge for project managers to implement and execute risk management is the risk aversion among stakeholders. Sometimes project managers avoid talking about risks with stakeholders in order not to create a disturbing project environment, and just act on the consequences of negative events, but neither identifies, nor manages them as a risk [27]. Institutional pressures from sponsors and executives to get the project done quickly force project managers to deem process risk identification unnecessary, because recurrent plan and documentation activities do not fit unrealistic deadlines [24].

Project control requires a well-planned risk management, conducted by the project manager, and executed by the project team to avoid 'firefighting' activities, rather than proactively managing and eliminating potential risk threats [24]. After risk identification and assessment, new threats are not identified while the project is executed. Even when formal changes to the project occur, the risks are not reassessed and revaluated [12]. The control of risks is a challenge for project managers. Though conducting some degree of risk assessment and classification, risks are not managed continuously, turning risk management activities into a reactive process only [22]. Risk factors should be dynamically monitored and tracked during all the project cycle [13].

By reviewing literature, we identify a positive relation between risk management and project success. At the same time, we identify risk management issues or even the option not to manage risks. Once the project manager decides to manage risks, the use of an appropriate tool can help him/her in the risk management processes and improve communication between the project team and stakeholders [16].

2.2 Social media and wiki

The introduction of Web 2.0 tools in project management facilitates the deployment of the Project Management 2.0 (PM 2.0) concept. From an IT perspective, it is possible to define PM 2.0 using the formula: (PM 2.0 = PM 1.0 + distributed collaboration), where PM 1.0 is the traditional project management, and distributed collaboration is guided by open communication, which thrives on collective intelligence to support decision makers [28].

The use of Web 2.0 tools is gradually increasing and gaining acceptance in organizations, evidenced by the increasing use of the term Enterprise 2.0. The term Enterprise 2.0 refers to the use of Web 2.0 tools in organizations. The use of collaborative and interactive Web 2.0 concepts and technology has great potential for flexible integration and ad-hoc information exchange among collaborators [3]. These tools enable organizations to communicate interactively and

engage with their supply chain and provide their customers with a sense of empowerment. Communication tools support social bonding across any distance, creating a virtual work environment and creating virtual colleagues [29].

Establishing a sense of unity to create a team and stimulate the ability of individuals to collaborate and work effectively as a team is a challenge for managers [30]. As face-to-face communication is not always possible, communication technology is crucial to develop trust within distributed project teams [30]. In order to increase the probability of success to establish a team and enhance the intensity of collaboration and trust in projects, communication and participation need to be addressed through an integrated project methodology [3]. Web 2.0 concepts and technologies can be used to promote participation and open a corporate dialog, stimulating participation and cooperatively working on the identification, rating, and commenting of issues, creating businesses discussions instead of only consuming content [3,31].

Enterprise Collaboration Systems are software systems that combine enterprise social software like wiki, with traditional groupware components, like e-mail, databases, libraries to support organizations specifically in internal business communication, collaboration, and content and knowledge sharing activities [32]. Enterprise Collaboration Systems support the collaborative work of employees, comprising all areas of collaboration such as information and content sharing, communication, cooperation and coordination [33]. These large volumes of social content are comprised of a wide variety of documents (e.g. wiki entries), many of which contain important business information that requires systematic management [34]. Rather than functioning as a channel of communication delivery only, Enterprise Collaboration Systems provide a platform upon which social interaction can occur [34].

Wiki applications have high potential to facilitate knowledge creation, sharing, use and integration. The use of wikis is increasing in different contexts, such as education, research, business, government and the public domain. It enables a collaborative environment, permitting volunteers and groups to create and edit documents incrementally [35]. One page of wiki may store information in different formats (e.g. text, links, images and videos), to collaboratively capture and share business information and knowledge [34]. Various features characterize Wiki technology including interlinking, collaborative edition and preview. There are a number of other features related to wiki, covering such aspects as structure, syntax, security and personalization [36]. The features of Wikis have made it a unique philosophy regarding knowledge sharing. Unlike other Web 2.0 tools, which tend to focus on sharing and broadcasting individual opinions, wikis focus more on consensus and collaborative understanding of contexts.

An advantage of using Wikis is the feature that allows tracking and revisions. Malicious attempts to misinform can be quickly revised or reverted to the previous version. The edit history can be used by the administration to identify the content and users that created it, preventing anonymous collaboration and discouraging the creation of content that is not aligned with the organization's policy [37]. Wikis stimulate collaboration between companies; with asynchronous collaboration, the natural flow of information allows the spreading of knowledge construction. This will benefit organizations that are expanding their business, developing a collaborative exchange of information between companies in different regions [38]. In addition, knowledge content from one company can be incorporated by another without the need to handle staff allocation [38]. Wikis are useful for knowledge dissemination and project documentation, they confront the users with unused ways of working with IT systems [3].

Comparing the literature about threats as difficulties in managing risks in projects with wiki tool characteristics makes it possible to relate them. Wiki tools can enhance risk management by applying some important steps recommended in risk management guides, or by supporting risk management gaps. Table 1 shows risk management issues, difficulties or recommendations and wiki characteristics that can help in risk management issues.

Although some project managers identify and register risks, the problems and difficulties controlling them include poorly managed identified risks and lack of a tool to help constant monitoring [12]. Wikis enable discussion between their users and can help to organize and track information, transforming information collected into a center of discussions [6]. The ability to track information allows the project manager to keep risk information up to date and shared with all the team and with stakeholders.

Table 1. Risk Management issues and Wikis characteristics.

Risk Management Issues/ Difficulties/ Recommendations	**Author(s)**	**Wiki Characteristics**	**Author(s)**
Risk should be identified by different levels of an organization	[13, 15]	Wikis are used to gather and disseminate information from/to different levels in organizations.	[3,37]
Risk can occur due to lack of information.	[15]	Web 2.0 tool enables the gathering of information from many points of view	[39]
Risk identification and assessment are important steps for successful risk management	[15, 40]	Wikis allow the gathering of information from the project team, stakeholders and project committee.	[28]
Establish recurrent communication for internal team and stakeholders	[15,30 ,40]	Wiki applied to projects allows the project manager to share information with the project team and stakeholders.	[41]
Some PM tend to ignore risks when they perceive that they disturb the project environment.	[24,27]	Wiki's collaborative nature encourages negotiation and discussion and aids in achieving consensus	[4]
Project manager's perception of self-efficacy can interfere with risk perception	[42]	Implementation of wikis stimulates the culture of collaboration	[6]
There are problems and difficulties in controlling identified risks	[12,13,22]	Wiki users can help to organize and track information.	[34]

3. Method

By adopting interpretivism, we aim to seek an in-depth and context-specific understanding of lived or inner experience of PM practitioners. Figure 1 shows the research workflow adopted, and each square represents a different step.

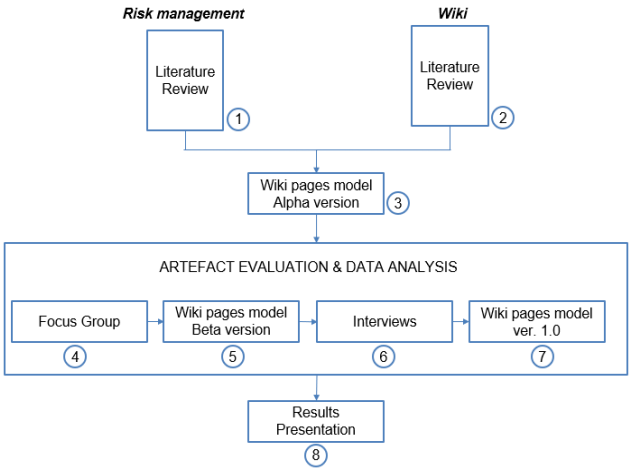

Figure 1. Research Workflow.

The first and second steps of this research were related to the literature review presented in section 2. Step 1 was the literature review on risk management in projects, and started with a search in scientific databases, such as ScienceDirect, Scopus, Wiley and Emerald Insight. The search on each database started with a query: 'risk

management' and 'project management', reading the abstracts and selecting papers for detailed analysis according to their assumptions. The criteria for selection were papers with risk management definition in IT projects or papers presenting difficulties with risk management in projects.

In step 2, we conducted searches on the same databases of step 1. The first query was: "web 2.0" and "definition", the second query was: "wiki" and "organization" or "company", and the third query was: "wiki" and "project". The papers returned on the results had their abstracts analyzed and if the content was aligned with the research assumption, with positive or negative aspects, the paper was downloaded for a detailed reading and then cited, if used, in the literature review.

According to the literature review, we developed an alpha version of W4RM to be presented to participants in the focus group in step 3. Step 4 was an exploratory focus group of IT project managers. This focus group was directed to explore the project manager's experience with risk management in past projects, their experience with risk management tools and the success or not of this execution. The research looked for opinions about W4RM, identifying strengths, weaknesses and functionalities to be added, changed or deleted. The focus group had seven participants and one of the researchers as moderator. All participants are experienced IT project managers, with three to 23 years acting as project managers, and ages 36 to 53. The focus group was used to explore project manager experiences in managing risks, encourage discussions among participants about best practices, difficulties and recommended steps to be taken by project managers.

To stimulate interactions, we structured the focus group protocol to investigate four main topics. The first topic was about the difficulties that managers are facing in managing risks, the second was how they execute the risk management process, the third was about how familiar they are with web 2.0 tools, and the fourth aimed to gather input about the framework in the alpha version. In the first part of the section, focus group participants talked at length about the barriers they are facing, such as groups of resistance in their companies. The difficulties cited by two or more participants were grouped into five groups of coding. Appendix A shows the topics discussed on focus group meeting.

Based on the results of the focus group, we built the beta version of the wiki pages framework in step 5. This beta version was developed adding the changing characteristics identified as important by the focus group. The size and quantity of changes for this version were not pre-defined at this time, due to the characteristic of qualitative research, and it was expected that there would be an interaction between participants, with discussions, agreements and disagreements regarding the framework. The researchers were responsible for defining what suggestions would or would not be adopted.

In step 6, for the individual interviews, the number of interviews was not pre-defined and new interviews were held until data saturation. The total of interviews was 12; the criteria for choosing participants were project managers with risk management experience, and Portuguese or English speakers. In order to include a foreign point of view, the researcher invited two people from the USA and one person from Mexico to participate and contribute with their perspective. Regarding the industry sector, this research contains respondents from four different industries: Telecoms (1), Financial (4), Retail (2) and IT (5). Adding participants from multiple industry sectors can avoid any bias from a sole sector.

All the interviews were done via Skype and recorded using MP3 Skype recorder. We transcribed the interviews using the Express Scribe Transcription software. The average time for each interview was 30 minutes. Transcriptions were from five to eight pages each, generating 85 pages of transcription to be analyzed. We used MAXQDA and Excel to analyze the results. MAXQDA use is part of the analysis to encode the transcriptions and find repetitions and groups of citation. Excel was used to group and categorize data. Appendix B shows the topics and questions of the interviews.

We generated the W4RM framework (Figure 2) based upon literature review, focus group and individual interviews in step 7. The next section presents and discusses W4RM. Step 8 was the development and the presentation of the study in this article.

4. Findings

To present the results, this section follows the sequence described in the research design. The content analysis was executed twice, the first to analyze the focus group and the second to analyze the interviews. As a result, researchers were able to develop a more mature framework based upon data analysis to be described in this section. Figure 2 shows the Alpha version of the W4RM, which is the artifact developed in this research.

Figure 2 contains three delimited sections, External Access, Wiki Pages and PM tools integration. The Wiki Pages section is the core of the framework, containing all the pages that will be accessed by the collaborators. These pages will be used to register RM methodology defined by the company, risks registered, discussion forums to be used and moderated by the community, project information that can be linked with risks and discussion threads. Tutorial pages are stored to help new users become familiar with the use of wiki and with the framework. Other sections are used to consume data from Wiki Pages. External access is proposed to feed information to databases and some monitoring tools like RSS. PM tools integration aims to feed risk information to any other database used by project managers or Project Management Office (PMO) to integrate project information.

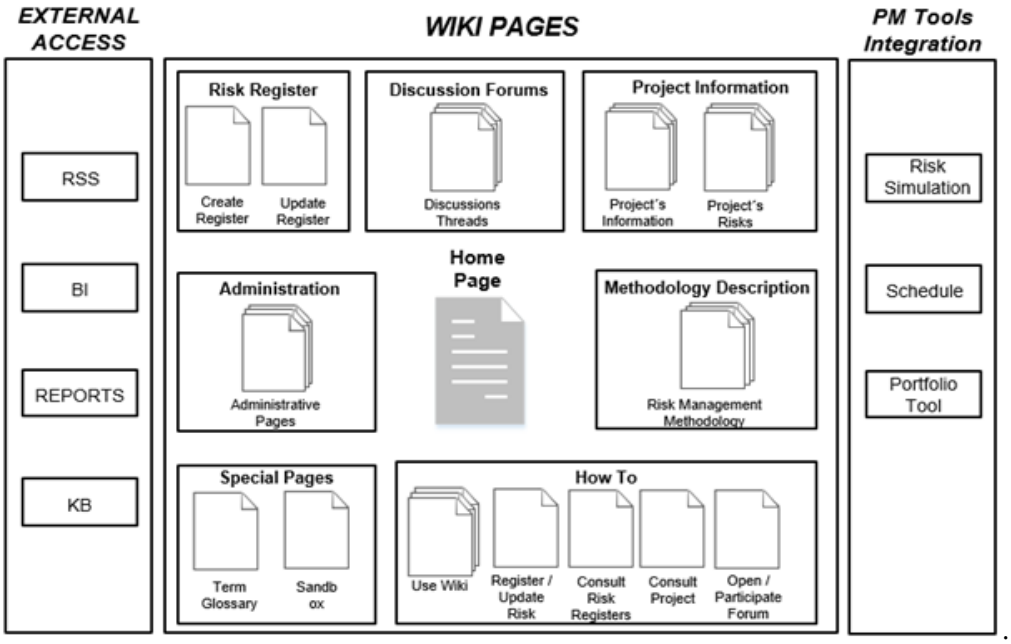

Figure 2. The Wiki for Risk Management (W4RM) Framework.

4.1 Exploratory focus group analysis

In the focus group, we aimed to understand how experienced IT project managers are managing risks. They were encouraged to talk about how they deal with risks in real life and not how they should act according to risk management standards or best practices guides. During the interview, when a participant mentioned some difficulties or some activity that he/she does, but assumed that it is not how it should be done, the mediator encouraged the other participants to say if they do or do not behave the same way.

In the first part of the section, focus group participants talked at length about the barriers they are facing, such as groups of resistance in their companies. The difficulties cited by two or more participants were grouped into five groups of coding (GC).

GC1: Lack of feedback: Difficulty in receiving feedback from the project team, stakeholders and/or sponsor was cited by all participants

(FG05): I can meet with the project team and list risks. However, it's impossible to receive any feedback about the risk status.

(FG07): At the beginning of the project, the team accepts collaborating with risks, but receiving updates is not easy during the execution phase.

GC2: No sponsorship support: When project managers try to present some risks in the project to the sponsor, the sponsors do not usually want to talk about this issue.

(FG03) Some sponsors in my projects just refuse to talk about risks. The term risk just scares them.

GC3: Lack of Contingency Costs: Contingency costs are connected with the difficulty described as no sponsorship support. Sponsors classify any funds for risk contingency as a waste of money, assuming that the project manager and team members need to prevent any risk event without any extra money.

(FG07): After finishing the project plan with the team, I made a presentation to the sponsor explaining the risk and requesting a contingency budget. The sponsor said that I was increasing project costs before starting it, and would not approve any extra cost.

GC4: Reduction of confidence in project manager: One important fact that can stop a project manager from talking about risks is their image in front of the others. Participants said that when they are trying to talk about risks in projects, sometimes this conversation can be identified as a lack of competence on the part of the project manager or an attempt to justify future project delays.

(FG01) Once I did risk identification with a large impact on the project. I requested a meeting with the team to talk about alternatives, but during the meeting, one person said that I was being pessimistic talking about a risk like that. Some team members agreed with him, and as a result, I just ignored that risk.

GC5: Not managing risks for all projects: The option to manage a risk or not is in the hands of the project manager. Participants did not manage risks for all projects. Some participants have their own policy to decide to use risk management or not. They reported that due to difficulties in talking about risks, they avoid this type of discussion in minor projects. In this kind of project, some participants adopt a pre-defined risk list and others just ignore the risks.

(FG07): My decision is based upon project costs and innovation. For projects with minor costs and with known technology, I prefer not to manage risks.

(Moderator) Why do you prefer to ignore the risks?

(FG07): The difficulty in talking about risks is sometimes so great that dealing with the problem when it occurs is better than trying to manage risks.

The second section of the focus group aimed at finding how project managers execute risk management activities. The first question was an open question for project managers to describe what activities they execute and how. Comparing this with the literature review, it was possible to observe that the project managers are carrying out the steps found in the literature. However, none of the participants is taking all the recommended steps in the standard guides. The steps are adopted partially without any particular rule to define which step to take or ignore. Participants who mentioned using standards partially cited PMBOK® from PMI and ASAP from SAP.

After obtaining spontaneous opinions about risk management activities done by participants, the moderator started a discussion about what the state of the art should be for risk management processes in their opinion. The reason for including this topic is to find out what the most important actions and behavior expected by project managers are for the entire company, including the project managers, themselves if they are conducting risk management in a proper way. The opinions were centered on collaborative actions; project managers expect a process not focused only on their role; they expect collaboration from all the team, giving proactive input about existing risks and identifying new risks.

(FG06): After finishing the risk management plan, it would be perfect to see information being disseminated by the whole team. In this case, the project manager will have a helper role, acting on questions about the process, getting approval from the management team and obtaining contingency funds.

(FG03): It would be great if we had input from the team right after any new risk is identified.

The last section of the focus group was focused on analyzing and discussing the artifact proposed in this research. This section started with a detailed presentation of the framework in the development version. The mediator presented the artifact as an existent artifact developed by another researcher in the past, which this research would be planning to adopt, and requested some input concerning their opinions analyzing this framework.

Regarding how this framework could help them to manage risks, one of the main ideas discussed by participants was about disseminating knowledge. According to participants, this tool can capture specialists' opinions and be available to everyone in the company. This framework can be used to stimulate participation. The PMO can encourage interactions by keeping a repository of the adopters and by showing how the collaboration supported the project.

One important aspect discussed by participants was how this framework could help create a corporate risk management culture. To the participants, this could not be done just with the framework implementation. The project should be a risk management implementation process using this framework as the tool to support the defined process. From this point of view, the PMO should be in charge of the project, starting the risk management process with directors and managers after obtaining support from them for the process. The tool should be ready to be implemented.

Another aspect debated by participants was the role of the project manager when the framework is adopted. Participants agreed that if the project manager's role is changed, the risk management process will become a collaborative process, permitting everyone on the team to be the driver for any risk. This change can diminish conflicts between the project manager and team, and the project manager can be a mediator in risks discussion and not the driver.

Based upon the input of the participants, a new version of the framework was developed. For this version, the external access layer presented in Figure 2 was introduced. Comparing the version before and after the focus group, no section was deleted for the new version and just a new layer was added to allow integration with external tools.

4.2 Interview analysis

The interview protocol was created to gather experience in implementing and managing the risk management process of twelve experts. The respondents were encouraged during the interviews to talk about their experience, about what, in their opinion, had contributed or not to a successful risk management process implementation and project risk management activities. The goal of the interviews was to understand risk management in real life, gathering points of view from project managers and their experience in projects. After explaining the objective of the interview to the respondent, and getting information about the respondent's profile, the interview was structured in four sections with a specific and complementary goal for each section.

The first section of the interviews aimed at an in-depth conversation about risk management in real life, proposing discussions about what worked or not for respondents while they were managing their projects. Five of the respondents had experience implementing the risk management process. Three of them had participated in the implementation, collaborating in the implementation in the role of counselor, giving opinions about what would work or not and feedback on the application of the process in projects. Two of them had experience as the project manager in charge of the risk management implementation process.

Analyzing the transcription of the answers regarding the risk management process, some of the recurring words cited by respondents were related to culture, barrier, resistance and the project manager. All the respondents with experience in the risk management implementation process cited these words in different contexts, but in all of the contexts, these words were cited with relevance to the process. For successful implementation, according to respondents, the PMO or any other department in charge of the implementation cannot neglect these aspects.

Respondents identified different types of barriers. All of them described that they found initial support inside their companies when the implementation process started, but discussions particularly about risk management in specific projects suffered resistance. One of the respondents said that his team was very uncomfortable creating a list of risks in the project and communicating this to the CIO (Chief Information Officer).

(E09): To discuss risks, I sent an invitation for a meeting with all the team. When we started a brainstorming session to identify potential risks, one of the participants said that he was uncomfortable writing a specific risk and reporting it to the CIO.

The corporate culture was an important aspect cited by respondents. To implement and execute risk management, it is necessary to identify how the company deals with risks. For this identification, it is important to analyze how the word risk can affect employees. Four of the participants identified their companies as not familiar with risk discussions. Although risk is intrinsic in business, it is not discussed.

We asked respondents for their opinion about what is important for a successful risk management process. Some of the facts related to previous questions were repeated, for example, cultural aspects and a well-defined project manager role. New factors were described by respondents, such as training for project teams, an adequate tool to support the process, collaboration of the project team and implementation of the PM methodology. These factors were cited by a significant part of the respondents. Therefore, the researcher coded them as an important group of critical success factors. Some factors cited were the creation of a PMO, project manager hiring, the creation of a risk management community and a risk management fund to be used by all corporate projects.

Corporate risk management training is one of the most important critical success factors for respondents. In their opinion, employees do not have a clear understanding of what risk is. Without a clear concept of risk, these are not prepared to collaborate with a risk management process. There is a need for corporate training, starting from the basic concepts about what risk is, what an event that may cause risk is, to the techniques to identify risks and risk response strategies.

The second section of the interview aims to understand the collaboration among all employees at the respondent's companies and what needs to be improved in this process. According to respondents, project managers are in charge of all activities, while others collaborate when asked by the project manager and there are employees that do not accept cooperating with risks. Due to this scenario, risk management is restricted by project manager bias. If he/she feels that the project has a low risk, the risk management process can be neglected.

After process implementation, training or meetings to establish and communicate the importance of risk management and collaboration from team members increases, but after some time, this participation diminishes. Maintaining a spirit of collaboration regarding risk management in team members is a huge challenge. Respondents described different examples of how difficult this is for different reasons, and in their opinion, sometimes with team members' excuses for not participating.

(E02): Keeping the team collaborating means keeping the company collaborating. Everyone should be working on that, the steering committee should discuss risks for the whole project and give support to project management and encourage the project team.

The third section of the interview was about an adequate tool for risk management, and the importance of the tool to support the risk management process. According to the respondents, a tool will help the project to gather the information needed, communicate with the project team and with stakeholders. An efficient tool will keep risk registers available for everyone that needs this information, and will be used as a knowledge base for future projects.

Although the respondents agree that a tool is important to the process, many of them, when asked to answer, emphasized the importance of team collaboration. A tool will help project managers to manage risk, but input from team members and their collaboration are the factors that make the process successful or not. A company should bear in mind that just the fact of acquiring a risk management tool will not be enough to run the process; the focus should be on people and the tool to support them.

In the fourth section of the interview, respondents were asked to give their opinion about how this tool can help the risk management process, what the strengths and weaknesses are, and were asked for suggestions on changing the framework. The adoption of the framework to support the risk management process was perceived as positive by all respondents. This tool can support the process and stimulate team collaboration, creating an environment to permit team members to participate, give their input about risk information. One aspect cited by respondents is integration with other PM tools. As the framework is based upon wiki pages that do not do any kind of quantitative analysis, this tool should be integrated to store risk quantitative analysis and link with correspondent risks. A scheduling tool should be integrated to risk management; if the company adopts a web-based schedule tool, the risks related to any scheduled activity should be linked and accessed from the framework.

Participants mentioned, regarding companies that adopt portfolio tools, that it is important to create integration. A new project in the portfolio can be linked to existing risks identified in similar projects, and any new information about the risk will feed all projects affected by that. This integration can help diminish rework, and information does not need to be duplicated in different projects in the portfolio.

(E03): We cannot focus only on the tool, we need to focus on the entire process and emphasize the need for teamwork.

(E05): There are managers who think that if they acquire a tool that has been running successfully in another company, the result will be the same in their company. It is not just about acquiring a tool, people should be prepared and motivated to participate.

5. Theoretical and practical contributions

This research contributes to the literature by proposing a more collaborative Risk Management in projects, by means of a prescriptive framework. This research is classified as incremental originality [43] by introducing the W4RM framework. W4RM was built by gathering best practices in Risk Management literature and Wiki features to support IT PM. W4RM, as a prescriptive framework, denotes an action-oriented form of science, which is concerned with the development of recommendations on how to solve practical problems [44]. To the best of our knowledge, this paper is the first to propose the use of social media (a wiki) to support Risk Management. As a result, this paper introduces a new artifact to a traditional problem in the PM field.

Through the adoption of a constructivist ontology for this research, social interactions with practitioners served as an important pillar to sustain all the results presented. The focus group and interviews permitted the researcher to stimulate debates among experts regarding their problems and challenges in real life, connecting this research to the reality of project managers. W4RM is the result of these debates in groups and individual points of view analyzed by the researcher. Practitioners can adopt W4RM as a tool to support risk management. According to the results found in this research, project managers and PMOs are facing difficulties in implementing and executing risk management. The adoption of a collaborative tool with the schema suggested by W4RM can help them to improve collaboration, as well as help solve the difficulties they themselves described. W4RM serves as a means to facilitate project manager communication with the project team and stakeholders regarding risks. This framework will keep risk policies available for the employees in the company, helping project managers who perceive a disturbance to the project's environment when talking about risks [27]. Kutsch and Hall [23] describe that project managers do not talk about risks to prevent anxiety in the team and stakeholders. To face this issue, W4RM helps disseminate communication about risks and establishes a risk management culture in the community, defining institutional benefits before project initiation.

Studies report difficulties for the project manager regarding continuous risk management after risk identification [12, 13, 22]. W4RM is a collaborative tool that helps create an environment of collaboration from the community and to the community, facilitating continuous risk management. Project managers can inherit the community bias established in the framework to encourage collaboration with risk management alongside the project. Participants of this community can be in charge of identified risks, maintaining communication about any update of specific risks. This sense of collaboration may be used to keep the community identifying new risks and relating these risks with one or more

projects. This attribute of W4RM can also help project managers with problems related to the lack of feedback concerning risk events occurrence, and document consequences.

6. Conclusion

This research shows how a wiki can support risk management in IT projects by proposing a prescriptive framework (W4RM), which was validated by PM experts through discussion in focus groups and individual interviews. Practitioners confirmed problems and difficulties found in the literature. Although risk management is recognized as an important process to support project success, it is executed partially. Project managers and PMO managers are unanimous about the need for collaboration from the project team. Risk management is practiced as an activity with the project manager in charge. Most of the project managers mention corporate culture as a barrier to the discussion of risks. They also agree that implementing a risk management process with a collaborative tool can create a culture to foster risk discussion, process participation and specialist discussions.

The findings reported are subject to at least two limitations. First, case studies were not conducted to validate and evaluate the framework proposed. Second, practitioners recognize that only implementing a tool is not enough to change a risk management culture; a robust implementation should be planned to gradually develop the raising of the entire company's awareness of the relevance of risk management. These issues should be taken into account in future research, which includes the deployment of W4RM in IT projects using action research or design science research to validate this framework in the field.

References

[1] K. Jugdev, D. Perkins, J. Fortune, D. White, and D. Walker, "An exploratory study of project success with tools, software and methods," *International Journal of Management Project Business*, vol. 6, no. 3, pp. 534–551, Jun. 2013.

[2] E. Constantinides and S. J. Fountain, "Web 2.0: Conceptual foundations and marketing issues," *Journal of Direct, Data and Digital Marketing Practice*, vol. 9, no. 3, pp. 231–244, 2008.

[3] A. Auinger, D. Nedbal, and A. Hochmeier, "An Enterprise 2.0 project management approach to facilitate participation, transparency, and communication," *International Journal of Information Systems and Project Management*, vol. 1, no. 2, pp. 43–60, 2013.

[4] B. Gholami and S. Murugesan, "Global IT Project Management Using Web 2.0:," *International Journal of Information Technology Project Management*, vol. 2, no. 3, pp. 30–52, 33, 2011.

[5] M. Ikemoto, S. Gantman and M. S. Chaves, "Use of Social Media in IT Project Management: A Literature Review Based on Hermeneutics and a Research Agenda". *Iberoamerican Journal of Project Management*, vol. 8, no. 1, 87-107, 2017

[6] C. Standing and S. Kiniti, "How can organizations use wikis for innovation?," *Technovation*, vol. 31, no. 7, pp. 287–295, Jul. 2011.

[7] P. Louridas, "Using wikis in software development," *Software IEEE*, vol. 23, no. 2, pp. 88–91, 2006.

[8] M. Tessi and M. S. Chaves, "Applying a Collaborative Model to Support the Management of Lessons Learned in a Private Security Project: A Design Science Research Approach," *IEEE Latin America*, vol. 8, no. 1, 1513-1519, 2017.

[9] R. Winter and M. S. Chaves, "Innovation in the management of lessons learned in an IT project with the adoption of social media," *International Journal of Innovation*, vol. 5, no. 2, 156-170, 2017

[10] S. J. Andriole, "Business impact of Web 2.0 technologies," *Communications of the ACM*, vol. 53, no. 12, pp. 67–79, 2010.

[11] J. Firmenich, "Customisable framework for project risk management," *Construction Innovation*, vol. 17, no. 1, pp. 68–89, Jan. 2017.

[12] H. Sanchez, B. Robert, M. Bourgault, and R. Pellerin, "Risk management applied to projects, programs, and portfolios," *International Journal of Managing Projects in Business*, vol. 2, no. 1, pp. 14–35, Jan. 2009.

[13] Y. Hu et al., "An integrative framework for intelligent software project risk planning," *Decision Support Systems*, vol. 55, no. 4, pp. 927–937, Nov. 2013.

[14] I. Glória Júnior, M. S. Chaves, and F. Silveira, "Identification and Mitigation of Risks in IT Projects: A Case Study during the Merger Period in the Telecommunications Industry," *Revista Gestão e Projetos*, vol. 8, no. 3, 1-17, 2015

[15] Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)–Sixth Edition*,Newtown Square, PA: Project Management Institute, 2017.

[16] H. R. Kerzner, *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, John Wiley & Sons, 2017.

[17] Office of Government Commerce, *Managing Successful Projects with PRINCE2: 2009 Edition*, Stationery Office Books, 2009.

[18] O. Zwikael and M. Ahn, "The effectiveness of risk management: an analysis of project risk planning across industries and countries," *Risk Analysis: An International Journal*, vol. 31, no. 1, pp. 25–37, 2011.

[19] J. Oehmen, A. Olechowski, C. Robert Kenley, and M. Ben-Daya, "Analysis of the effect of risk management practices on the performance of new product development programs," *Technovation*, vol. 34, no. 8, pp. 441–453, Agosto 2014.

[20] D. Pimchangthong and V. Boonjing, "Effects of risk management practices on IT project success," *Management and Production Engineering Review*, vol. 8, no. 1, pp. 30–37, Mar. 2017.

[21] S. Liu and L. Wang, "Understanding the impact of risks on performance in internal and outsourced information technology projects: The role of strategic importance," *International Journal of Project Management*, vol. 32, no. 8, pp. 1494–1510, Nov. 2014.

[22] K. de Bakker, A. Boonstra, and H. Wortmann, "Does risk management contribute to IT project success? A meta-analysis of empirical evidence," *International Journal of Project Management*, vol. 28, no. 5, pp. 493–503, Jul. 2010.

[23] E. Kutsch and M. Hall, "The rational choice of not applying project risk management in information technology projects," *Project Management Journal*, vol. 40, no. 3, pp. 72–81, Setembro 2009.

[24] W. Gachie, "Project risk management: A review of an institutional project life cycle," *Risk Governance and Control: Financial Markets & Institutions*, vol. 7, no. 4–1, pp. 163–173, 2017.

[25] N. B. Moe, T. Dingsøyr, and K. Rolland, "To schedule or not to schedule? An investigation of meetings as an inter-team coordination mechanism in large- scale agile software development," *International Journal of Information Systems and Project Management* , vol. 6, no. 3, p. 15, 2018

[26] R. A. Teubner, "IT program management challenges: insights from programs that ran into difficulties," *International Journal of Information Systems and Project Management*, vol. 6, no. 2, p. 22, 2018

[27] E. Kutsch, "The effect of intervening conditions on the management of project risk," *International Journal of Managing Projects in Business*, vol. 1, no. 4, pp. 602–610, Setembro 2008.

[28] H. R. Kerzner, *Project management 2.0: leveraging tools, distributed collaboration, and metrics for project success*. John Wiley & Sons, pp. 4-5, 2015.

[29] B. Großer, "Virtual teamwork in the context of technological and cultural transformation," *International Journal of Information Systems and Project Management*, vol. 5, no. 4, p. 15, 2017.

[30] O. Stawnicza, "Distributed team cohesion – not an oxymoron. The impact of information and communications technologies on teamness in globally distributed IT projects," *International Journal of Information Systems and Project Management*, vol. 3, no. 2, p. 17, 2015

[31] E. Bonsón, L. Torres, S. Royo, and F. Flores, "Local e-government 2.0: Social media and corporate transparency in municipalities," *Government Information Quarterly*, vol. 29, no. 2, pp. 123–132, 2012.

[32] C. S. Greeven and S. P. Williams, "Enterprise collaboration systems: addressing adoption challenges and the shaping of sociotechnical systems," *International Journal of Information Systems and Project Management*, vol. 5, no. 1, p. 19, 2017.

[33] P. Schubert and J. H. Glitsch, "Use Cases and Collaboration Scenarios: how employees use socially-enabled Enterprise Collaboration Systems (ECS)," *International Journal of Information Systems and Project Management*, vol. 4, no. 2, p. 20, 2016.

[34] V. Hausmann and S. P. Williams, "Issues for the long-term management of Social Business Documents," *International Journal of Information Systems and Project Management*., vol. 4, no. 3, p. 17, 2016.

[35] S. J. Zhao, K. Z. K. Zhang, C. Wagner, and H. Chen, "Investigating the determinants of contribution value in Wikipedia," *International Journal of Information Management*, vol. 33, no. 1, pp. 83–92, Fevereiro 2013.

[36] I. Lykourentzou, F. Dagka, K. Papadaki, G. Lepouras, and C. Vassilakis, "Wikis in enterprise settings: a survey," *Enterprise Information Systems*., vol. 6, no. 1, pp. 1–53, 2012.

[37] T. P. L. Grace, "Wikis as a knowledge management tool," *Journal of Knowledge Management*, vol. 13, no. 4, pp. 64–74, Jul. 2009.

[38] J. Payne, "Using wikis and blogs to improve collaboration and knowledge sharing," *Strategic HR Review*, vol. 7, no. 3, pp. 5–12, 2008.

[39] S. S. Shang, E. Y. Li, Y.-L. Wu, and O. C. Hou, "Understanding Web 2.0 service models: A knowledge-creating perspective," *Information & Management*, vol. 48, no. 4, pp. 178–184, 2011.

[40] Team, S. C. P., *CMMI for Development v1. 3*. Lulu. com, 2010

[41] R. E. Levitt, "Towards project management 2.0," *Engineering Project Organization Journal*, vol. 1, no. 3, pp. 197–210, 2011.

[42] A. Jani, "Escalation of commitment in troubled IT projects: Influence of project risk factors and self-efficacy on the perception of risk and the commitment to a failing project," *International Journal of Project Management*, vol. 29, no. 7, pp. 934–945, 2011.

[43] K. G. Corley and D. A. Gioia, "Building theory about theory building: what constitutes a theoretical contribution?," *Academy of management review*, vol. 36, no. 1, pp. 12–32, 2011.

[44] F. Ahlemann, F. E. Arbi, M. G. Kaiser, and A. Heck, "A process framework for theoretically grounded prescriptive research in the project management field," *International Journal of Project Management*, vol. 31, no. 1, pp. 43–56, 2013.

Appendix A. Focus group protocol

Aspect	#	Question
Barriers and difficulties in risk management	1	What difficulties have you dealt with as you manage risks in IT projects?
	2	Can you list, in topics, these difficulties?
	3	Do you apply risk management in all projects that you manage?
	4	For those who don't apply risk management to all projects, "What are the main characteristics of the projects that you apply risk management?"
	5	How is your relationship with sponsors and stakeholders in the risk management process?
Risk Management Processes	6	What are the main steps that you apply to manage risks?
	7	How do you identify risks?
	8	How do you evaluate risks?
	9	How do you communicate risks?
	10	How are risks monitored and updated?
	11	According to your experience, what is the project management role in risk management
	12	In your opinion, what could the state-of-art be for a project manager role managing risks?
Web 2.0 tools		*Explaining concepts of Web 2.0 tools*
	13	What are the Web 2.0 tools that you know?
	14	In your opinion, how can a web 2.0 tool help manage risks?
Framework		*Framework alpha version presentation*
	15	What is your opinion about the use of wiki pages to create this framework?
	16	What are the positive and negative aspects of this framework?
	17	What changes do you suggest for this framework?

Appendix B. Interview protocol

Aspect	#	Question
Respondent Profile	1	How old are you? How long have you been working as a project manager?
Risk Management Experience	2	What is the business sector of the organization you work for? Do you work as an employee of the organization, contractor or partner?
	3	Do you have experience in working with project management methodologies?
	4	Can you describe your experience in managing risks in projects?
	5	Have you implemented any risk management processes? If you have, how was this experience?
	6	In your opinion, is risk management important for project success? If so, why?
Collaboration in Risk Management	7	In your opinion, in risk management, what are the roles of project team members, project sponsors and stakeholders? How do you work with these different groups (team members, sponsors, stakeholders)?
Risk Management tools	8	In your work, how do you monitor the risks you identify during the project life-cycle?
	9	Do you report every risk you identify or do you omit some? Are there any types of risks you cannot inform to the ones involved in the project?
	10	In your opinion, how can a Web-based tool or application help project managers in their work in risk management?
	11	What are the most required functions for PM tools?
		Concepts of Web 2.0 technology
	12	What is your opinion about adopting a Web 2.0-based tool to manage IT project risks?
Framework	13	Do you have any experience in using wikis in professional settings? Or have you ever participated in implementations of Wikis in organizations?
		Presentation of the beta version of W4RM framework
	14	What is your opinion about the framework?
	15	What changes would you suggest?
	16	What practical advice would you give for a future implementation of W4RM framework in organizations?
Respondent Profile	1	How old are you? How long have you been working as a project manager?

Biographical notes

Rogerio Alves Soares
Rogerio Alves Soares is currently a Ph.D. student in Business Strategy Management at Nove de Julho University. He holds a Master's degree in Project Management from Nove de Julho University. His research interest are in project management practices and theories. His current research focus for the Ph.D. thesis aims to investigate stakeholder engagement theories, the use in projects and the direct relation with project performance.

Marcirio Silveira Chaves
Marcirio Silveira Chaves is an Associate Professor in the Business School at Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil where he leads the research group Managing Projects and Information Technology - MProTech. He holds a PhD in Informatics at University of Lisbon, Portugal. Dr. Chaves' areas of interest in teaching and research are Project Management, Information Systems, Social Media and Knowledge Management. He has supervised 15 Master students. His research accomplishments have been published in over 70 peer-reviewed papers with more than 1000 citations in reputed outlets and conferences. His current h-index is 16. He is a member of the editorial board of three journals: Iberoamerican Journal of Project Management, Journal of Information Technology Management, and Tourism & Management Studies. Dr. Chaves regularly serve as a reviewer in journals such as International Journal of Information Management, European Business Review and Knowledge Management Research & Practice. He has also experience as coordinator in national and international research projects funded by Brazilian and European official agencies.

Cristiane Drebes Pedron
Cristiane Drebes Pedron is a Professor of Information Systems and Innovation at the Nove de Julho University, in São Paulo, Brazil. Cristiane holds a PhD Degree from Instituto Superior de Economia e Gestão (ISEG) at the University of Lisbon, in Portugal. She is a Member of the Advance Research Center in Portugal. Her main areas of interest are customer relationship management, information system and innovation, and project management.


SciKA

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm


SciKA

International Journal of
Information Systems and Project Management

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

Available online at www.sciencesphere.org/ijispm