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Smart Project Management Information Systems (SPMIS) for Engineering Projects – Project Performance Monitoring & Reporting

John van Besouw
Taryn Bond-Barnard

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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 ninth volume of IJISPM. In this issue, readers will find important contributions on the paradoxical tensions of project management, junior project management professionals' skills, Project Management Information Systems, and violations and sanctions of the General Data Protection Regulation (GDPR).

The first article, "A framework for paradoxical tensions of project management," is authored by Juhani Iivari. According to the author, research into organizations has concluded that organizational effectiveness is paradoxical, i.e., effective organizations have attributes that are simultaneously contradictory, even mutually exclusive. Although projects are temporary organizations, the paradox lens has largely been omitted in their context. This paper is an attempt to rectify the situation. It introduces a framework of eleven paradoxical tensions concerning priority, structure, and execution of projects, wishing to encourage future research on paradoxical tensions of project management.

The title of the second article is "An analysis of violations and sanctions following the GDPR," which is authored by Wanda Presthus and Kaja Felix Sønslien. This article investigates the violations and sanctions that have occurred following the implementation of the GDPR. The GDPR came into effect in May 2018 with the aim of strengthening the information privacy of European Union/European Economic Area citizens. Based on existing taxonomies of (i) potential consequences of violating the GDPR (including surveillance, discrimination), (ii) an analysis of 277 sanctions, and (iii) interviews with experts, the authors offer a mapping of the violations and sanctions almost two years after the regulation was implemented. The most typical complaints were: unlawful processing and disclosure of personal information, failure to act on and secure subject rights and personal information, and insufficient cooperation with supervising authorities. The authors' analysis also indicates an increasing number of fines over time. Regarding size, the fines range from 90 euros to 50,000,000 euros. While research on GDPR violations and sanctions is somewhat scarce, this study confirms GDPR complexity. However, the study provides insight into some of the challenges. The contribution is mainly practical and aimed at managers in any organization whose goal is to protect information privacy and to learn from the mistakes made by other companies.

The third article, authored by William E. Hefley and Mário Bottion, is entitled "Skills of junior project management professionals and project success achieved by them." New graduates are often placed into project management roles but may face challenges. This study surveyed managers from Brazilian organizations and gathered information on the environment, practices, and results of new graduates in project management roles. In-depth interviews were executed with a set of managers to collect further insights into new graduates' performance in project management. This article examines the preparation and performance of new graduates in project management roles. It addresses specific project management skills and competencies that are involved in delivering successful projects and how these relate to project success or failure. It concludes that new graduates are often not fully prepared for project management roles and fail to conduct comprehensive project preparations, often missing risk management; their soft skills are not fully developed, creating further challenges; and the corporate environment towards project management may not lead to developing well-prepared project managers.

"Smart Project Management Information Systems (SPMIS) for Engineering Projects – Project Performance Monitoring & Reporting" is the fourth article and is authored by John van Besouw and Taryn Bond-Barnard. Engineering projects are becoming increasingly complex as projects get larger and as technology improves. Greater competition worldwide

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has meant that projects are delivered quicker and cheaper. This requires sophisticated Project Management Information System (PMIS) technologies to be adopted to improve efficiency and quality on projects. PMIS data and reports can be used to understand better the risk exposure, resource utilization, profitability, and scheduling of a project. It also informs strategic project decisions and performance monitoring and reporting. Unfortunately, project data is often fragmented and embedded in different systems. This article investigates several commercially available PMIS to compare the functionality of these systems. A qualitative study using semi-structured interviews was conducted with purposively selected project systems experts at twelve project-based organizations. Thematic analysis revealed what functions PMIS fulfills, how these systems are integrated, and how they facilitate project monitoring and reporting. Moreover, a novel model for the basic architecture of a "Smart" Project Management Information System (SPMIS) is proposed.

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.

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A framework for paradoxical tensions of project management

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A framework for paradoxical tensions of project management

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Viewpoint

Abstract:
Research into organizations has concluded that organizational effectiveness is paradoxical, i.e., effective organizations have attributes that are simultaneously contradictory, even mutually exclusive. Although projects are temporary organizations, the paradox lens has largely been omitted in their context. This paper is an attempt to rectify the situation. It introduces a framework of eleven paradoxical tensions, concerning priority, structure, and execution of projects, wishing that it would encourage future research on paradoxical tensions of project management.

Keywords:
project management; paradox lens; ambidexterity.

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1. Introduction

The paradox lens has aroused considerable interest in organization studies [1]-[6]. Cameron [1] argues that organizational effectiveness is inherently paradoxical: "To be effective, an organization must possess attributes that are simultaneously contradictory, even mutually exclusive" (p. 544-545). Recognizing that projects are temporary organizations [7], [8], one could expect that the paradox lens would be of interest in their context, too.

Despite its potential relevance to project management (PM), the paradox lens has received very little attention in PM research. A literature analysis of paradoxical tensions in PM research (Section 2.3) indicates that the paradox lens has received scant attention therein and has primarily been applied as a research instrument – as theory or meta-theory – for analyzing and making sense of project management: each paper proposes a set of tensions unique to the study.

The purpose of this paper is to provide a framework of more typical paradoxical tensions in the context of (individual) projects. The focus lies in sets (n > 1) of co-existing paradoxical tensions rather than in a single tension. The proposed framework originates from the information systems (IS) development and the agile software development (ASD) context - as explained in the accompanying paper [9]. Therefore, the framework is most relevant in the case of design-oriented projects. The term "design-oriented" suggests that interest does not only lie in pure design projects such as media projects [10] or architectural design projects (e.g., [11], [12]), but covers projects in which design – both as the verb and noun – is an essential or core activity and output. Design as an output is abstract and typically is expected to exhibit some innovativeness.

This paper aims at answering the following research question: *What are typical and persistent paradoxical tensions encountered, especially in design-oriented projects?* The idea is that tensions are concrete enough so that project managers can recognize them and persistent so that they are faced constantly [2]. The proposed tensions individually are not necessarily new. Some of them - if not most - have individually been identified in the PM literature. The contribution of this paper lies in the framework and in the whole set of paradoxical tensions.

This paper makes both theoretical and practical contributions. The concrete paradoxical tensions provide new insight into the complexity and difficulty of project management. Even though not claimed to be exhaustive, they also provide avenues for future research.

More generally, the paper is in line with recent proposals to redirect research on project management [13]-[15]. The paradox lens as a theoretical framework illustrates the complexity and ambiguity of project management; the concrete paradoxical tensions of the structure reflect the social nature of projects (in terms of power, communication, rewarding, and participants); the tensions imply a broader conceptualization of projects (multi-disciplinarity, with multiple purposes, contestable, negotiable throughout), and the resolution of the tensions trusts on reflection rather than following the detailed procedures prescribed by PM methods and tools. Compared with [13], the only clear exception is the focus of on "product creation" rather than on "value creation". It will be justified in Section 3.

The next section introduces the "paradox lens" as the theoretical background of this paper and the framework of eleven paradoxical tensions. The following three sections explain the tensions in detail and justify their relevance in the PM context. Section 6 discusses research implications and practical implications of the framework and limitations of the paper. It outlines how future PM research could and should be conducted when focusing on typical paradoxical tensions of project management.

2. Theoretical background and prior research

Drawing on the literature on organizational paradoxes [1]-[3], Section 2.1 introduces the concept of "paradox", "paradoxical tension", and related concepts. After this introduction, Section 2.3 outlines the framework of eleven paradoxical tensions and Section 2.3. summarizes prior research on paradoxical tensions of project management.

2.1 Paradoxical tensions

Modern organizations face increasing complexity due to the higher volatility, uncertainty, and ambiguity of their business environment, pulling organizations in multiple, competing directions [16]. This has stimulated scholars to view them through the paradox lens to understand such competing tensions [2]. Cameron [1] interprets a paradox as "an idea involving two opposing thoughts or propositions which, however contradictory, are equally necessary to convey a more imposing, illuminating, life-related or provocative insight into truth than either factor can muster in its own right".

Paradoxes are closely related to terms such as dilemmas, dualities, dialectics, contradictions, tensions, and ambidexterity. Cameron [1] notes that the idea of 'paradox' differs in nature from that of 'dilemma', which is often used as a synonym. Smith and Lewis [2] distinguish paradoxes, dilemmas, and dialectics. They suggest that a "paradox" denotes "Contradictory yet interrelated elements (dualities) that exist simultaneously and persist over time; such elements seem logical when considered in isolation, but irrational, inconsistent, and absurd when juxtaposed" (p. 387). A "dilemma" on the other hand comprises "competing choices, each with advantages and disadvantages", and "dialectics" refers to "contradictory elements (thesis and antithesis) resolved through integration (synthesis), which, over time, will confront new opposition".

The ambidexterity perspective [17]-[19] is closely related to the paradox perspective. The literature on ambidexterity, however, typically focuses on a single tension between exploitation and exploration [20] or alternatively alignment and adaptability, "ambidexterity" referring to the ability to both exploit and explore.

This paper does not consider terminological choices essential here. However, since the literature on the paradox perspective applies quite a stringent interpretation of "paradox", I prefer to speak about "paradoxical tensions" rather than "paradoxes". The tensions to be introduced in this paper are not necessarily counter-intuitive, absurd, and intrinsically unreasonable enough to be considered genuine "paradox". Contrary to Fairhurst et al. [3], this paper also includes tradeoffs among paradoxical tension. However, the paradox lens implies that dilemmas and tradeoffs are not treated as either-or-choices, but the competing demands of the tension must be addressed simultaneously (both-and) [2].

2.2 The conceptual framework for paradoxical tensions of systems development

A literature analysis to be introduced in Section 2.3 indicated that PM research had paid scant attention to paradoxical tensions of project management. I was able to identify only fourteen relevant papers, each of them proposing its own set of tensions. The aim of this paper is to introduce a framework of more general and typical paradoxical tensions originating from the IS development context [9].

Due to its origin, the framework is most relevant in the case of design-oriented projects, in which design (as a verb) is an essential part of the process and outcome (design as a noun). Design projects in many respects resemble "soft projects" [21]. The design output is abstract by nature, the goals are often ambiguous, there are many alternatives to be considered, the development of alternatives typically requires close participation of a number of stakeholders with different interests and expertise, there is a constant negotiation between stakeholders, and the quality of alternatives is to a large extent a subjective issue. As a consequence, design-oriented projects are characterized by intellectual complexity, ambiguity, equivocality, and learning.

One can distinguish three groups of paradoxical tensions in the project context: those concerning project goals and performance (priority tensions), those concerning project organization or structure (structural tensions), and those concerning the project execution process (execution tensions). Figure 1 depicts the framework.

Priority tensions deal with the importance and attention imposed on alternative or complementary goals of the project. Those identified in Figure 1 form an extension of the traditional project goals or performance dimensions (cost, time, quality) [22], [23]. These extensions will be explained in detail in Section 3.4. The first and third priority tensions are from Hage [24], who suggests them as fundamental problems of organizational effectiveness. The tension between development time and development effort is well-known in software engineering (SE) [25].

The four structural tensions reflect the classical structural characteristics of organizations: centralization of power, formalization of work, stratification of rewards, and organizational complexity [24], respectively. These concepts are introduced at the beginning of Section 4.

The four tensions of execution are inspired by Boehm and Turner's [26] contrast between disciplined and agility in the SE context.

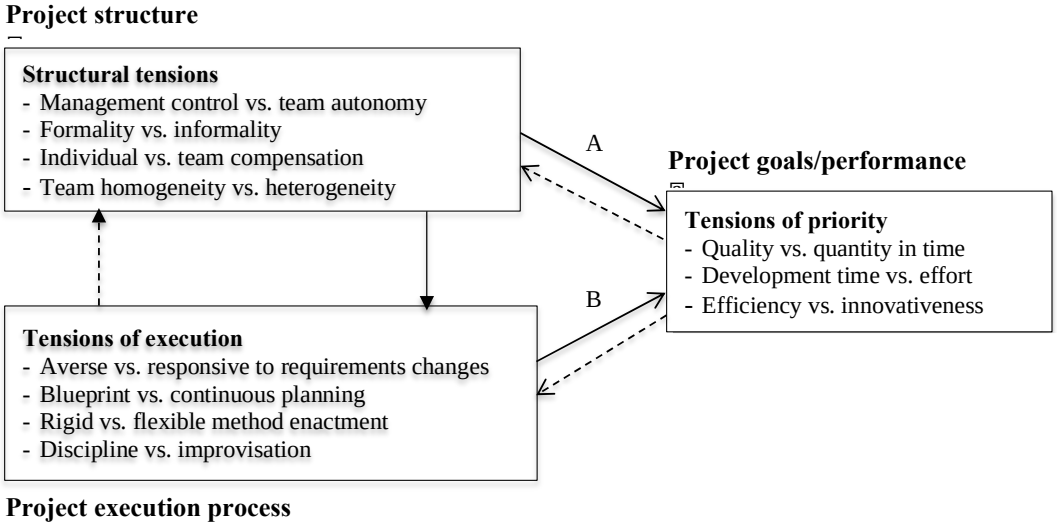

Fig. 1. The conceptual framework of paradoxical tensions in ASD (adapted from [9])

Figure 1 suggests that the project goals/performance, structure, and execution form a mutually interacting system. The solid arrows depict the "real process" of how the project structure affects the execution process, and both of them affect the project performance. The dotted arrows describe the reverse "feedforward and feedback processes" of how the project goals – and later project performance and related discrepancies - guide the project structure and the project execution. In a similar way, the experience from the execution process may lead to deliberate structural changes.

Each of the eleven tensions will be individually argued and explained in detail in Sections 3-5. Arrows A and B will be discussed in Section 6.

2.3 Prior research on paradoxical tensions in project management – literature analyses

The topic of this paper is related to a massive body of literature. I conducted three separate literature analyses of prior research on paradoxical tensions in project management:

1. Analysis of to what extent the paradox lens has been implicitly or explicitly applied in the PM literature.
2. Analysis of to what extent each of the eleven paradoxical tension of Figure 1 has been addressed in the PM literature.
3. Analysis of to what extent the PM literature has empirically investigated the impact of tensions of structure and tensions of execution on project performance (arrows A and B in Figure 1).

The first and third analyses were "semi-systematic" processes with the objective to gain a reasonably convincing understanding of PM research in question. The focus of the first analysis was in sets (n >1) of tensions as indicators of implicit or explicit application of the paradox lens, whereas the third analysis focused on individual paradoxical tensions.

To find out to what extent the paradox lens has been applied in the PM literature, I conducted Google Scholar searches in September 2020. The aim was to conduct a comprehensive search so that it covers various scientific conferences, too. Therefore, I preferred Google Scholar to Scopus and Web of Science. Referring to the terminological confusion discussed above, I used the search formula "paradoxes/tensions/dilemmas/ contradictions/ ambidexterity in/of project". Since I was interested in the application of the paradox lens (or similar) rather than in individual "paradoxes/tensions/dilemmas/contradictions, I used the plural of the keywords. The analysis process and its results are described in Appendix A.

The first analysis indicates that PM research in question has been very limited and fragmented. I was able to identify only fourteen relevant papers, each of them proposing its unique set of paradoxical tensions.

To find out to what extent the PM literature has empirically investigated the impact of tensions of structure and tensions of execution on project performance, I decided to limit the search to mainstream PM research as represented by *International Journal of Project Management* and *Project Management Journal*. Furthermore, because of the "causality" implied in the question, I focused on explanatory/predictive quantitative studies rather than on qualitative ones. I did a number of searches using the opposite ends of each tension with their "indicators" as keywords, including alternative project performance dimensions in search terms. In order to identify explanatory/predictive quantitative studies, I used typical statistical concepts as additional search terms. The analysis process and its results are described in Appendix B.

The results of this third analysis identified thirteen relevant papers. From the viewpoint of research into paradoxical tensions, all of them had limitations. Ten of the thirteen papers included only one dimension of project performance as the dependent variable, eliminating in that way the chance to investigate possible paradoxical demands imposed by different project priorities. Furthermore, only three of the thirteen papers included as independent variables constructs that can be interpreted as opposite ends of paradoxical tension. None of the papers included the opposite ends of a paradoxical tension as separate constructs and, at the same time, comprising more than one dimension of project performance.

The second literature analysis just attempted to identify prior research relevant to each tension and to refer to it according to the normal academic practice. This analysis mainly focused on the mainstream PM literature but was not strictly confined to it. It also attempted to make use of existing systematic literature reviews as much as possible.

3. Paradoxical tensions of priority

This and the following two sections introduce the eleven paradoxical tensions in more detail and attempt to argue for their relevance in the PM context by identifying justificatory arguments in the PM literature.

3.1 Introduction

There is a massive body of literature on the success criteria of projects [27], [28]. Project success is traditionally evaluated in terms of the "iron or golden triangle": time (schedule), cost (budget), and quality [22], [23] with trade-offs between them [29]-[31]. Atkinson [22] proposes that the golden triangle should be extended to capture organizational benefits and benefits to the stakeholders. Winter et al. [13] echo his view, proposing a change from product creation to value creation as a primary focus of project management thinking. At the same time, they point out that the value creation often takes place a long time after the project, as a temporary organization, is closed.

To clarify the issue, it has been suggested that one should distinguish "project management success" and "project success" [32], [33] or "project efficiency" and "project success" [34]. Adapting these suggestions, this paper distinguishes "project performance" and "project success". Terminologically, "project performance" is preferred in this paper, since "project management success" gives an impression that the success in question is just a management issue and because "efficiency" in this paper is used in a more specific meaning than in [34]. "Project performance" assesses how well the project was carried out using criteria that can be evaluated during the project execution or shortly after it. "Project success", on the contrary, refers to the totality of positive and negative effects (benefits and side effects) of

project outcome, which often accrues over time after the project closing and can just be predicted and *a priori* evaluated during the project execution.

The focus of the tensions of priority lies in "project performance" rather than in "project success". In the view of Zwikael et al. [35]-[37], it is the project governance (the project owner) rather than project management who is accountable for "benefits realization" or project effectiveness more broadly (including also negative side effects). When considering the tensions of priority, one should note, however, that project governance and project management are highly interdependent. When the project objectives, including project scope, are renegotiable throughout the project [13], there is an obvious need for interaction between the project owner, project manager, and other stakeholders to agree on objectives and expected benefits.

3.2 The tension between quality and quantity in time (speed)

Quantity refers to the amount of project output (artifact) completed. Quality refers to the degree to which extent the project output satisfies customers' needs. As a consequence, one can distinguish two aspects of the quality of product output: quality of customer requirements and quality of (technical) implementation.

The tension between quantity and quality is age-old. Referring to Woodworth (Woodworth, R.S., The accuracy of voluntary movement, *Psychological Review*, 3, 1899), Beersma et al. [38]) write that "complex tasks require some degree of both speed [≈ quantity in time] and accuracy [≈ quality], but there are trade-offs that make meeting both of these task requirements at the same time difficult" (p. 574), and these trade-offs are ubiquitous. Hage [24] sees the dilemma between quality and quantity per unit of time (i.e., average speed, shortly "speed") as one of the fundamental problems of organizational effectiveness. This tension is prevalent, especially in labor-intensive work such as the first-line service work [39] and scholarly research [40].

Although speed and quality are frequently mentioned as project performance dimensions in the PM literature, it is difficult to find papers that see any tension between them. The IS and SE literature provides some examples, however. It has become an issue in the context of ASD projects when the central priority has been to increase the speed [41], [42] and in particular in the case of startup companies [43], [44]. Note also that the tradeoff between quantity of time (speed) and quality does not contradict with findings that ASD has improved both the speed of software development and the quality of the developed software when compared with the traditional waterfall model [9].

3.3 The tension between development time and development effort

In the context of traditional software development, it is generally accepted that, while the technology of software development is given, compressing the development time beyond some point will increase the development effort required [25]. Brooks' [45] paradoxical law "Adding manpower to a late software project makes it later" (p. 25), on the other hand, implies that beyond some point, additional effort - if it requires additional people - cannot substitute the time but increases the development time required. However, the ASD community does not see the tension between development time and development cost problematic. The reason may be that the software development in ASD progresses in terms of time-boxed sprints rather than phases. Despite that, the choice of sprint length is not necessarily trivial [46]. Furthermore, if an ASD project is governed by the completion date and budget planned at the beginning of a project (as in [47], for example), it obviously encounters similar problems as traditional software projects: risks of schedule and budget overruns.

The PM literature implicitly or explicitly recognizes that there is a trade-off relationship between development time and development effort [48]-[50]. Shr and Chen [48] point out in the context of construction projects that shortening the time increases the construction cost due to multiple shifts and overtime work. Oyedele [50] recognize working long hours and excessive workload due to tight deadlines as constituents of project-induced stress and as a demotivator in design projects.

3.4 The tension between efficiency and innovativeness

Design-oriented projects are usually expected to exhibit some innovativeness, leading to the tension between efficiency and innovativeness. It is close to the tension between efficiency and flexibility extensively discussed in organization theory [51], the need for flexibility often being justified by the need to innovate. Also, the ambidexterity between exploration and exploitation reflects the tension between efficiency and innovativeness/flexibility [20].

As a consequence, there is a huge body of related literature in the case of traditional "permanent" organizations, but not so much in the case of temporary organizations such as projects [52]-[54]. Yet, the tension between efficiency and innovativeness/flexibility is recognized in the PM literature (e.g., [19], [52], [55]-[60]).

Much of the latter research draws on the ambidexterity perspective. There is, however, a fundamental difference between the tension between exploitation and exploration in the ambidexterity literature and the paradoxical tension between efficiency and innovativeness in this paper. Ambidexterity is an organizational capability or competency that affects the performance of an organization after a considerable time-lag [54]. Efficiency and innovativeness in this paper, on the contrary, are introduced as two project performance dimensions. Taking a short time frame, any resource slack – whether financial, time available, or excess personnel – is bad from the viewpoint of efficiency both in the case of permanent and temporary organizations. But this efficiency gain is achieved at the cost of innovativeness since slack resources tend to foster innovation both at the organization level and project level [61].

3.5 Summary

Figure 2 summarizes the above discussion as a "golden triangle" of paradoxical tensions of project performance. It extends the original triangle to comprise quantity, efficiency, and innovativeness and related three tensions. For completeness, it includes risk [42] and satisfaction [62] as additional criteria, the related arrows underlining that performance along the six dimensions affects the satisfaction with the project performance and that delay risk, cost overrun risk, quality risk [63] as well risks of low novelty and inefficient execution [64] affect project performance risk.

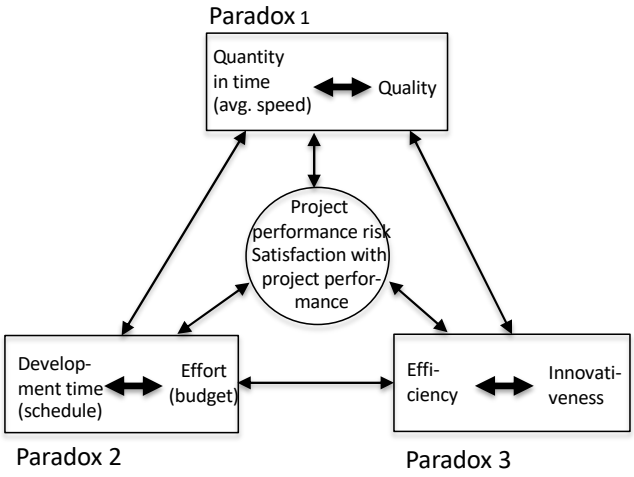

Fig. 2. The "golden triangle" of paradoxical tensions of project performance [9]

4. Paradoxical tensions of structure

4.1 Introduction

Organization studies have identified a number of dimensions to characterize organization structure. Hage [24] focuses on four of them: centralization of power, formalization of work, stratification of rewards, and organizational complexity. *Centralization* is the degree to which power and control are concentrated to relatively few, i.e., how decisions, especially strategic ones, are made only by the elite and how many by the entire personnel; *formalization* refers to the degree to what extent the work is codified into rules, procedures and regulations; *stratification* describes the concentration of rewards and other benefits of groups relative to other groups [24], [65]; and *organizational complexity* refers to the concentration and diversity of different specialists in an organization (determined by specialization, differentiation, and professionalism) [66]).

Reflecting these four structural dimensions, this paper identifies four paradoxical tensions: management control vs. team autonomy, formality vs. informality, individual vs. team-based rewarding, and homogeneity vs. heterogeneity of participants. Differing from the above four structural characteristics (centralization etc.), the tensions are not assumed to continuous dimensions, but opposite ends of each tension entail qualitatively different structural mechanisms to structure the project.

The opposite ends also tend to support different dimensions of project performance (especially efficiency contra innovativeness), accentuating their paradoxical nature. The literature in organization studies (e.g., [24], [67]) and on innovation diffusion [65] largely agrees that low centralization of power (team autonomy), low formalization of organizational work, and high organizational complexity (heterogeneity of members) support organizational innovativeness. Hage [24] also claims that low stratification of rewards (e.g., team-based rewarding) fosters innovation. At the same time, it is believed that more structure (such as higher centralization, formalization, and specialization) promotes efficiency not only under stable environmental conditions [68] but also under changing conditions [69].

4.2 Management control vs. team autonomy

The tension between management control and team autonomy has been extensively discussed at the team level. Magpili and Pazos [70] - in their literature review of factors that affect team performance and successful implementation of self-managing teams - identify as a major challenge how to balance team's autonomy while providing some basic guidance and structure, implying that both are needed. A self-managing team "is a group of individuals with diverse skills and knowledge with the collective autonomy and responsibility to plan, manage, and execute tasks interdependently to attain a common goal" (p. 4). Since Magpili and Pazos do not distinguish different dimensions of team performance, one cannot draw direct conclusions about the influence of the tension between management control and team autonomy on the priority tensions. However, they assess that self-managing teams work best when they execute tasks with high uncertainty, high interdependence, low routineness, high task and technological novelty, and high innovativeness. This is highly compatible with the characteristics of many design-oriented projects and underlines the significance of relative autonomy of self-managing teams for innovativeness.

Even though not explicitly recognizing the tension between managerial control and team autonomy, among *control modes* (e.g., [71]), output control, input control, and behavior control reflect "bureaucratic" managerial control [72], clan control emphasizes team autonomy and self-control reflecting individual autonomy [73]. Furthermore, control styles such as enabling control [71], empowerment [74], and shared leadership [75] increase autonomy within the project team.

Wiener et al. [71] reviewed 57 papers addressing IS project. According to their review of the effects of control modes on project performance, there is wide agreement that all the above control modes have significant positive effects on project performance in the case of internal IS projects, whereas, in the case of outsourced projects, the results are mixed. Studies are also inconclusive as to whether the control modes complement, substitute, or simultaneously do both. At the same time, they note that project performance is usually examined at an aggregate level or as a single performance

dimension and acknowledge that some studies provide initial evidence for partly inverse control effects on project efficiency, quality, and adaptiveness (p. 754).

There is also a considerable number of papers published in PM journals, which analyses control and leadership in projects ([75] for a review). The tension between managerial control and team autonomy has also been recognized therein [76]-[79], the general perception being that team autonomy is needed in projects which prioritize innovation since hierarchical control tends to stifle creativity. Appendix B summarizes empirical findings of explanatory/predictive quantitative PM research related to the relationship between managerial control/team autonomy and project performance.

4.3 Formality vs. informality

As noted above, formality – as the degree to what extent the work is codified into rules, procedures, and regulations – is widely used to characterize organizations. Automation of work – either automation of entire jobs or specific tasks – implies extreme formalization so that a job or task can be executed by computers. Standardization and formalization are also closely related [66] since standards normally must be documented into rules and regulations.

The tension between formality and informality is closely related to the tension between management control and team autonomy as exemplified by the common distinction between formal control and informal control, formal control covering output control, input control and behavior control, and informal control clan control and self-control (e.g., [71]). The focus of the latter tension is, however, in the distribution of power, whereas formality vs. informality describes the degree of formalization.

Formalization does not concern only control but also communication [80], is related, for example, with team spirit and trust [81], knowledge sharing [82], problem-solving [83], and project documentation [84]. Projects typically comprise a mixture of formal and informal communication, depending on the nature of the project (e.g., [85], [86]). Appendix B summarizes empirical findings of explanatory/predictive quantitative PM research related to the relationship between formality/informality and project performance.

4.4 Individual vs. team-based rewarding

This paper views the tension between individual and team-based rewarding at the level of team members in projects rather than at the level of project partners. Motivating team members is an important issue in all work-related teams, and rewards have a significant role in it [87]. Most of the papers on the topic view individual rewards and shared (team-based) rewards as either-or choices. Since both of them have shortcomings, Pearsall et al. [87] propose hybrid rewards, which are based on both individual performance and team performance. In their view, hybrid rewards are beneficial in the case of teams with high task interdependence, where both individual effort and high levels of collective interaction are required. Design work in design-oriented projects is typically highly interdependent.

Pearsall [87] also hypothesizes that teams with hybrid rewards outperform teams with individual rewards due to increased information allocation (meaning that team members can develop deep, discrete areas of expertise and gain access to each other's knowledge when needed) and that teams with hybrid rewards outperform teams with shared rewards due to reduced social loafing (or free-riding).

Although alternative reward mechanisms of team members are recognized in the PM literature [88]-[95], the said literature has paid relatively little attention to the tension between individual and team-based rewarding [96]. Appendix B summarizes empirical findings of explanatory/predictive quantitative PM research related to the relationship between individual/team-based rewarding and project performance.

4.5 Homogeneity vs. heterogeneity of participants

Homogeneity and heterogeneity are the opposite ends of the diversity dimension that has been widely investigated in the context of teams [97], [98]. This paper focuses on the task-related diversity rather than on the bio-demographic one since the former has been found to be a more significant predictor of team performance than the latter one [97].

Horwitz and Horwitz [97] found that task-related diversity has a significant positive relationship with the quality and quantity of team output. Focusing on team innovation in their meta-analysis, Hülsheger et al. [98] found support for the positive relationship between job-relevant (task-related) diversity and innovation. They also raise the question, if job-relevant diversity is a predictor of innovation, is the relationship linear or curvilinear? Li et al. [99] partially answer this question. They found that the curvilinear relationship between functional background (job-relevant) diversity and team ambidexterity.

Team diversity has also received some attention in the PM literature [93], [100]-[103] (see Appendix B).

4.6 Summary

Just as the three tensions of priority, the four structural tensions are also internally interrelated (see Figure 3). Walton's [104] meta-analysis provides empirical evidence that the three constituents of organizational complexity (task specialization, vertical differentiation, horizontal differentiation), (de)centralization, standardization, and formalization are highly correlated. Ramesh et al. [53] imply that formalization may intervene in almost all four aspects of the structure.

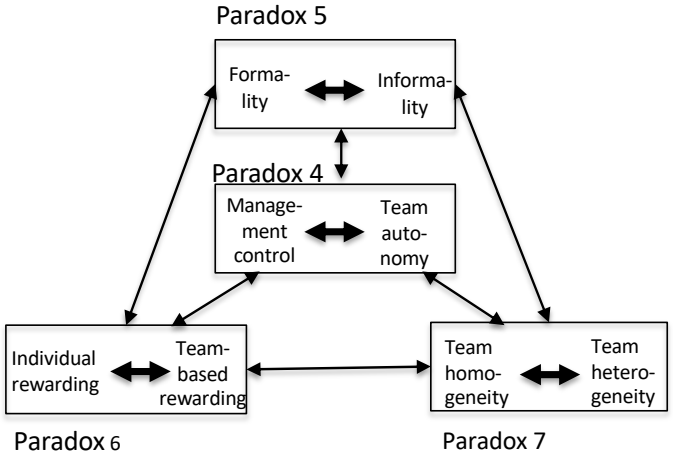

Fig. 3. Paradoxical tensions of structure [9]

5. Paradoxical tensions of execution

Ideas of agile software development (ASD) has received some attention in the PM literature [105]-[111], the ideas being generalized to project management in general under the label "agile project management" (APM) [105].

Boehm and Turner [112] make distinctions between disciplined and agile on the one hand and plan-driven and agile on the other hand to contrast ASD with more traditional systems development approaches. These widely cited distinctions comprise at least four dimensions: 1) Averse vs. responsive towards requirements change; 2) Blueprint planning vs. continuous planning; 3) Rigid vs. flexible method enactment; 4) Discipline vs. improvisation.

5.1 Averse vs. responsive towards requirements change

Requirements refer to the agreed-upon functionality to be provided by the project output (functional requirements) and related quality of the delivered functionality (non-functional requirements). According to Conboy [113], readiness to changes is a key characteristic of agility. Conforto et al. [108] suggest that agility "is the project team's ability to quickly change the project plan as a response to customer or stakeholders needs, market or technology demands in order to achieve better project and product performance in an innovative and dynamic project environment" (p. 667).

Such changes may concern the project scope, functional requirements, and non-functional quality requirements. They may narrow the scope and lower the requirements or widen the scope and raise additional or higher requirements. In the ASD context, the pressure to keep the deadlines may lead to narrowing the scope and making quality concessions [114], [115]. The iterative and incremental nature of ASD, on the other hand, may lead to scope or feature creep [116] due to the marginal analysis when the "value increase" of an additional feature seems to exceed its development cost.

Requirements prioritization in ASD is the gate that determines the extent to which the proposed requirements and related changes are responded to. It is not an objective process. Ramesh et al. [117] note that it may also be prone to conflicts in the case of several customers, and Heikkilä et al. [118] write that "gut-feeling, lobbying, politics, sell-in and strong individuals affect the requirements prioritization in practice" (p. 117). Rolland [119] describes some of his experiences of requirement engineering in large ASD projects caused by the sheer number of user stories (close to 2500 in one project). Some requirements may also be prioritized so low that they effectively are rejected. So, in real life, ASD/APM teams may be more or less ready and/or able to respond quickly to requirements changes.

5.2 Blueprint vs. continuous planning

The distinction between plan-driven and agile [112] gives a distorted view of the agile approach as if it were not driven by plans at all. Actually, it is also plan-driven but based on a "philosophy" of planning different from the waterfall model.

The tension between blueprint planning and continuous planning is adapted from Faludi [120]. He makes a distinction between the blueprint mode of planning, "the production of glossy plans and the unswerving execution of proposals they entail", and the process mode of planning "whereby programs are adapted during their implementation as and when incoming information requires such changes" (pp. 131-132). The blueprint planning in the agile context is usually called "upfront planning" or "front-end planning".

It is clear that the agile approach primarily follows the process mode of planning (called "continuous planning" in the following), but it is unclear to what extent it is or should be governed by blueprint planning. Serrador and Pinto [107] claim that the agile approach does not totally abandon upfront planning, although it attempts to minimize it. If an agile project is to be governed by an overall project budget and schedule, front-end planning is obviously needed to produce the required budget and schedule. Front-end planning is also recommended for designing the software architecture [121]. Since normally non-functional requirements such as security, maintainability, and usability concern the whole system and cannot be localized into any individual user story or its implementation, the agile team(s) should also have design standards and principles that guide the teams to take these qualities into account in a consistent way. This requires some upfront planning. Related to usability, the book of Cockton et al. [122] includes several articles that argue for front-end planning to make ASD more user-centered.

5.3 Rigid vs. flexible method enactment

It has been recognized in the PM literature that "one size does not fit all" in the case of PM methods [110], [123], [124]. As a consequence, PM methods are specialized for different application areas, or general methods are tailored to "fit" the type of project, its application area, characteristics of permanent organizations involved and their contexts, and other project characteristics such as its size and task interdependence [125], [126].

It is less widely recognized that the selected method for a project may be adapted during the project execution. When explaining the Agile Manifesto, Fowler and Highshmisth [127] emphasize that agile methods are not assumed to be followed slavishly. Howell et al. [124] and Lippe and vom Brocke [128] point out that the situational contingency factors may change during the project execution, and therefore there may be a good reason to change or adjust the selected project structure PM approach in use. The tension between rigid vs. flexible describes whether the selected PM method in use is adapted or not.

5.4 Discipline vs. improvisation

Boehm and Turner [26] state at the beginning of their book, "Discipline is the foundation for any successful endeavor" (p. 1). Later they introduce agility as a counterpart of discipline and contend that every successful endeavor in our changing world requires discipline and agility. I agree with them but prefer to consider improvisation rather than agility as a counterpart of discipline.

There has been some interest in improvisation in the PM literature [129]-[131]. Leybourne and Sadler-Smith [129] see improvisation as a combination of intuition, creativity, and bricolage. In the case of bricolage, the use of resources available when improvising mainly draws on tacit knowledge and experience [129], [131]. Therefore, it is difficult to be sure that improvisation is creative and novel in any sense. As a consequence, instead of "novelty" I see "spontaneity" as the key in improvisation.

In line with [26], the point is that all successful projects need both discipline and spontaneous improvisation. Whether traditional PM or agile methods, management control and formality, planning (both blueprint and continuous) as well as PM methods, including techniques, "practices" and tools, make the process more disciplined. On the other hand, no PM method is detailed enough to completely determine the project execution and/or to take all emerging situations into account. Therefore, there is by necessity some space and also a need for improvisation.

5.5 Summary

Figure 4 illustrates the four paradoxical tensions of project execution, emphasizing that they are interrelated and form a totality. It includes the tension between discipline vs. improvisation in the center, emphasizing that the way the other three tensions are addressed affects to what extent the execution is disciplined and to what extent in an improvised (spontaneous) way.

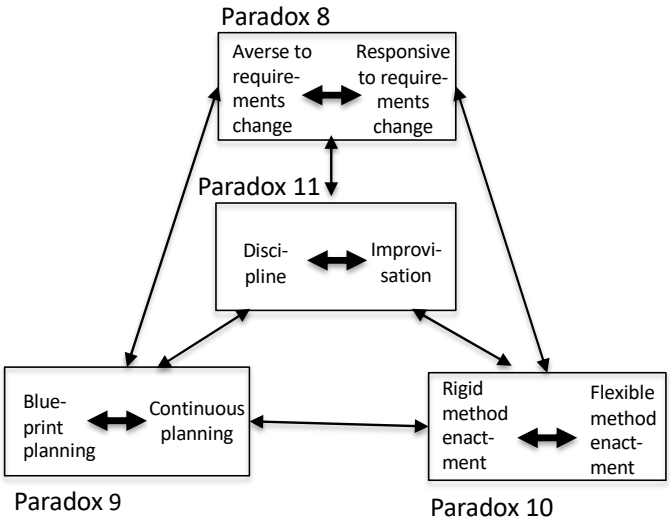

Fig. 4. Paradoxical tensions of execution (adapted from [9])

6. Discussion and final comments

As implied by Figure 1, the paradoxical tensions of priority, structure, and execution are interrelated. Figure 5 illustrates the resultant structure, including project success (value, effectiveness) for completeness.

This section discusses the significance of the framework for PM research and practice.

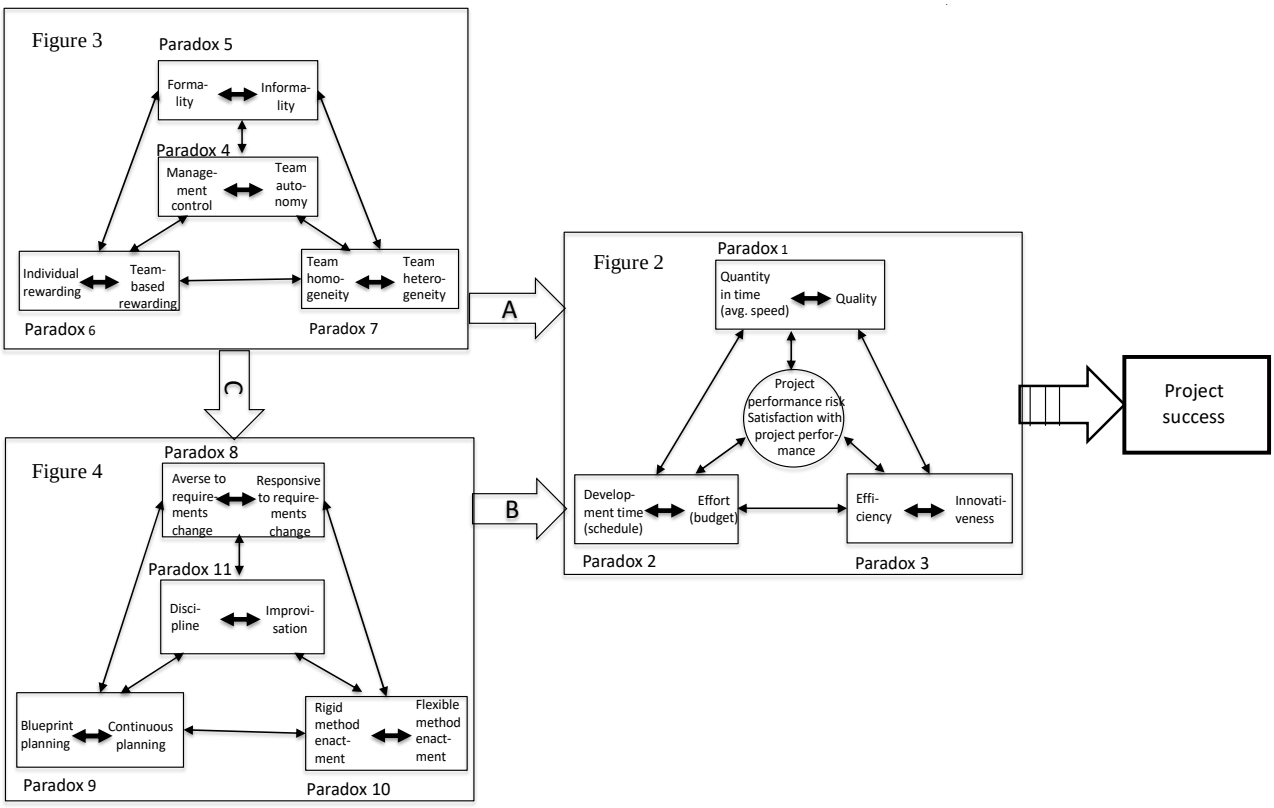

Fig. 5. Summary of the framework

6.1 Research implications

Empirical research informed by the paradox lens has mainly been qualitative, as evidenced by the introduction to the special issue of Organization Studies on paradoxes, tensions, and dualities of innovation and change [4]. Following this path, future qualitative PM research could attempt to validate the existence of the paradoxical tensions in projects, being open to additional ones. Researchers could focus on whether they are able to identify such tensions and whether practitioners participating in the investigated projects are able to recognize them, too.

As for explanatory/predictive quantitative PM research, future PM research could investigate whether the opposite ends of each tension tend to support different dimensions of performance (arrows A and B in Figure 5). To do it systematically explanatory/predictive PM research should:

1) include the opposite ends of each tension as separate constructs and
2) include a representative set of dimensions of project performance.

In order to find out the current status PM research related to arrows A and B, I conducted a literature review reported in detail in Appendix B. It identifies thirteen PM papers that are related to the arrows A and B.

None of the thirteen papers explicitly addresses any of the paradoxical tensions. Most of them (10) includes a single dependent variable (aggregated or one-dimensional construct of project performance). One of the papers, [129], has two project performance dimensions, and two studies, [93] and [103], include three dimensions.

Liu and Cross [93] distinguish team effectiveness (“as “the extent to which the project outputs achieved the performance expectations of key project stakeholders”), team efficiency (“the ability of the project team to meet its

budget and schedule goals (…) and utilize resources within constraints") and innovation "the creative accomplishment of teams in generating new ideas, methods, approaches, inventions, or applications" (p. 1152). From the viewpoint of this paper, their most interesting finding is that team's functional diversity had a significant negative effect on team efficiency but no significant effects on team effectiveness and innovation. The non-significant impact on innovation is quite surprising when compared with the dominant view (see section 4.4) and is against the hypothesis suggested by the authors.

Recker et al. [103] also include three dimensions of project performance – software functionality, process performance, and customer satisfaction – although their main analysis aggregates them into a single construct (IS development success). Their Appendix B reports, however, results when the three dimensions are kept separate. Recker et al. investigate how three ASD practices affect two aspects of responsiveness to requirements changes - "software team response extensiveness" (the extent to the software team actually incorporated various requirement changes) and "software team response efficiency" (i.e., the additional effort required by the software team to incorporate the requirements changes) and further on IS development project performance. They found that "software team response extensiveness" had significant positive effects on software functionality and on customer satisfaction but a negative effect on process performance. "Software team response efficiency", on the other hand, had significant positive effects on each of the three dimensions of project performance. Interestingly but understandably, these results imply that being aversive to requirements changes is positive from the viewpoint of process performance and being responsive is beneficial from the viewpoint of software functionality and client satisfaction.

The interest of Leybourne and Sadler-Smith [129] lies in the role of intuition and improvisation in project management. They separate two dimensions of project performance: internal (schedule, cost, scope) and external (related to the customer). They did not find improvisation to affect significantly either dimension of project performance but did find faith in intuition to be positively related to the external project performance.

With a few exceptions, the papers do not distinguish the opposite ends of tensions as separate constructs. Liu and Wang [78], however, separate behavior control and outcome control, clan control, and self-control. In principle, behavior, control and outcome control reflect management control, clan control reflecting team autonomy, and self-control reflecting individual autonomy [73], but measurement instruments in [78] seem to confuse the situation.

Wu et al. [80], as another exception, illustrate a potential tension between formality and informality. They report that formal communication and informal communication have statistically significant but opposite effects on three types of conflicts (relational conflicts, process conflicts, task conflicts), which affect project performance. Since they measure project performance using a single construct, one cannot judge whether formality versus informality may have significantly different effects on dimensions of project performance.

Hsu et al. [102] distinguish shared leadership (associated with team autonomy) and vertical leadership (associated with managerial control) in addition to value diversity. Most interestingly, their study found that vertical leadership positively moderates the predominantly negative impact of value diversity on shared leadership and negatively moderates the positive effect of shared leadership on system quality.

It is remarkable that none of the studies include the opposite ends of a paradoxical tension as separate independent variables and, at the same time, comprise more than one dimension of project performance. As a consequence, there is a clear opportunity for future PM research in this respect. Even though projects differ and there are a number of contextual factors involved [125], [126], I believe that such a research programme could provide a cumulative body of knowledge about the paradoxical nature of project management.

6.2 Practical implications

It is also my hope that the eleven tensions provide new insight to PM practitioners - especially of design-oriented projects - but at the same time are concrete enough that they can recognize them in their daily practice. Readers interested in practical implications, please have a quick look at Figures 2-5.

More concretely, the eleven tensions provide a framework for retrospective evaluation of each ”sprint” and for planning the next one: what went well in the previous sprint and what could be improved in the next sprint. In the case of each tension, the questions could be: “Is it in balance”, “Do we need A more or B more?”. For example, “Was quantity (or speed) and quality in balance?”, “Do we need better quality or more quantity (or speed)?”), when one considers a project in question, its purpose, and the situation at hand.

6.3 Limitations

The list of tensions is by no means assumed to be exhaustive but can be expanded with additional ones, e.g., exploitation vs. exploration, incremental vs. radical change, and others. It is obvious, however, that too many are too many. So, one should be able to identify the most “fundamental” tensions.

A second clear limitation of this paper is that it is solely based on my armchair reasoning, supported and inspired by a vast body of relevant literature.

6.4 Final comment

It is 25 years ago when I introduced the first ideas of this paper [132] without much impact. Since then, I have occasionally returned to the idea of the paradoxical nature of systems development projects [133], [134]. I am not totally sure whether the question has been about my 25-year obsession or about being at least 25 years ahead of my time. Anyway, this paper, together with the accompanying paper [9], will be my last attempts to promote these ideas. My hope still is that they encourage younger researchers to grasp the opportunity to investigate project management in terms of paradoxical tensions.

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Appendix A. To what extent the paradox lens has been applied in the PM literature?

To find out an answer to the above question, I conducted a Google Scholar search in September 2020. The aim was to conduct a comprehensive search so that it covers various scientific conferences, too. Therefore, I preferred Google Scholar to Scopus and Web of Science.

Referring to the terminological confusion discussed Section 2.1, I used the search formula "paradoxes/tensions/ dilemmas/contradictions/ambidexterity in/of project". Since I was interested in the application of the paradox lens (or similar) rather than in individual paradoxes/tensions/dilemmas/contradictions, I used the plural of the keywords.

The initial search led to 481 hits. After that, I excluded all citation hits ("**[CITATION]**") and papers not in English. Publications not published on scientific forums were also excluded. If a paper used a keyword in a totally different meaning (e.g., "contradiction" to refer to inconsistencies of research results), or if it just referred to another paper with one of the keywords in the title of the reference, it was not included. I also excluded papers that discuss "ethical dilemmas", since they typically represent either-or choices rather than both-and ones. Also, papers that addressed tensions of project-based learning/education rather than of project management and tensions of research on project management were excluded.

Finally, I ended up with fourteen papers summarized in Table A.1. It indicates that the paradoxes lens has implicitly or explicitly been applied mainly as a research instrument - theory or meta-theory - for analyzing and making sense of project management, emphasizing uniqueness rather than typicality. They report quite diverse sets of paradoxical tensions. One reason is that they originated from quite different types of projects. The only commonality between the papers is that the last three of them applied the framework for organizational tensions - introduced by Smith and Lewis [2] - distinguishing paradoxes concerning belonging, learning, organizing, and performing.

Table A.1. Prior research on paradoxical tensions of managing projects

Paper	Source/focus	Paradoxes/dilemmas/tensions/contradictions
Lewis et al. 2002 [135]	Quantitative: Product development projects	Emergent vs. planned style of project management reflecting tensions between emergent vs. determined, divergent vs. convergent thinking, freedom vs. structure, and inside vs. outside. The two styles differ in the way they address monitoring, evaluation, and control. The planned style relies on monitoring milestones, evaluation by formal reviews, and directive control, whereas the emergent styles relies on monitoring understandings, evaluation by wider information gathering, and participative control.
Andriopoulos and Lewis 2009 [136]	Qualitative: Project-based organizations proving NPD consultancy	Strategic intent: Profit vs. breakthroughs (≈ efficiency vs. innovativeness) Customer orientation: Tight coupling vs. loose coupling Personal drivers: Discipline vs. passion
DeFillippi 2009 [10]	"Qualitative": Media projects	1. Individualization vs. collective belonging 2. Creative autonomy vs. corporate control 3. Creative exploration vs. commercial exploitation
Aubry and Lievre 2010 [137]	Qualitative: Two projects of polar expedition	Ambidexterity - tension between exploitation and exploration - tension between planning/rationalization and adaptation/learning
Brady and Maylor 2010 [138]	Mixed?. A project designing, developing, and eventually manufacturing a new piece of military hardware	The improvement paradox: A project-based organization performing poorly and in need of improvement in its management of projects was not pursuing any improvement activities. The project form of organization is lauded as the one most likely to deliver innovative solutions whilst at the same time being resistant to changes in its own structures and processes The good behaviors and practices that had served the project so well in the construction phase seemed to be abandoned as it moved into operation
Leminen et al. 2015 [139]	Qualitative: Open innovation projects using the living lab approach	1. Living lab creates feasible results not initially targeted. 2. Monetary incentives decrease motivation. 3. Those with resource lack would profit most from living labs, but those with resource slack will reap the benefits. 4. Collision of user-centric and user-driven mindsets. 5. Heterogeneous customer needs require increasing the number of users. 6. Conflicts and collisions speed up innovation development. 7. New inexperienced users speed up the product development.
DeFillippi and Sydow 2016 [140]	Conceptual: Project networks	1. The distance paradox: Tensions between the temporary and permanent organization. 2. The learning paradox: Tensions between knowledge creation and transfer. 3. The identity paradox: Tensions between individual and collective identity. 4. The difference paradox: Tensions between crafting and standardizing practices. 5. The temporal paradox: Tensions between past, present, and future project work
Samset and Volden 2016 [141]	Qualitative: Large public investment projects	1.The success paradox: Success is measured in terms of tactical performance rather than strategic performance 2. The paradox of the significance of front-end management: Fewer resources are used upfront to identify the best conceptual solution (project governance) than to improve tactical performance during implementation (project management) 3. The paradox of early information overflow: Decisions are based on masses of detailed information upfront rather than carefully selected facts and judgmental information relevant to highlight the essential issues 4. The paradox of the opportunity space: The choice of conceptual solution is made without systematically scrutinizing the opportunity space upfront 5. The paradox of strategic alignment: Strategy and alignment of objectives are highlighted as essential concerns, but in most cases, the internal logic of causalities and the probabilities of realization are erroneous 6. The cost estimation paradox: The focus is on the final cost estimate (the budget), while early cost estimates are overlooked 7. The paradox of disregarded analyses of costs and benefits: Detailed estimation of cost and benefits is commonly done upfront but disregarded by decision-makers, who tend to emphasize other aspects 8. The paradox of "predict and provide": The tendency is to choose a "predict-and-provide" strategy rather than explore alternative solutions 9. The paradox of perverse incentives: Public investments with no financial obligations for the target group may cause perverse incentives and result in counterproductive projects 10. The paradox of myopic decisions: Long-term viability is the intention, but the planning

Paper	Source/focus	Paradoxes/dilemmas/tensions/contradictions
		horizon is too short, resulting in sub-optimal choices that one will regret later
Ahuja et al. 2017 [11]	Qualitative: Architects in complex, urban renewal projects	1. Tensions related to design control 2. Tensions related to professional autonomy => Identity paradox
Boonstra et al. 2017 [142]	Qualitative: A project developing an electronic health record system	Tensions related to technology: 1. Standardized vs. customized 2. Large scope vs. small scope Tensions related to work organization: 3. High impact vs. low impact 4. Integration vs. differentiation Tensions related to project process: 5. Top-down vs. bottom-up 6. Big bang vs. incremental 7. Differentiated vs. integrated
Manzoni and Caporarello 2017 [12]	Qualitative: Architectural design studio	Performing (goals) – creating a high-level symbolic project that is also profitable Belonging (identity) – projecting the lead architect's views while incorporating the ideas of clients and other architects Organizing (processes) – making architecture musical, structured and emotional all at the same time Learning (knowledge) – balancing the interplay of innovation and tradition
Maylor and Turner 2017 [143]	Projects: Systematic literature analysis, workshops with managers related to projects	A tension between having to follow a process and a manager having the flexibility to respond in the best way they see fit at the time, whatever the process says. Too little time spent defining the work can lead to longer project duration, but too much time expenditure can lead to diminishing returns
Delisle 2019 [144]	Projects: Content analysis of two books on PM	Learning tension Past-Future Cyclic-Linear Beginnings-Ends Performing tension Short-Long Term Constraints Belonging tension Temporary- Permanent Unicity-Repetition Organizing tension Predictive-Adaptive Flexibility-Control
Labelle et al. 2019 [145]	A complex design project of a biorefinery	Belonging tensions Performance tensions Learning tensions Level tensions (systematic, organizational, individual) Change tensions (radical, incremental, urgency of the situation) Temporal tensions Spatial tensions

Appendix B. To what extent quantitative PM research has investigated the impact of tensions of structure and tensions of execution on project performance?

To find out an answer to the question above (see arrows A and B in Figures 1 and 5 in the main text), I conducted Google Scholar searches in November 2020. I limited the searches to explanatory/predictive quantitative studies because of the focus on the "causality" implied by the arrows A and B.

I did a number of searches using the opposite ends of each tension with their "indicators" as keywords (e.g., "output control", "input control", "behavior control" for "managerial control"; "empowerment" and "shared leadership" for "autonomy"), including alternative project performance dimensions (such as "project performance", "project efficiency", "project effectiveness") in search terms. In order to identify explanatory/predictive quantitative studies, I used typical statistical terms ("correlation" and "regression") as additional search terms.

The searches identified thirteen papers listed in Table B.1 with their findings related to the tensions. It should be noted that Table B.1 does not report all results of the reviewed papers, just those related to the paradoxical tensions identified in this paper.

As general observations, Table B.1 indicates that there are clearly more quantitative studies related to the paradoxical tensions of structure than on those of execution. A possible explanation may be that the latter tensions are related to ASD, even though they have much longer intellectual roots in IS and SE research [9]. As far as ASD and APM are considered, they are easily condensed into a single variable such as "agility-based project management approach" [110] without separating characterizing features of agility and their effect on project performance. Most studies (10 out of 13) include only one dependent variable (project performance dimension), one study ([129]) including two performance dimensions, and two studies ([93] and [103]) three dimensions.

Table B.1: Summary of results of the papers

Relationships	**Type of projects**	**References**
A: Structure -> Project performance		
Management control vs. team autonomy:		
Team autonomy ++> Teamwork effectiveness (moderated by team dispersion) Team autonomy o+> Quality of decision-making ++> Teamwork effectiveness (moderated by team dispersion)	Miscellaneous	Bourgault et al. 2008 [146]
Behavior control (≈ managerial control) ++> Project performance (relative to schedule + budget + quality + client satisfaction + goals) Outcome control (≈ managerial control) ++> Project performance Clan control (≈ "client involvement") ++> Project performance Self-control (≈ team autonomy) oo> Project performance All significant relationships are moderated by organizational environment risk and team risk so that higher risk decreases the positive impact of the control mechanism in question.	Medical IS projects	Liu and Wang 2016 [78]
Outcome control (OC) (≈ managerial control) ++> Project performance Behavior control (BC) (≈ managerial control) ++> Project performance	Dwelling fit-out projects	Ning et al. 2017 [147]
Value diversity -o> Shared leadership (≈ team autonomy) (positively moderated by vertical leadership (≈ managerial control) Shared leadership ++> System quality (negatively moderated by vertical leadership) Value diversity --> System quality	IS develop-ment projects	Hsu et al. 2017 [102]
Formality vs. informality:		
Formalization of decision processes o+> Team effectiveness (moderated by team dispersion) Formalization of decision processes ++> Quality of decision-making ++> Team effectiveness (moderated by team dispersion)	Miscellaneous	Bourgault et al. 2008 [146]
Formal communication ++> Relationship conflict Informal communication --> Relationship conflict Formal communication --> Process conflict Informal communication ++> Process conflict	Miscellaneous	Wu et al. 2017 [80]

Relationships	Type of projects	References
Formal communication --> Task conflict Informal communication ++> Task conflict Relationship conflict --> Project success Process conflict --> Project success Task conflict ++> Project success		
Individual rewarding vs. team-based rewarding:		
Team-based financial incentive ++> Knowledge management performance of NPD teams (positively moderated by knowledge codifiability and teachability) Non-financial incentive ++> Knowledge management performance of NPD teams	New high-tech product development projects	Zhang and Zhang 2014 [92]
Reward interdependence (≈ team-based rewarding) ++> NPD team collaboration (negatively moderated by team size and functional team heterogeneity) Nonfinancial incentives ++> NPD team collaboration (negatively moderated by team size).	New product development projects	Zhang et al. 2019 [95]
Team homogeneity vs. team heterogeneity:		
Value diversity ++> Task conflict Value diversity ++> Relationship conflict Information diversity ++> Task conflict Demographic diversity ++> Relationship conflict Task conflict ++> Communication Task conflict ++> Balance of contributions Relationshp conflict oo> Communication Relationship conflict --> Balance of contribution Communication ++> Project performnce (goals met + quatity of work completed + schedule + efficiency + morale) Balance of contribution ++> Project performance	IS development projects	Liang et al. 2012 [100]
Team's functional diversity oo> Team effectiveness (≈ quality + satisfaction + success) Team's functional diversity --> Team efficiency (cost-efficiency + time-efficiency + schedule + budget) Team's functional diversity oo> Innovation	Miscellaneous	Liu and Cross 2016 [93]
Knowledge heterogeneity ++> Team performance Knowledge heterogeneity ++> Knowledge reuse ++> Team performance Knowledge heterogeneity ++> Employee relationships ++> Team performance	Engineering design teams	Zhang and Li 2016 [101]
Value diversity --> System quality Shared leadership ++> System quality	IS development projects	Hsu et al. 2017 [102]
Reward interdependence (≈ team-based rewarding) ++> NPD team collaboration (negatively moderated by team size and functional team heterogeneity)	New product development projects	Zhang et al. 2019 [95]
C: Execution -> Project performance		
Averse vs. responsive to changes:		
Software team response extensiveness ++> Software functionality Software team response extensiveness ++> Customer satisfaction (satisfaction with the developed system) Software team response extensiveness --> Software team response efficiency Software team response efficiency ++> Software functionality Software team response efficiency ++> Process performance (budget, schedule) Software team response efficiency ++> Customer satisfaction	Agile IS development projects in one organization	Recker et al. 2017 [103]
Blueprint vs. continuous planning:		
Planning (= the proportion of total development time spent defining product requirements prior to the start coding) oo> Development time Build frequency --> Development time	Software development projects	Callahan and Moretton 2001 [148]
Rigid vs. flexible method enactment		
Discipline vs. improvisation:		

Relationships	Type of projects	References
Faith in intuition oo> Internal project performance (schedule, budget, scope) Faith in intuition ++> External project performance Improvisation oo> Internal project performance Improvisation oo> External project performance	Miscellaneous	Leybourne and Sadler-Smith 2006 [129]

Legends: ++> significant positive relationship, --> significant negative relationship, oo> non-significant relationship, +o> moderated relationship in which the relationship turns into insignificant when the moderator has a high value, o+> moderated relationship in which the relationship is insignificant when the moderator has low value and insignificant when the moderator has high value.

B.1. Managerial control vs. team autonomy

Bourgault et al. [146] investigated the effect of team autonomy and formalization of the decision-making process on the quality of decision-making and further on teamwork effectiveness. Teamwork effectiveness in their study referred to "the perceived performance by team members on items such as task completion, goal achievement, sharing information, conflict resolution, problem-solving, and the team's ability to create and sustain a good working environment" (p. S102). They found team autonomy to have a significant positive direct effect on teamwork effectiveness, moderated by team dispersion so that in the case of moderate project dispersion, the effect was almost significant ($p \leq 0.10$), and in the case of high dispersion, it was significant (the authors use "moderate" and "high" to characterize the opposites of dispersion). Furthermore, formalization had a positive indirect effect on teamwork effectiveness via quality of decision-making, the effect of team autonomy on quality of decision-making being insignificant when teams were moderately dispersed and almost significant when they were highly dispersed.

Liu and Wang [78] investigated the impact of behavior control, outcome control, clan control, and self-control on project performance (the degree to which the project goals were achieved, the project was within budget and schedule, and was of high quality). They found all the forms of control, except self-control, to have a significant positive direct effect on project performance, whereas the effect of self-control was insignificant. In principle, behavior control and outcome control reflect management control, clan control reflecting team autonomy, and self-control reflecting individual autonomy [73]. Liu and Wang [78], however, measure behavior control and outcome control exercised by the client rather than by management. More confusingly, the items of self-control seem to reflect team autonomy rather than individual autonomy, and the items of clan control seem to measure something like the client's "involvement" with the development team. The insignificant effect of self-control (≈ team autonomy) on project performance is against the authors' initial hypothesis.

Ning et al. [147] focused on the effects of outcome control, behavior control, trust in contractor's competence, and trust in contractor's good intentions on project performance, reporting all of them to have a significant positive effect.

Hsu et al. [102] investigated the effects of value diversity, shared leadership, and vertical leadership on system quality. They found that value diversity generally has a negative effect on shared leadership, moderated by vertical leadership so that when vertical leadership is very high, the effect is positive but weak. Shared leadership has a positive impact on system quality, moderated by vertical leadership so that when vertical leadership is high, the positive effect is lower than in the case of low vertical leadership. Value diversity was also found to have an almost significant ($p \leq 0.10$) direct effect on system quality. The results of [102] describe how diversity (homogeneity vs. heterogeneity) and shared leadership (autonomy), and vertical leadership (managerial control) may be interrelated.

B.2. Formality vs. informality

In the above-mentioned study of Bourgault et al. [147], formalization was found to have an almost significant direct effect on teamwork effectiveness ($p \leq 0.10$) moderated so that the effect was insignificant when teams were moderately dispersed and significant when teams were highly dispersed. Furthermore, formalization had a positive indirect effect on teamwork effectiveness via quality of decision-making,

Wu et al. [80] analyze formal communication, informal communication, and communication willingness as determinants of three types of conflict - relational conflicts, process conflicts, task conflicts. Each of the types of conflict is assumed to affect project success. They report that formal communication and informal communication have

significant but opposite effects on the three types of conflict. Since they measure project success using a single construct, one cannot judge whether formality versus informality may have significantly different effects on dimensions of project success.

B.3. Individual vs. team-based rewarding

Zhang and Zhang [92] and Zhang et al. [95] investigate the impact of team-based rewarding and non-financial incentives in the new product development (NPD) context, using knowledge management performance of NPD teams and NPD team collaboration as the dependent variables, respectively. Both studies find that team-based rewarding has a positive impact on the dependent variable in question. The former study suggests that the relationship is positively moderated by knowledge codifiability and teachability, and the latter study that the relationship in question is negatively moderated by team size and team heterogeneity.

B.4. Team homogeneity vs. team heterogeneity

As introduced above, Hsu et al. [102] and Zhang et al. [95] include diversity or heterogeneity in their models and will not be discussed in more detail here.

Liang et al. [100] investigate the impact of value diversity on project performance (goals met, amount of work completed, within schedule, efficiency, morale), including information diversity and demographic diversity as controls. Their results imply that both information diversity and value diversity have a positive indirect effect on project performance via their positive effects on task conflict, which affects communication and balance of contribution positively, the latter two influencing project performance positively. At the same time, value conflict and demographic diversity have negative indirect effects on project performance via their positive effects on relationship conflict, which negatively affects the balance of contribution and communication (even though insignificantly the latter) and therefore negatively on project performance.

Liu and Cross [93] study twelve determinants of project performance, among them team diversity. They distinguish three dimensions of performance: team effectiveness ("the extent to which the project outputs achieved the performance expectations of key project stakeholders", team efficiency ("the ability of the project team to meet its budget and schedule goals (…) and utilize resources within constraints") and innovation (the creative accomplishment of teams in generating new ideas, methods, approaches, inventions, or applications") (p. 1152). They found that the only significant relationship between the team's functional diversity and the three dimensions of project performance is the negative relationship between the team's functional diversity and efficiency. Opposite to their hypothesis that there is a positive relationship between team's functional diversity and innovation, they did not find the relationship significant.

Zhang and Li [101] investigate the direct effect of knowledge heterogeneity on engineering design team performance and indirect effects through employee relationship and knowledge reuse. Despite their *a priori* assumption of negative effects of knowledge heterogeneity, they found it to have only positive direct effects on employee relationships, knowledge reuse, and engineering design team performance.

B.5. Tensions of execution

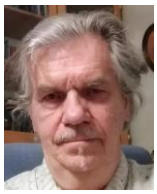
The interest of Recker et al. [103] lies in how three ASD practices – stand-up meetings, collective code ownership, pair programming – affect responsiveness to requirements changes and further on IS development project performance. They include three project performance dimensions - software functionality, process performance, and customer satisfaction. Although their main analysis aggregates them into a single construct (IS development success), their Appendix B reports results when the three dimensions are kept separate. They found that "software team response extensiveness" (the extent the software team actually incorporated various requirement changes) had a significant positive direct impact on software functionality and customer satisfaction and a significant negative direct effect on "software team response efficiency" (i.e., on the additional effort required by the software team to incorporate the requirements changes). "Software team response efficiency", on the other hand, had significant positive direct effects on each of the three dimensions of project performance. A detailed analysis of their regression coefficients suggests that

direct effects of "software team response extensiveness" outperform the indirect effects. Since process performance was affected by "software team response efficiency" only, the total effect of "software team response extensiveness" on process performance is negative.

Callahan and Moretton [148] investigate determinants of software development time. They found planning (all upfront analysis, design, and planning before starting coding) to be insignificant as a determinant of project duration, whereas build frequency significantly decreased the duration. Although they refer to the iterative nature of software development in the sense of the spiral model [149], it is likely that their sample of software development projects is biased towards traditional waterfall-type development. It would be interesting to see to what extent their findings are valid in a more agile way of developing software.

The interest of Leybourne and Sadler-Smith [129] lies in the role of intuition and improvisation in project management. They separate two dimensions of project performance: internal (schedule, cost, scope) and external (related to the customer). They did not find improvisation to affect either dimension of project performance significantly but did find faith in intuition to be positively related to the external project performance.

Biographical notes



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An analysis of violations and sanctions following the GDPR

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Abstract:
This paper investigates the violations and sanctions that have occurred following the implementation of the General Data Protection Regulation (GDPR). The GDPR came into effect in May 2018 with the aim of strengthening the information privacy of European Union/European Economic Area citizens. Based on existing taxonomies of (i) potential consequences of violating the GDPR (including surveillance, discrimination), (ii) an analysis of 277 sanctions, and (iii) interviews with experts, we offer a mapping of the violations and sanctions almost two years after the regulation was implemented. The most typical complaints were, in descending order: unlawful processing and disclosure of personal information, failure to act on and secure subject rights and personal information, and insufficient cooperation with supervising authorities. Our analysis also indicates an increasing number of fines over time. Regarding size, the fines range from 50,000,000 euros to (symbolic?) 90 euros. While research on GDPR violations and sanctions is somewhat scarce, our study mainly confirms existing findings: that the GDPR is complex and challenging. However, our study provides insight on some of the challenges. Our contribution is mainly practical and aimed at managers in any organization whose goal is to protect information privacy and to learn from the mistakes made by other companies. We also welcome more research on the topic.

Keywords:
privacy; General Data Protection Regulation; GDPR; data management; violations; sanctions.

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1. Introduction

Our society has undergone many revolutions, from steam engines and electricity to the introduction of information systems and social media. New and rapid technological advances merge the physical, digital, and biological worlds. It is easy for companies to collect, store and use data about individuals, and the amount of data available is growing at an astounding rate [1, 2]. At the same time, the importance of regulations concerning individual privacy is increasing [3]. '*The right to be let alone*' was declared in 1890 by Warren and Brandeis as they saw the need for laws to protect individuals [4]. While many researchers refer to Warren and Brandeis, few mention that is was the portable camera that activated this concern [5]. Approximately one century later, Weiser argued that technology could enable firms to make unpleasant use of the information they collect [6]. Technology is advancing faster than the law [5] and human perception [7], and the vast amount of consumer data allows for its unprecedented use for business purposes [8].

One example of the most comprehensive information privacy violations was revealed in March 2018—the Facebook-Cambridge Analytica case. Personal information of up to 87 million Facebook users globally was collected without their consent. It is alleged that this information was used to target individuals in various campaigns, with positive outcomes for those using the data. The information has been linked to, for example, the US presidential campaign in 2016 [9], the Kenyan elections in 2013 and 2017 [10] and Brexit in 2016 [11].

Over the years, privacy has become deeply intertwined with technology [12]. Consequently, the European Commission proposed the General Data Protection Regulation (GDPR) in 2012, and it was approved by the European Parliament and the European Council in 2016. It was to be enforced on May 25, 2018 but was delayed until July 1, 2018 in European Free Trade Association (EFTA) states. However, it was *'the most lobbied against legislation in European history, with almost 4,000 amendments'* [13 p. 24, 14]. This might be a result of the demands placed on companies, as the GDPR regulates what and how they can use and process information. Ultimately, this can affect how they conduct their business and can lead to major changes in business models to ensure survival. The GDPR seems a good idea on paper, but it is difficult to comply with [3]. Concerns have been expressed in the US, where regulations resembling the GDPR are being enforced in states such as California and New York. Companies fear that it will be impossible to comply with a patchwork of multiple regulations [7]. Despite these obstacles, the GDPR is referred to as setting a global standard for privacy [13].

The sanctions for violating the GDPR can be substantial, and some have already been enforced. These include the epoch-making examples of large fines levied against Google in France [15] and against a German real estate company [16]. However, any company that collects customer data belonging to the European Union (EU) or the European (EEA) must comply with the GDPR regardless of size (small or large), type (profitable or non-profit) or nationality (European or non-European). Moreover, if they do not collect customer data, the company probably has a website, and websites must comply with the GDPRs rules regarding cookies and the right to forgotten for visitors from the EU and the EEA [17]. However, complying with the GDPR is not without challenges [18] and our research question pertaining to this is *What types of violations and sanctions have occurred following the implementation of the GPDR?*

The remainder of this paper is structured as follows. Section 2 covers related research on information privacy and the GDPR. Section 3 describes how we collected and analyzed our data. Sections 4 and 5 detail the study findings and limitations and discusses future research opportunities. The conclusion in presented in Section 6.

2. Related Research

This section presents related research on information privacy and frameworks, followed by a brief presentation of the GDPR in an information systems context. However, there are also some references to juridical publications.

2.1 Information privacy

The need for privacy protection was established even before advanced technology [4], and currently the common definition is the ability for one to control information about oneself. However, according to Solove *'Privacy seems to be about everything, and therefore it appears to be nothing'* [19]. When talking about privacy, it is often related to our fears and anxieties. What seems to be missing is the translation of why privacy problems are harmful, which makes it difficult for companies to develop policies and attempt to solve the issues [19]. Solove developed a taxonomy to address these problems that consist of four main harmful activites: information collection, information processing, information dissemintation and information invasion. For this paper, we found that Solove's taxonomy covered most of our scope; however, Solove does not specifically include actors such as *Authority* outside a company or *Controller* within a company. This might be because Solove's point of departure is the data subject and because the GDPR was yet to be implemented. Therefore, we examined the work of Colesky et al. [20], whose point of departure is the organization. As shown in Fig. 1, the two frameworks overlap nicely with the data subject, which we illustrate by means of the dotted circle. We also observe that Colesky et al. [20] offer some solutions to reduce harmful actions, which are to separate, hide, abstract, and minimize data.

Our purpose for connecting the two frameworks is to illustrate the complexity of information privacy, but also to provide an overview when presenting the GDPR in the next section. For example, *Authority* in Fig.1 can be a country's data protection authority or a law firm. It is the country's data protection authority that will issue the sanction. The *Controller* typically represents the management of a company, however, it can also be an individual person, as we will demonstrate in the discussion. Finally, the *Data Subject* is the individual, who is to be protected by the GDPR, for example in the role as a consumer, web-browser, or a citizen of the EU/EEA.

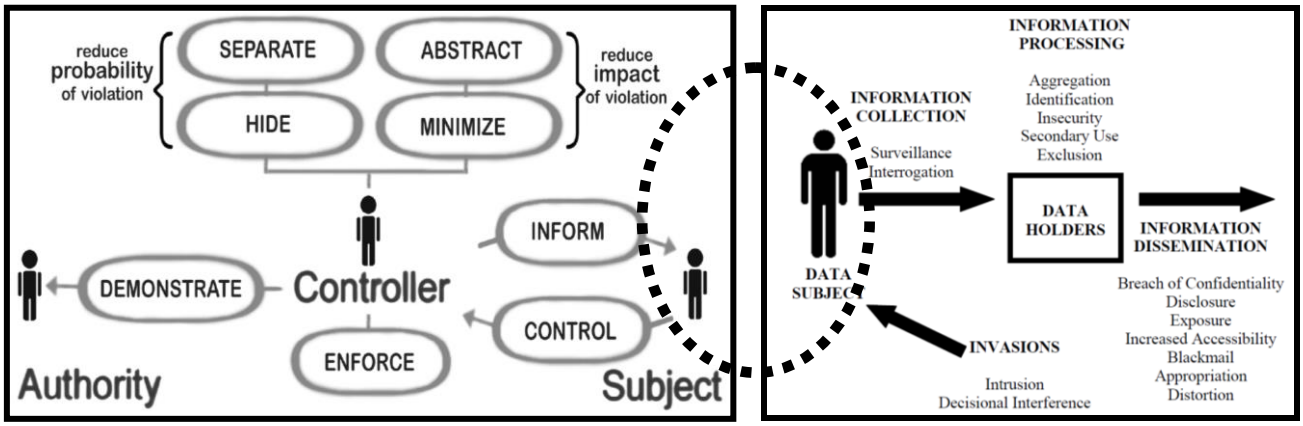

Fig. 1. Our illustration (dotted circle) of the overlap of frameworks by [20 p. 39] and [19 p. 490].

2.2 The General Data Protection Regulation (GDPR)

The GDPR was enforced after six years of preparation and debate. It supersedes various privacy regulations in EU and EEA countries, with the main changes being extended territorial scope, new definitions (for example data portability), new provisions and principles (for example data minimization) and added conditions concerning children's consent [21]. The role of national data protection authorities is strengthened, as they can impose substantial penalties on those who infringe data subject rights of up to 4% of global turnover or 20 million euros, whichever is higher [7, 21, 22]. A

survey of 62 companies in 2018, right before the GDPR was implemented, revealed some confusion about the penalty. One participant pondered:

> *"I do not understand how to calculate this fine. It reads:* 'up to €20 million or 4% of the company's global annual turnover of the previous financial year, whichever is higher'. *How this could ever be more than €20 million is beyond my comprehension"* [22 p. 10].

The fine can indeed be above 20 million euro. The aforementioned survey asked the companies to calculate the amount of a hypothetic fine. The paper reported that the highest amount could be as much as €1 666 892 392 (almost 1,7 billion euro) and another company found it to be as low as 400 euro. These results demonstrated large differences, both in terms of revenue and economic consequences for the companies who partook in the survey.

The implementation of the GDPR entails benefits in addition to challenges for companies. A literature review identifies several benefits including risk identification, better data management, security measures, and training awareness [18]. However, the digital revolution has led to a lag between existing regulations and how they are practiced [23]. Regulations are often so overwhelming that they tend to scare organizations away from creating new business. For regulations to be successfully implemented and enforced, Dunlap, Cummings and Janicki [24] state that authorities should provide sufficient expertise. Koops argues that this has not been done. What the GDPR does in practice is to make data protection more complicated with ambiguous phrasing and complex dependencies between some of the articles [3]. Koops further argues there is a disconnection between law and reality. Concurring with this, Tikkinen-Piri, Rohunen and Markkula [25] and Mansfield-Devine [26] argue the GDPR does not 'spell out' what companies need to do to become compliant.

Existing research has started to pay attention to violations, but also inventive ways to avoid complying to the regulation. For example, one study reveals that web sites do not offer a proper way to opt out of cookies, and some websites simply refuse access users in the EU [27]. A related study claims that Internet usage has indeed improved privacy rights but mostly for EU citizens and less for US citizens [17]. For example, the empirical study by Dabrowski et al. found that EU citizens are less likely to receive persistent cookies. Sanchez-Rola et al. [27] state that:

> '*From an economic point of view, stakes are big: on the one hand, fines imposed because of non-compliance to the GDPR can be very large; on the other hand, though, the main source of income of many websites is advertising, and we speculate that […] letting users easily opt out from tracking could negate them a part of their income that could potentially be even larger than the fines they could face. Uncertainty with respect to the scope of the legislation and the likelihood of it being enforced may also be involved*' [27 p. 10].

Tambou [15] states that the fine imposed by the French Data Protection Authority on January 21, 2019 was not the first. However, the significant amount of 50 million euros demonstrated the effect of the GDPR and can be representing a paradigm shift. Tambou describes how Google tried to argue against the fine but in vain [15]. A preliminary study by [28] aims at developing a conceptual framework of privacy violations.

Researchers outside the European border are also taking a greater interest in the GDPR. For example, [29] explores the beneficial and questionable consequences of advanced technology, and [7] have suggested several solutions, such as algorithmic transparency and the creepiness scale. The creepiness scale puts the data subject in focus when it comes to companies' use of personal data and algorithms. Watson and Nations [7] categorized the data subjects' reaction from "this is helpful"; "this is creepy"; "this is so wrong". For example, when LinkedIn uses algorithms to match job recruiters and applicants it is perceived as helpful, but if companies use algorithms to screen job applicants based on analyzing their smile it is perceived to be wrong. It should be mentioned that use of algorithms and automated decision making is not illegal per se, however a company must inform the data subject that algorithms (may) have affected the outcome.

Another study from the data subjects' (in this case as the role of consumers) perspective was conducted by [30]. Based on a survey, three insights were gained in the wake of the implementation of the GDPR: (1) consumers had increased knowledge about their information privacy; however, they remained rather unconcerned about executing their enhanced rights. (2) About 50% of respondents felt that they had control of their personal data, while almost 40% stated that they had no control over their personal data. (3) The consumers had trust in companies' management of their personal data.

Summing up the existing research, we observe an increased interest in information privacy and the GDPR. So far, most researchers agree that the aim of the GDPR is positive but that the regulation is challenging for organizations. There are several studies on the potential harmful consequences of the lack of privacy, and many conceptual frameworks exist. Because the GDPR is relatively new, less research has addressed violations and sanctions. We aim to fill this gap.

3. Method

This is mainly a qualitative study, and we collected data from three main sources. First, a review of related research was conducted between 2018 and 2020, resulting in our theoretical framework (Fig. 1, presented above). Second, interviews with four experts were conducted in 2018 and repeated in 2020 (three of them answered). We also e-mailed two other juridical professionals in 2020 because some questions arose from our findings. Third, an analysis of violations and sanctions based on two official websites was conducted from January 1 to April 1, 2020.

Table 1. Summing up our sources of qualitative data collection

Data source	Date conducted	Outcome
Related research	2018 and 2020	Theoretical framework based on Colesky et al. [20 p. 39] and Solove [19]. The framework is found in Fig. 1 in section 2.
Interviews with 4 experts	2018 and 2020	Seven interview transcripts.
Juridical advice from 2 professionals	2020	Two e-mail transcripts, in order to shed additional light from our findings.
2 different websites	2020	Analysis of 277 GDPR violations and sanctions.

3.1 Collection and analysis of the four expert interviews in 2018 and 2020

In spring 2018, right before the implementation of the GPDR, we conducted four interviews with experts in their fields. They were chosen based on their diverse roles and relevance vis-à-vis the GDPR, allowing us to illuminate the regulation from a broad perspective. All four participants granted us permission to refer to them by professional title:

1) General Secretary, The Norwegian Computer Society
2) Lecturer and privacy researcher, University of Oslo
3) Advocate, specialist in technology and privacy
4) Commissioner, The Norwegian Data Protection Authorities

The interviews in 2018 were conducted face to face between March 8 and April 13 and lasted between 30 and 40 minutes. All the participants agreed to having the interviews recorded, and they received the transcripts the following day. The recordings were deleted immediately after approval. The semi-structured interview questions, which are based on the existing research in Section 2, covered the following:

1) What are the expected advantages and disadvantages of the GDPR?
2) Is the GDPR about security or privacy?
3) What kind of impact will the GDPR have on data subjects and organizations?
4) What do you think about the sanctions and authority control?

Based on our observation of the many violations and sanctions in the wake of the implementation, we wanted to obtain more insight. We contacted the same four experts, who were happy to share their knowledge with us. The follow-up interviews with the same participants in February 2020 were conducted by e-mail, and the answers were returned the same way. Three participants provided thorough answers, while the fourth apologized for not being able to participate. The essence of the follow-up questions was as follows:

1) Are you surprised by the violations, and do you see any patterns?
2) Are the sanctions fair?
3) What are the benefits/challenges for the data subjects after the implementation of the GDPR?
4) Does the hysteria around the GDPR prevail?
5) Has the GDPR had the intended effect on organizations and data subjects?

The analysis of the transcripts was guided by the themes of the questions, but we also made clusters by creating a matrix and reducing the text, as suggested by Miles and Huberman [31].

3.2 Collection and analysis of the two websites on GDPR violations

As of April 2020, there are several websites that offer an overview of the violations and sanctions following the implementation of the GDPR. To compare the results, we chose two websites: *GDPR Fines Tracker & Statistics* (https://www.privacyaffairs.com/gdpr-fines/) (left side in Fig. 2) and *GDPR Enforcement Tracker* (https://www.enforcementtracker.com/) (right side in Fig. 2). *The GDPR Enforcement Tracker* was also recommended by the advocate. This website allows filtering by country or choosing from among the 99 GDPR articles.

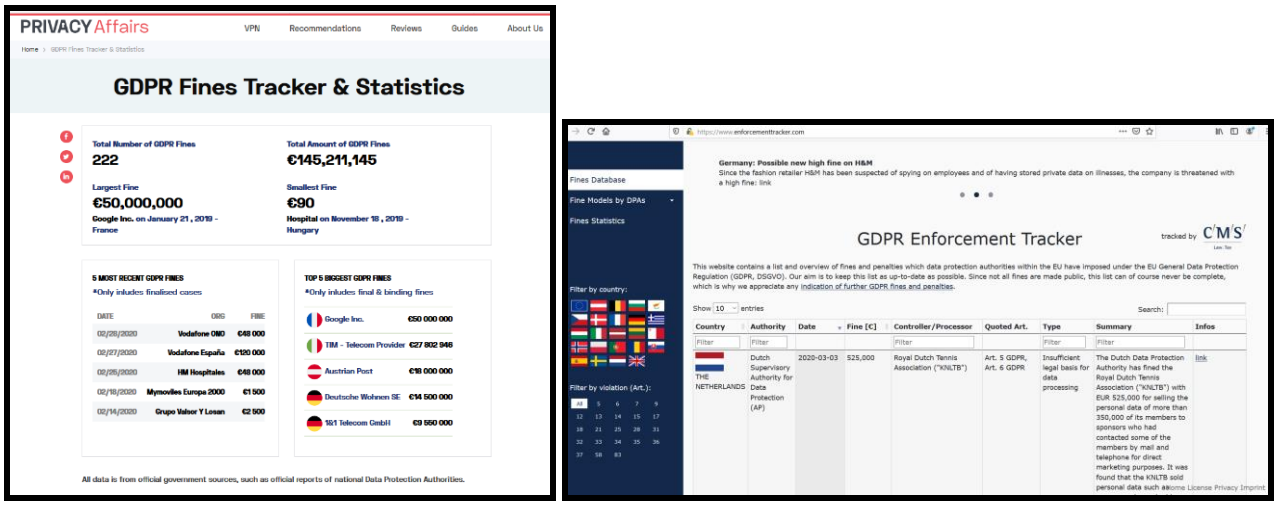

Fig. 2. *GDPR Fines Tracker & Statistics* and the *GDPR Enforcement Tracker*. Screen shots taken on March 9, 2020 and March 4, 2020, respectively.

Both websites offer structure and search function, but we wanted an in-depth analysis and a comparison. First, we only included the fines that were reported on both websites (Fig. 2). This excluded 23 cases; 15 were listed on *The Enforcement Tracker* but not *The Fines Tracker & Statistics*, and 8 vice versa. We also excluded fines that were not settled by March 31, 2020, such as those levied against Marriott International and British Airways. Another issue was that some of the fines had been based on multiple privacy breaches. In those cases, we clustered according to the largest breach.

Second, we manually loaded the content from the two websites into a Microsoft ® Excel sheet. This allowed us to use Excel's filtering, searching and visual graphics in order to analyze and cluster the data. Thus, all figures in Section 4 are

our creation. The clusters were identified by means of selected GDPR articles, in addition to simple cluster techniques facilitated by reducing text [31] and creating small tables. Our goal was to pinpoint the concreate violation. For example, where the website read: "Failure to comply with processes principles", our analysis would divide this into "failure to act on subject request" and "unlawful processing of personal information".

3.3 Summing up the methods section

Our method for this whole study was guided by the *ladder of abstraction* from Carney (1990), cited in [32]. The researcher climbs the three main steps of the ladder by summarizing the data and identifying themes and trends before trying to explain the findings. This ladder proved useful for our study; however, it is worth mentioning that several iterations were made between steps 2 and 3, as illustrated in Fig. 3.

Step 3 (constructing an explanatory framework) New insights and confirmation of Colesky et al. (2016)'s and Solove's taxonomies (2006)	**Sections 4-6 in this paper:** Findings, Discussion and Conclusion
Step 2 (identifying themes and trends) Themes: clusters of violations, insights from experts Trends: increasing academic interest in privacy, increasing number of sanctions in the industry	**Sections 4 and 5 in this paper:** Findings and Discussion
Step 1 (summarizing and packaging data) Common traits of existing frameworks, interview transcripts in tables, matrix based on the website findings	**Section 3 in this paper:** Method

Fig. 3. Our complete method using *the ladder of abstraction* [32]

4. Findings

In this section, we present our findings from the interviews and from the analysis of the websites.

4.1 The interviews with experts pre-GDPR in 2018

In general, all four experts were positive about the coming GDPR and saw it as a necessity to increase awareness of privacy. The General Secretary of the Norwegian Computer Society argued that the handling of personal information had been inadequate, as '*companies do not have a conscious relationship to the information they actually have*'. In addition, supervision by the authorities had been lacking, and the '*GDPR makes people aware of this*'.

We observed that the various roles of our participants may have influenced some of their answers. For example, the General Secretary of the Norwegian Computer Society and the Commissioner of the Norwegian Data Protection Authorities had different perspectives on the regulation itself. While the Commissioner argued that it is a '*well written regulative*', the General Secretary claimed that the GDPR had been rushed through. Despite this, the General Secretary *loved* the citizen aspect of the regulation; however:

> '*The problem is that individual citizens really don't have a clue about it…[…]…Some of the articles you can read 2000 times, and still not get any wiser*' and '*I hope this [GDPR] leads to increased attention towards person value, but I believe the changes will be less significant than they should be*'.

The lecturer and privacy researcher at the University of Oslo agreed that even though the GDPR is better than the prior Privacy Act (in Norway), the phrasing is still obscure, making it difficult to '*give precise advice on the regulation*'. The lecturer also emphasized how the GDPR should have been more explicit: '*they have tried to ensure that there is some room for courts of law to create precedence in some areas. By making it a bit vague, they make this possible*'. The advocate stated that '*It is not possible to make a distinct regulation, because it will not be able to cover everything*'.

Regarding the fairness of the sanctions, the participants agreed on the necessity. The Commissioner of the Norwegian Data Protection Authorities stated that '*Sadly, there has to be a possibility of sanctions. If not, there is no leverage to ensure the fulfilment of regulations*'.

4.2 The interviews with experts following the GDPR in 2020

As mentioned above, we were able to conduct a follow-up interview with three of the four experts. None of them were surprised by the number of breaches and had expected more, but they suspected that not all violations are reported. According to the Commissioner of the Norwegian Data Protection Authority, '*a clear pattern of the cases is due to human error, poor training and lack of competence*'. The advocate was surprised that only two fines have been given in Norway as of February 2020. Regarding the fines, the experts perceive them as justified. The lecturer and privacy researcher points to the difficulty of *Article 17: The right to erasure* and points to the case in France with Google who defended itself based on this right (as also described by [15]). The commissioner says that it remains to be seen how the various data protection authorities will form a unified front.

In addition to the remaining difficulties with interpreting the regulation, all three experts agree that the GDPR has strengthened the rights of the data subject. The commissioner is pleased that more breaches are being reported, such as lack of access or lack of deletion. However, the advocate points to the cookie confusion on websites. This issue is addressed by existing research; however, the advocate sheds some new light, stating that:

> '*Gathering information about website users and customizing content and features on web pages is something most users probably want, but now there seem to be websites that completely refrain from collecting personal information. It is both unnecessarily from a legal point of view, and it impedes services offered and users' experience of websites and services. But this is a lack of understanding of the regulations, and not the GDPR itself*'.

4.3 The two websites for fines

Having scrutinized and compared the two websites, we present the following insights: (i) number of fines for each country, (ii) the size of the fines, (iii) clustering the five most frequent type of fines, and (iv) a timeline. Each insight is presented followed by an explanation.

Starting by the number of fines, we found that the total as of March 31, 2020 was 227. Fig. 4 shows that Spain has the most fines in Europe at 64. Lithuania, Malta, Croatia, and the UK account for one fine each.

Second, regarding the size of fines, the largest was given to Google in France (50,000,000 euros), while the smallest was given to a hospital in Hungary (90 euros). Google did not follow the principles of transparency, sufficiency of information and the presence of a legal basis. The hospital was fined for charging a copy fee and violating a patient's right to access data. A company cannot charge for a request for information, at least not for the first request [21]. In total, the sum of fines amounts to over 150,000,000 euros as of March 31, 2020.

Third, we carefully studied all 227 fines and clustered them into five main types (Fig. 5). Most of the fines were given for unlawful processing and disclosure of personal information; failure to act on and secure subject rights and personal information; and insufficient cooperation with supervising authorities. In two cases, the websites did not reveal the reasons for the fines (indicated as 'unknown' in Fig. 5). Following are the five clusters and some of the typical reasons for the fines:

1) unlawful processing of personal information: lack of legal basis of processing and lack of consent, especially regarding surveillance

2) disclosure of personal information: third parties acquired access to personal information without a legal basis or consent and publication of personal information on a company's website

3) failure to act on subject rights: failed to delete personal information upon subjects' request (subjects had not been informed about data processing)

4) failure to secure personal information: lack of organizational and technological measures, such as access management, securing containers and hacking prevention

5) insufficient cooperation with supervising authorities: company did not comply with measures imposed by the Data Protection Authority and refused to comply with the obligation to appoint a data protection officer

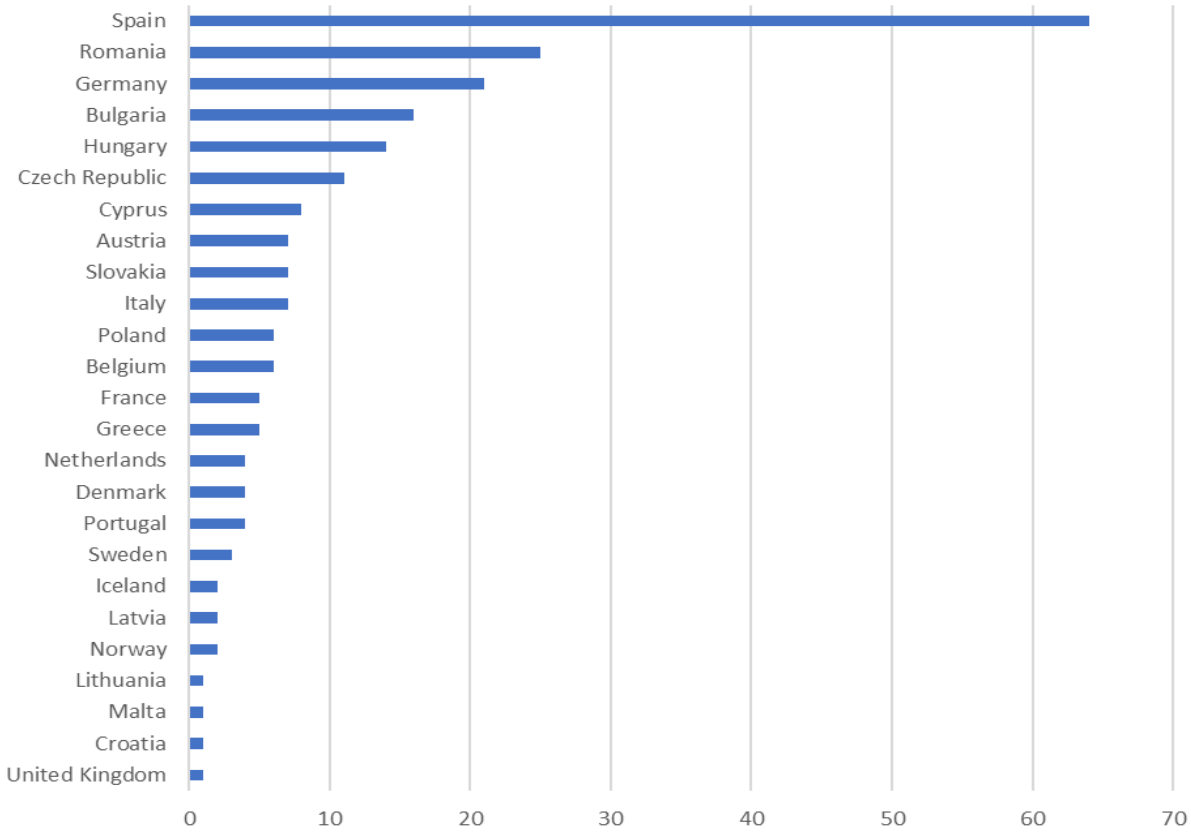

Fig. 4. Number of fines based on country

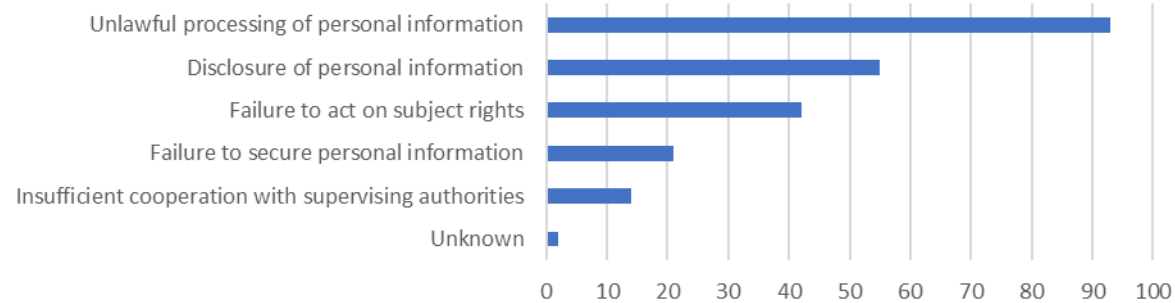

Fig. 5. Our clustering of the reasons for the 277 sanctions given as of March 31, 2020

From this clustering, we can also derive the most violated Articles of the GDPR (of which consists of 99 Articles and can be found here: https://gdpr-info.eu/). At the time of this study, the most frequently violated Articles were 5 and 6. Specifically, we found that Article 5, point (b): *Principles relating to processing of personal data* was most frequently violated. An excerpt of Article reads:

> '*…collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, in accordance with Article 89(1), not be considered to be incompatible with the initial purposes ('purpose limitation');…'* (https://gdpr-info.eu/).

Fourth, we created a trend line with dates of when the fines were given (Fig. 6). The graph starts in May 2018 when the GDPR came into effect and indicates an increase in fines over time (there were also 15 more fines, but the websites did not specify the dates and consequently they are omitted in this illustration).

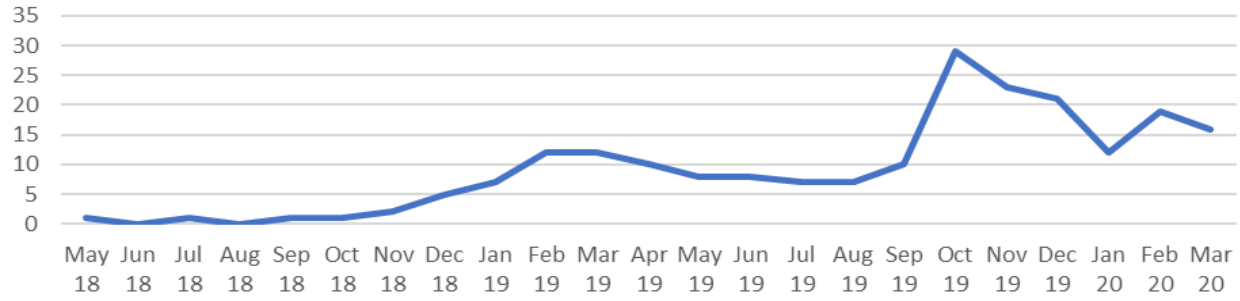

Fig. 6. Number of sanctions over time

5. Discussion

This section briefly discusses the findings from Section 4 and maps them against related research from Section 3. The four insights from the website analysis structures the section. The contribution is presented before pointing to limitations and suggested future research.

5.1 Number of sanctions for each country

According to the interviewed experts, the fines that have been given are not surprising, and they are justified. The experts mentioned that some fines may be the result of *'bad luck'* (at getting caught). For example, we do not believe that Spain is the 'bad seed' in Europe, despite the country's many sanctions. While we acknowledge that *'bad luck'* is probably not a favored term in research, it was nonetheless mentioned by the experts. The large diversity in the number of sanctions per country could also be explained by the fact that GDPR has replaced more than 40 privacy acts in European countries, thus a unified understanding is yet to be achieved. Koops [3] argues how this contributes to develop an incoherence between law and reality, and the advocate agreed and even claimed that parts of the regulation are '*not adjusted to the real-world (…) Some of the regulations is basically impossible*'. Both Koops and the advocate particularly referred to the articles on erasure.

5.2 The size of the fines

As presented in the Related Research, the potential size of fines can be substantial. Our findings range from Google in France (50,000,000 euros), to a hospital in Hungary (90 euros). The latter case makes us ponder, as most companies should be able to come up with 90 euros. Perhaps it was symbolic? The reason for the hospital fine was unlawful charging of a copy fee and for violating a patient's right to access data. These reasons are at least possible to rectify, which could be one reason for the low amount. Or, could it be due to the greater need of a hospital for Hungary: While

all of our experts agreed on the necessity of fines, they were equally unsure about the enforcement. According to the advocate, '*The Norwegian Data Protection Authority cannot give fines to everyone who is not totally compliant, that is impossible*'. With over 577,067 Norwegian companies (per 2018), the General Secretary argued that the Norwegian Data Protection Authority would lack the capacity to inspect all companies and had to prioritize the ones with sensitive personal data. Some of the participants argued that giving fines is the last solution; for example, the General Secretary said that '*because if they do so, it doesn't solve the problem itself*'. If a company gets a large fine, there is a risk of them becoming insolvent and sending employees to the Norwegian Labor and Welfare Administration, which is not beneficial for either the company or society. Therefore, the authorities will have to evaluate the consequences of imposing sanctions. However, the commissioner was certain that they would conduct signal audits, that is, using one company to set an example regarding the importance of the regulation.

On the one hand, existing research state that companies want to comply [22], but on the other hand, research also finds that the lack of resources as one of the biggest challenges for companies [18]. The General Secretary in the Norwegian Computer Society emphasized that '*unfortunately, I meet more and more people who say fuck it. They argue that they do not have the resources to prioritize it*'. The company attitude seemed to be that this issue was to be dealt with when or if it happened. The websites do not reveal whether warnings were given in all 277 cases we studied, so we cannot claim that warnings are always given before sanctions. However, we do observe several cases where the companies were given the possibility to rectify the situation but failed to seize the opportunity.

5.3 Clustering the five most frequent type of violations

We were somewhat surprised by the nature of the most frequent violations. From Solove's [33] taxonomy (right side of Fig. 1) the violations typically fall under *information collection* and *information processing*. Some of the reasons, according to the experts interviewed, might be complexity, lack of resources and lack of understanding, which has also been cited many times in the existing research. Despite this, we are puzzled. Should not some of these violations have been easily avoided? Why has so many failed to cooperate with the authorities? While some researchers have suggested that the emergence of big data would entail greater privacy risk (for example [29, 34]), our findings rather reveal that the violations are not necessarily rooted in big data.

In addition, from our own analysis of the websites we observe that private individuals have also been sanctioned. All seven of these cases related to 'non-compliance with lawful basis for data processing'. One case concerned disclosure of personal information, and the remaining six cases concerned surveillance (for example a trainer who filmed the team players in the wardrobe). Such surveillance can easily get out of hand. The Norwegian Data Protection Authority filed a complaint against a grocery store on February 28, 2020. The store manager filmed four under-aged people who stole, but this was not the problem. Rather, the violation was that the manager sent the film to an acquaintance, asking "Is this your son?" The mother replied "No, not my son" and forwarded the film to her son who then sent it to his classmates. Soon, the identity of the young shoplifters was exposed. The complaint, which can be read in full (Norwegian only) at https://www.datatilsynet.no/aktuelt/aktuelle-nyheter-2020/varsel-om-overtredelsesgebyr-til-butikk-tilknyttet-coop-finnmark/, does not include further discussion about the mother or the children who forwarded the film. We asked the juridical advisor at the Norwegian Data Protection Authority about the responsibility of the mother. The juridical advisor admitted that the Authority must prioritize their resources, but the most important issue was to target the data controller, which was also explained by the second juridical expert. This case, which was not settled at the time of publishing this study, is an example of the complexity of the GDPR's many articles, roles [20] and stakeholders, including the grocery store, the Data Protection Authority, the mother and the children. Whether the mother should have forwarded the video or whether she is to be considered as a data controller is beyond the scope of this paper.

We had expected more cases related to cookies and automated decision making [7]. One reason can be that it is easier to discover and prove that "you are filming me in the wardrobe" versus calling up your bank and claim "your algorithms are discriminating me".

5.4 Dates and timeline of sanctions

Our graph reveals a spike in October 2019, but we do not know the reason for this. One possibility is that the authorities accumulate the cases and settle them at the same time. Another possibility lies in the reply from one of the experts interviewed, who said that perhaps the countries are awaiting each other's actions. This spike aside, the graph indicates an increase in sanctions. Our graph may also demonstrate that the sanctions given in the wake of the GDPR have strengthened the rights of the data subject and increased the responsibilities of companies. However, both our expert interviews and related research agree that there are challenges associated with human interpretation of the regulations. It will be interesting to follow the trend of the graph in the future. We are only humble researchers, but we hope that this study provides insights to companies. Our implications for controllers are provided in Table 2 in the next section.

5.5 Contributions, limitations, and suggested future research

Our contribution is mainly for practitioners, as we offer a mapping of the violations and sanctions following the GDPR up to March 31, 2020. Table 2 presents the top five most common violations and our comments on what companies can do to learn from other's mistakes. We acknowledge that the comments are abstract, but they are based on real-life sanctions.

Table 2. Our main findings and implications for the controllers

Violations identified in our study	**Comments on implications for the controllers**
Unlawful processing of personal information	It is worth the effort to obtain control over the data being processed. Based on our study, this is a good place to start.
Disclosure of personal information	Our study does not indicate that disclosure was deliberate; rather, it appeared accidental in most cases.
Failure to act on subject rights	Establish routines for data management.
Failure to secure personal information	Gain knowledge or focus on how to protect personal data.
Insufficient cooperation with authorities	Follow the advice of data authorities, especially by ensuring routines and appointing a data protection officer (if needed). It should be easy to avoid a fine related to this type of violation.

Our study has several limitations, some of which are opportunities for future research. The first category is scope. The ethical aspects are beyond the scope of this study; we have focused only on juridical violations of the GDPR. In this regard, we have not paid attention to the potential non-monetary consequences of violating the GDPR. Existing research has mentioned loss of reputation [18], but more research should be conducted to determine what other impact receiving a fine might have on a company beyond monetary loss. For example, the Cambridge Analytica case resulted in a #deleteFacebook campaign, but the number of Facebook members still increases steadily [35]. Future studies can therefore investigate the effect of GDPR on the GAFA companies (Google, Amazon, Facebook, and Apple) and other large tech companies. Likewise, a study could be done on whether the GDPR has impacted companies' business models in general.

The second category regards our method. Starting with the most obvious, more in-depth case studies should be made on some of the cases from the websites we have analyzed. For example, we do not know the reason for the many violations of insufficient cooperation with authorities (as found in Table 2). Our first reaction was that this should be easy to avoid, but there may be reasons that are not listed in the websites. We also observe that some of the fines were reduced or completely withdrawn, but we did not investigate this further. It would be interesting to investigate if there are any typical actions that a company can take to make amends and reduce the impact once they have received an official complaint. Another limitation pertaining to our method is that our interviews were all conducted with Norwegian experts. We hope that future research can build on this article by interviewing similar respondents in Europe, but also in the USA where comparable laws and regulations are emerging. Finally, we welcome future researchers to duplicate and/or build on our analysis so that either confirmation and/or contraction can be made.

6. Conclusion

This explorative study has investigated the research question *What types of violations and sanctions have occurred following the implementation of the GPDR?* Based on an analysis of 277 violations and sanctions, we identified five main violations:

1) unlawful processing of personal information
2) disclosure of personal information
3) failure to act on subject rights
4) failure to secure personal information
5) insufficient cooperation with supervising authorities

Regarding the scope of the sanctions, the fines range from 50,000,000 euros to (perhaps symbolic?) 90 euros. Based on interviews with experts, the reasons range from companies saying: *'let's risk it'*, via wanting to protect information privacy but failing to understand the 99 articles of the GDPR, to simply poor data governance. We have addressed the implications for the companies in Table 2. Our contribution is mainly practical and aimed at managers in any organization whose goal is to protect information privacy and to learn from the mistakes made by other companies.

However, we argue that every actor - whether it be the authority (data protection authority), the controller (the company or processor) or the data subject (the individual) - has a responsibility. By analyzing and mapping the violations and sanctions, we hope that our study can contribute to a better understanding of the GDPR, both for the industry and academia. Albeit our study confirming existing research of the challenges of complying with the GDPR, the issues addressed in this paper should remain interesting to researchers in the future, as our findings indicate an increase in violations and sanctions.

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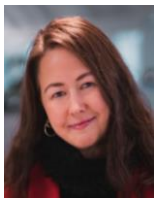
Biographical notes



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Skills of junior project management professionals and project success achieved by them

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Abstract:
New graduates are often placed into project management roles, but may face challenges in these roles. This study surveyed managers from Brazilian organizations and gathered information on the environment, practices and results of projects where new graduates were in project management roles. In-depth interviews were executed with a subset of these managers to further collect insights into issues surrounding new graduates' performance in project management. This paper examines the preparation and performance of new graduates in project management roles. It addresses specific project management skills and competencies that are involved in delivering successful projects and how these relate to project success or failure. The conclusions determined that new graduates are often not fully prepared for project management roles and fail to conduct comprehensive project preparations, often missing risk management; their soft skills are not fully developed creating further challenges; and the corporate environment towards project management may not lead to developing well-prepared project managers.

Keywords:
new graduates; project management; soft skill; project success; Brazil.

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1. Introduction

No matter the size of the organization involved, project management is closely related to current performance. When proven project management practices are implemented in organizations, organizations have higher rates of project success and are more successful in achieving business outcomes [1]. Project management has also been shown to be highly related to project success [2]. Use of a project management methodology (PMM) and use of a PMM that is robust enough to guide the project manager in comprehensive management of their projects both lead to higher levels of project success [3]. This makes project management a key skill for organizations to develop. Eighty percent of organizations consider that developing leadership and technical skills for managing projects is a priority for their organization [1]. This need to develop (or acquire skills) has also been shown to be important for program management [4], as well as project management. It has been noted that a "project manager's level of competency is often not equal to the new and dynamic challenges they encounter" [5], and their educational preparation may be lacking [6]. This need to develop effective project management skills may be especially true for new project managers.

Organizations hire new graduates who participate in and contribute to managing projects. The main research question of this study is:

RQ: How do new graduates perform in roles as project managers?

This paper addresses several fundamental questions about new graduates and their performance in project management roles. At what rates do organizations experience project success or failure, and what are the causes? Is the environment in their organizations adequately preparing new graduates for their project management roles? Are the project management skills needed present in new graduates when they leave their schools? Are these new graduates prepared for managing projects in their organizations? Are the project management methodologies used by these graduates sufficiently robust to lead to project success in their organizations? This paper examines the preparation and performance of new graduates in project management roles. It addresses specific project management skills and competencies that are involved in delivering successful projects, and suggests what can be improved so new graduates are prepared to manage projects and organizations can achieve the best results from developing and applying the skills and competencies of new graduates.

The next section presents a 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 follow. The final section of this study contains concluding remarks about the research and the list of main research findings, followed by research limitations.

2. Literature Review

2.1 Challenges of Preparing Project Managers

Project management remains a skill set that is in strong demand, not only in project management as a profession and career [7], [8], but also in other professions such as banking [9], construction management [10], information technology [11],[12], librarianship [13],[14], operations research [15], supply chain management (SCM) [16], and technical communication [17]. One study found that approximately 37% of jobs being recruited for in one professional field require project management skills [15]. A limited supply of project management resources has been acknowledged for quite some time [18]. The need for project management professionals continues apace, with a projection that 22 million new project management roles would be created around the world by 2027, with demand for project managers growing faster than that for workers in other occupations [19].

A recent study of American four-year college graduates and their employers found that "many employers see these new hires as poorly prepared for life on the job" [20]. The study goes on to indicate that thirty percent of graduates feel that their education did not well prepare them for their initial employment, and more specifically, that 19% of four-year graduates and 25% of two-year college graduates feel underprepared in project management. Most recent graduates

(67% of recent graduates) feel that they are very or completely prepared to manage projects using key steps, resources, and timelines [21]. However, the same study reports that 46% of hiring managers feel that recent graduates are very or completely prepared to use their skills in their new organization prepared to manage projects using key steps, resources, and timelines [21].

Institutes of higher education, including colleges, universities and polytechnics, are primary sources of education of new graduates entering the work force. Their education covers technical skills relating to project management, soft skills relating to people and relationships, and career readiness relating to a successful transition into the workplace [22], [23]. Graduates develop skills in project management skills (planning, leading, organizing, coordination and control though group projects in their education [24]. However, they noted that students had less experience with planning and especially with leading in projects in their academic settings.

The primary cause of failed projects is an inexperienced project manager in 20% of failed projects [1]. Another study [25] determined that there is a difference between the importance of individual project management skills in students' perceptions and the importance placed by employers and recruiters.

Project management capabilities (or the lack of them) have been shown to influence project success and failure [26-30],[2]. These capabilities span the typical project management lifecycle, but also include the front-end of projects before these typical project lifecycles begin, addressing program and portfolio management, development of the business case, benefits/value management and stakeholder management [26]. Capabilities addressing the front-end of projects have been shown to have a large influence on project outcomes [26]-[30], with Ahonen and Savolainen [27] finding that some projects were cancelled due to mistakes made before the project is started.

Sage et al. [31] suggest that project management failure is often assumed to be an evidence of deficient management, and thus, a problem that can be overcome by better management. It has been shown that investments in a project management, including dedicated Project Management Offices (PMOs), project management processes, standardized training and use of trained project management personnel, project management career paths, and standardized project management methodologies) were found to be positively related to qualitative and quantitative benefits accruing to the organization [32]. While it has been shown that these investments can lead to positive outcomes, it has also been shown that project management methodologies are sometimes not followed by project managers [33].

Organizations have needs for both training to accomplish current role assignments of their personnel, and competency development to address the future needs of the individual and the organization [35],[22]. Organizational efforts in project management training have been shown to impact project success, specifically a positive significant impact on schedule performance [36]. Organizations that invest in formal development of their project management personnel experience not only greater retention of those critical competencies than in organizations which do not invest in development, but also to greater project success in the organization [37]. This paper makes a contribution by addressing the need for competency development, which is not a common theme in studies of project success [38].

2.2 Need for Soft Skills as well as Project Management Skills

Technical, or hard skills, in project management are comprised of the project management competencies used in implementing common project management life cycles, embodied in standards and handbooks, such as the PMBOK [39]. Söderlund and Maylor [40] argue that the hard skills in project management are necessary, but not sufficient, to be successful in delivering projects and their benefits. Others, such as Ruuska and Vartiainen [41] have found that traditional project management competencies, even though they are perceived as being critical, are not in themselves sufficient, and there is a need for project managers to develop soft skills, such as communications. Mateo et al. [42], determined that the work environment of project managers demand both hard and soft skills. Recently, it has been predicted that the emerging work environment will place a greater importance on soft skills [43].

The International Competence Baseline defines project management competencies in three categories: technical, behavioral, and contextual competencies [44]. Soft skills encompass the behavioral and portions of the contextual competencies of the IBC4. One study determined that these soft skills were more important in hiring new graduates than

the technical skills [45],[46]. Soft skills have been identified as necessary competencies for project managers by numerous studies [10],[47]-[49],[34],[50]-[54]. In her review of generic qualities that are most valued by employers, Cicekli [55] determined that many of the skills sought by employers are generic or soft skills. These skills include communication, interpersonal and persuasive, and teamwork skills, time management, flexibility and the ability to deal with ambiguity and change, motivation, ownership and sense of achievement, organizational effectiveness, and leadership skills [48],[55]-[58].

However, Carvalho, Patah and Bido [36] concluded that the various bodies of knowledge [59] defining project management and their related maturity models focus mainly on the hard skills. There is a need for organizations to develop the project management competencies [22],[60] needed to effectively engage in project management roles by their new staff members. These needed competencies encompass not only the technical competence, but also contextual competence, addressing the context of the project and organization, and behavioral competence, relating to those soft skills and leadership skills necessary for project success [61],[47],[1],[44]. Azim et al. [56] argue that the importance of people aspects of projects and the underlying soft skills are essential for project success, while another study [58] concluded that soft skills have more influence on projects' success than do technical skills.

2.3 Project Management in Brazil

Among Latin American countries, Brazil is seen as having a leading role in the PM area, due to its large numbers of chapters of the main project management associations (PMI and IPMA), and has more than 15,000 certified Project Management Professionals (PMPs) [62] (cited in [36]). Benitez Codas [63] provides a historical perspective on project management in Brazil, emerging from industrial firms, construction, and hydroelectric projects. Brazil has been characterized "as an emerging economy is becoming a significant global player, not only in economic terms and the growing global impact of its multinationals, but also for its increasing role in science and technology." [64]. This background provides a rich organizational context for examining project management. Of the top 100 organizations in Brazil, sixty-four percent of these organizations have adopted some manner of formalized project management processes [65].

Project management skills are in demand in Brazil across multiple industry sectors [66], with a forecasted job demand of over one half million new project management roles forecast to be created by 2027 [19]. Studies focusing on project management issues within the Brazilian setting are rapidly emerging [34],[36],[51],[67]-[76], reflecting the growing importance of, and demand for, project management expertise in the region. However, in a recent study of project management in a large Brazilian financial institution, it was determined that a lack of adherence to project management methodologies was influenced by a lack of knowledge regarding project management and the methodologies in use [67]. This reported knowledge deficiency motivates this study of project management skills of new graduates in Brazil.

3. Method

This study focuses on understanding the performance of new graduates as project managers, and how their organizations and their processes enable or inhibit performance by new graduates in project management roles.

3.1 Research questions

The research questions are:

- RQ1: What rates of project success/failure and causes for failure do organizations experience?
- RQ2: What are the key attributes of the organizational environment that new graduates performing project management operate within?
- RQ3: Which skills were presented by new graduates as project managers?
- RQ4: What are the organizational needs and project management skills and how well are new graduates meeting these needs?

3.2 Research approach

This is a descriptive research study [77] that aims to observe and report certain phenomena relating to the skills of new project managers and the project success they achieve in Brazil. It is based on a mixed methods approach utilizing both survey research and interviews. In this study, the mixed methods approach allows triangulation by obtaining interview insights beyond the survey research.

A questionnaire-based survey technique has been widely employed in project management research [78],[79]. A questionnaire-based survey was used in the first phase of this research to collect the professional views on soft skills and project success. While the first phase of the research used survey-based research among managers, the second phase consisted of in-depth interviews with a subset of survey respondents. We validated survey responses and gained additional insights from the in-depth interviews.

3.3 Participants

Participants were volunteers and were recruited through their involvement in executive education programs or the American Chamber of Commerce.

In the first phase, the survey was conducted with mid-level and senior managers from several types of corporations in Brazil. Most of the participants' firms are multinational corporations or large Brazilian companies. Each participant was selected in order to ensure that each participant met these three criteria: (1) had experience with project management practices, (2) manage a team that executes projects, and (3) include within their reporting staff (during the recent past) project managers who were recent graduates.

The second phase, field research conducted in parallel with the survey, telephone interviews were held with a subset of the survey respondents. The six respondents who were selected from the survey population to take part in these interviews were all managers at multinational companies operating in Brazil; three were general managers and three were senior managers. The six interviewees met the selection criteria described above, including having recently had new graduates in project management roles in their reporting staff.

3.4 Materials

The online survey was developed and deployed using SurveyMonkey. The survey was structured as a questionnaire with multiple-choice responses. The questionnaire addressed the following topics:

- Project success: Project success was examined to understand the frequency of project success or failure, as well as eliciting which project success criteria [52],[68],[78],[80] were the proximate causes of project failures experienced. Chipulu et. al [68], have argued that cultural backgrounds may influence perceptions of project success/failure factors. For this reason, the second phase interviews were planned to better understand how new graduates performed and how their performance related to project success/failure.
- Evaluation of the organizational environment for project management: The company environment for the execution of projects was examined to understand the environment in which new graduates were employed. The intent was to explore if the environment was conducive to a successful project management across all phases (planning, execution and conclusion). The questions in this section were divided between evaluating the users' role and organization's project management environment.
- Evaluation of skills presented by new graduates as project managers: The skills of new graduates during the execution of projects was evaluated to determine which skills were more used and which skills were most lacking. The questions in this section were divided among these topics: scope definition, execution skills, and soft skills.
- Results of projects managed by new graduates: The results of projects managed by new graduates can be traced back in part as a result of their demonstrated project management skills. The questions in this section requested information on project failure rates (for the projects managed by new graduates), as well as the reasons for their failures and success.

- Needs of the company for project managers: What does the organization expect from new graduates' project management skills? What is the organization's perception of how well their new graduates are performing as project managers?

It was determined that the survey has face validity as, on review by the researchers of both the instrument and responses, the questions measure what they are intended to measure. The researchers also determined the survey has content validity as both researchers reviewed questions and ensured they cover relevant aspects to address the research questions being measured. Further reliability of the survey instrument was confirmed through the in-depth interviews as a means of assessing alternate-form reliability.

3.5 Procedure

The survey was available for a period of one month. The in-depth follow-up interviews were conducted during the same period. Interviews went into greater depth on the survey topics, emphasizing the interviewees' perceptions regarding new graduates as project managers, their performance and challenges.

4. Results

Seventy-two participants meeting the criteria were invited to complete the survey. Forty-five participants returned a survey and 38 completed the full survey, resulting in a participation rate of 52.7%. Respondents were from Brazilian firms and multi-national firms operating in Brazil from numerous industries, including banking and financial services, educational institutions, retail and consumer goods, high-technology, manufacturing, pharmaceutical, and transportation. The survey results were collected and tabulated in Excel and analyzed for the frequency of the responses. The following tables present the survey results addressing each of the topics surveyed.

Table 1 depicts the project failure rates in the participant's organizations. 21.05% of respondents report that projects usually fail in their organizations, while 78.95% report that projects occasionally fail. Respondents note that their organizations do not always have successful or failed projects, but that all organizations report that they have experienced failed projects.

Table 1. Project Failure Rates (N = 38)

	Never Fail	**Occasionally Fail**	**Usually Fail**	**Always Fail**
How often projects fail in your organization?	0.00%	78.95%	21.05%	0.00%

Table 1 illustrates that all respondents' organizations experienced both successful and failed projects. Table 2 addresses the causes of project failure and success reported by participants in their organizations. This table depicts common causes recognized by respondents, but does not explore the root causes behind these reasons for project failure and success.

Table 2. Reported common causes of project failure and success (N = 38)

Cause of Failure	**Frequency of Occurrence**	**Cause of Success**	**Frequency of Occurrence**
Lack of performance or did not achieved the specified outcome	13.16%	Performance or specified outcome achieved	76.32%
Overrun in costs	13.16%	Costs under budget	18.20%
Over the deadline	13.16%	Delivered before deadline	5.36%
Changes on scope during project execution	28.95%	Other	0.00%

Cause of Failure	Frequency of Occurrence	Cause of Success	Frequency of Occurrence
Changes in resource allocation during project execution	10.53%		
Risk factors not identified initially	18.42%	.	
Other	2.63%		

The organizational environment for project management addresses the interplay of the roles of end users, as stakeholders, and the authority which the organization assigns to project managers. Table 3 presents survey responses regarding the roles of stakeholders while Table 4 depicts the survey responses regarding the authority of the project manager regarding the project.

Table 2. Organizational Environment: End User Role (*N* = 38)

In a typical project, the end users describe:	Never	Occasionally	Usually	Always
What the best project return would be for them	2.63%	10.53%	39.47%	47.37%
What the minimum acceptable outcome of the project for them	0.00%	31.58%	44.74	23.68%
The bottom line impact of the project	0.00%	18.42%	31.58%	50.00%
Desired deadline and milestones of the project	2.63%	26.32%	42.11%	28.95%
Clear outcomes for the project	0.00%	13.16%	44.74%	42.11%

Table 4. Organizational Environment: Authority of the Project Manager (*N* = 38)

In a typical project, the project manager has authority to:	Never	Occasionally	Usually	Always
Terminate a project without obtaining the planned results when facts to base this decision on are presented	39.47%	34.21%	21.05%	5.26%
Select and/or change project participants	2.63%	31.58%	52.63%	13.16%
Propose modifications to the scope in order to achieve a cost, schedule and performance balance	0.00%	26.32%	34.21%	39.47%
Recognize project participants	2.63%	21.05%	42.11%	34.21%
Penalize participants that do not deliver in their commitments?	10.53%	31.58%	39.47%	18.42%

As new graduates join their organizations they are assigned to project management roles and perform in those roles. As we saw from the literature review, they must perform both project management activities and exercise tasks requiring soft skills as they perform in these project management roles. Table 5 presents the extent to which these new graduates in project management roles perform these tasks. Table 5 focuses on tasks in two key areas of project management: scope management (covering skills in project initiation and planning) and project execution (covering skills in planning, execution, monitoring and control of the project). Table 6 shows the performance of tasks requiring the use of soft skills by the new graduates.

Table 5. Typical project management activities performed by new graduates as project managers (*N* = 38)

	Never	Occasionally	Usually	Always
Scope definition: does the project manager conduct interviews that request:				
What resources would be available to complete the project	2.63%	18.42%	47.37%	31.58%
Who should participate on the project	0.00%	23.68%	42.11%	34.21%
Who are the key stakeholders	5.26%	31.58%	34.21%	28.95%
Previous experiences with similar projects	0.00%	26.32%	42.11%	31.58%
Reporting needs from end users	0.00%	28.95%	44.74%	26.32%
Execution: does the project manager develop, negotiate and maintain:				
Work Breakdown Structure	0.00%	39.47%	36.84%	23.68%
Project Schedule	2.63%	0.00%	34.21%	63.16%
Task list and Priorities	0.00%	2.63%	44.74%	52.63%
Risk / Potential Problems management	5.26%	39.47%	28.95%	26.32%
Commitments from the project participants to complete their project tasks on schedule and delivering the requested result.	0.00%	18.42%	53.26%	26.32%
Documentation and Review routines	0.00%	31.58%	50.00%	18.42%
Reporting	0.00%	28.95%	36.84%	34.21%

Table 6. Typical soft skills activities performed by new graduates as project managers (*N* = 38)

	Never	Occasionally	Usually	Always
Soft skills employed:				
The project manager sells the upgrade to participants and end users before or during the conduct of the project when a project objective can be upgraded (better result, lower cost, faster completion, longer commercial viability, etc.)	2.63%	21.05%	44.74%	31.58%
The Project Manager is able to persuade people to support the project using benefit-focused techniques.	0.00%	34.21%	39.47%	26.32%
When benefit-focused persuasion techniques are ineffective and the success of the project is put in doubt, the Project Manager is prepared to and effective at generating project support by appealing to authority.	0.00%	52.63%	36.84%	10.53%
Coaching is provided or arranged by the Project Manager for reluctant, underperforming participants before they compromise the project schedule.	0.00%	26.32%	52.63%	21.05%
Delegation is only used with project participants who are not fully skilled in their assigned tasks but who are motivated enough to learn how to perform them successfully.	0.00%	28.95%	50.00%	21.05%
Able but reluctant project participants are pre-sold on the project to gain their commitment and are regularly re-sold until their project responsibilities are completed.	5.26%	26.32%	60.53%	7.89%

The previous Tables examined which skills were utilized, but do not delve into the capabilities of the project managers in those projects. As project manager capabilities can influence the outcome of projects, we examined the skills and competencies of these new graduates performing in project management roles. Table 7 reports respondents' evaluation of the skills and competencies of new graduates in project management roles, in light of their organizations' needs.

Table 7. Evaluation of skills of new graduates in project management roles (N = 38)

	Poor	**Below Average**	**Average**	**Very Good**	**Excellent**
Ability of gather information and define project scope	7.89%	42.11%	28.95%	21.05%	0.00%
Evaluate project risks and manage them	26.32%	47.37%	18.42%	7.89%	0.00%
Evaluate resources needed and manage them	21.05%	50.00%	28.95%	0.00%	0.00%
Create a WBS (work breakdown structure) and/or Project Schedule	7.89%	28.95%	39.47%	21.05%	2.63%
Execute the project according to the plan	2.63%	28.95%	44.74%	23.68%	0.00%
Coordinate adjustments to the project, as needed	7.89%	52.63%	28.95%	10.53%	0.00%
Report out project completion rate and next steps	2.63%	26.32%	34.21%	31.58%	5.26%
Complete the project within the performance, time and costs planned	5.26%	26.32%	39.47%	26.32%	2.63%
Execute post-mortem analysis and gather learnings	5.26%	39.47%	39.47%	15.79%	0.00%

Table 8 presents the manager's ratings of the importance of project management skills of newly hired graduates, given their understanding of the needs of their organization.

Table 8. Importance of project management skills of newly hired graduates (N = 38)

	Not Needed	**Optional**	**Required**	**Important**
Project management	5.26%	23.68%	47.37%	23.68%
Project scope management	2.63%	10.53%	44.74%	42.11%
Project risk management	5.26%	7.89%	26.32%	60.53%
Manage project execution	0.00%	21.05%	65.79%	13.16%
Influence people to achieve goals	0.00%	15.79%	23.68%	60.53%
Conflict management to resolve project issues	2.63%	13.16%	18.42%	65.79%
Reporting and presenting skills	0.00%	15.79%	42.11%	42.11%
Different methods of project management (i.e., Agile, SCRUM, etc.)?	5.26%	50.00%	28.95%	15.79 %
Project management software skills	2.63%	26.32%	55.26%	15.79%

5. Discussion

5.1 The organizational environment for project management

A total of 86% of all surveyed managers responded that, in a typical project environment, project customers usually or always describe what the best project return would be, and 82% of customers usually or always communicate what is the "bottom line" of the project.

Related to the authority that is given to the project manager, the majority of respondents showed that the project manager cannot terminate a project, even when it is proven that the scope received is unattainable. Respondents reported that these terminations are allowed in 6.7% of their organization, but 77% of respondents described that the project manager is allowed to propose modifications to the scope to achieve the project results.

The project managers have limited freedom to select project participants (82% of the respondents described that a project manager usually or occasionally could select the project participants). Most organizations allowed recognition of project participants (80% of responses of "always" and "usually"), but did not support penalizing project participants who do not deliver their commitments (55% of the responses).

In the direct interviews a strong bias towards execution emerged. Few of the interviewed managers described all the phases of project planning, including risk management. The preparation phase was often confused with an initial interview where the goals of the project and deadlines were described, suggesting that project managers get directly into execution phase.

Summarizing the information collected in this part of the survey and the interviews regarding the organizational environment for project management, it can be concluded that in the typical project setting project managers have no clear planning phase where the desired project results are communicated, and very little attention is dedicated for project evaluation including risks analysis of the project. There is a strong focus on execution. In the execution phase, the project managers have relatively good freedom to select and recognize the project participants, but restricted freedom to address low performance. This is in contrast to more experienced project managers who tend to take a longer-term view and a higher-level view of their projects [79].

5.2 Results of projects managed by new graduates

Survey participants responded the main causes of project success as being when they achieve the desired outcome (76%) or when costs were under budget (18%). Fewer respondents (5%) indicated that executing projects within the agreed deadlines was the main cause of project success.

An estimated 55% of projects are described as failing in some aspect. It was also responded that projects led by new graduates "occasionally" (78.90%) fail in their organizations and the main causes are scope changes during project execution and risks that were not identified initially taking place. Changes in project scope and risks encountered account for 48% of project failures.

5.3 Evaluation of skills presented by new graduates as project managers

Organizations identify project management skills, emphasizing scope management and risk management, and soft skills, emphasizing influencing skills, conflict management, and communication (reporting and presenting) as important skills that newly hired graduates should have, as shown in Table 8. They also identify as necessary skills for managing project execution and using project management software. Knowledge of a diversity of project management methods was perceived as having lesser importance for new graduates.

Most of the responses showed that new graduates are usually executing interviews, meetings and information gathering to define a project scope but with some faults: 79% of responses showed that "always" or "usually" the new graduates as project managers collect information on resources available for the project and participants, but there is slightly

reduced attention to collect information on who should participate in the project, who are the key stakeholders, previous experiences of similar projects and the reporting needs of project customers. Over 5% of responses indicate that new graduates never address identifying who are the key stakeholders for their projects.

Table 7 shows that new graduates performing in project management roles are ranked average or below average for many of their project management skills. The weakest skills noted were risk management, resources evaluation/management, and making coordinating changes in the project. Stronger skills were noted in project execution-focused skills, such as executing the project, reporting on project status, and driving the project to completion.

In the interviews, it was also found that there is a lack of attention to risk management as no interviewed managers showed that new graduates executed any form of risk evaluation and management plan during the scope phase. This is consistent with other recent studies of project risk management which identified lack of competence or a fear of being perceived as not having competence as reasons for disengagement from risk management [81].

Related to project execution skills, the data collected shows that new project managers are focused on using a schedule and task list for managing their projects. New graduates use schedule and task lists as their main tools (97% respondents showing it as "always" and "usually") but a much smaller number of the new graduates are using WBS (work breakdown structure) and risk management as part of the project management (60% of respondents showed that WBS is at least "usually used" and 55% showed that there is active risk management for their projects). As a practice, routine reviews and reporting were rated lower with 50% of the responses showing that these actions "usually" take place in projects.

The soft skills of new graduates as project managers were noted as a concern by interviewees, consistent with the survey data collected. Of all skills assessed the majority of respondents felt that, at best, the new graduates "usually" showed the desired soft skills. This result is consistent with other studies of project management practice, as Carvalho [34] reports a lack of efficient use of performance reporting and communication planning, and that communications processes documented in organizations' project management methodologies are "neither followed nor prioritised by project managers". However, this skill assessment contrasts with the results of this and other studies [48] that have placed high importance on the soft skills needed by project managers.

"Selling up" was the only soft skill considered to be strong (76% of responses in "always" and "usually"); persuasion, delegation and coaching were considered weaker (44 to 52% of the responses showed that these were behaviors only seen "usually") but addressing low performance and issues were rated as weak (use of authority when needed was 52% in "occasionally"). This importance on influencing others is consistent with other studies, which have identified this as a highly important skill [50].

The lower frequency of demonstrated desired soft skills by new graduates could be related to their limited experience as professionals, but also with a lack of preparation during their academic life. Most interviewed managers believe that a better job must be done to develop such skills prior to the entry of graduates into the work life.

5.4 Future organizational needs for project managers

Survey respondents were requested to consider their organizations and their future needs in identifying what were the key aspects of project management that were needed, as well as ranking them in importance. The project management skill itself was considered as minimum required or very important by 71% of the respondents. Within the other most important skills were conflict management (65%), followed by the ability of influencing people to achieve goals and risk management, which has been identified by other studies as a critical dimension of project manager competencies [47].

As minimum skills required the ability to manage the project execution, ability to work with project management software and scope management were identified. Knowing different project management methodologies were considered to be less important.

Survey participants were requested to rate the skills of new graduates as project managers as compared to what was desired of new graduates. In all the aspects, new graduates were rated mainly between "below average" and "average", as shown in Table 7. Managers identified as stronger aspects of new graduates' performance their ability to create a WBS or schedule and then execute and complete a project according to a plan, and to report progress and next steps, while coordinating adjustments to the project, risk management, and evaluation and management of resources needed were rated as poor.

When asked the importance of skills, the most important, must-have skills are risk management, influencing skills, and conflict management. The skills that respondents felt were required of new graduates were project execution and ability to use project management software. The skill that respondents felt was not important at the entry-level was an understanding of a diversity of project management methods. It is very important to note that the very important skills for the organization are the ones that are being rated poorly for new graduates in their project management roles, especially risk management and soft skills. This is consistent with prior risk management research that showed that the soft side of risk management explains over 10% of project success [51].

A study focusing on the most important skills for successful project management identified that leadership and people-related skills were slightly more important than project planning and execution [5]. This contrasts with the results found with new project managers who were strongly biased towards project execution, lacked planning skills and were less effective in using the people and soft skills necessary to accomplish their roles successfully. Abramo and Maltzman [5] identify communication as both the most important project management knowledge area and as the most important personal competency for a project manager. This study shows that new project managers are rated poorly in this aspect of their performance.

5.5 Implications for Practice

A number of actions could be undertaken to improve the success of new graduates in project management. These actions could include actions undertaken by educational institutions, employers, and by new graduates themselves.

There is a perceived gap between what educational institutions are offering and what is needed to deal with projects in the ever-increasingly complex work environment, especially regarding soft skills [82]-[84],[43]. Educational institutions could explore ways to reinforce the preparation of their students to manage projects. A special focus must be on the project preparation phase (scope, WBS, risk management) and on soft skills; proficiency in these skills should be demonstrated by students in practical projects during their academic preparation. The PM Curriculum and Resources [85] establishes a proposed set of learning objectives and curricula that can be adapted by educational institutions to support development of project management educational offerings, including courses on project management foundations and on project teams, leadership, and communication.

Organizations could consider developing competency development actions for new graduates, including mentoring opportunities making available more experienced professionals to coach new professionals. This study confirms earlier research [6], as it shows that graduates are often arriving at their organizations with a basic education and set of skills, but they do not have all of the skills they will need to be successful project managers. Not all organizations are taking the steps needed to develop the needed skills and competencies. Worldwide, sixty percent of organizations provide training on project management tools and techniques, while 45% of organizations have a formal process for project management competency development [1]. Coaching and mentoring have been identified as critical capabilities in the competency development of an organization's human capital [26]. Mentoring has been identified as a technique for developing project management [86]. New graduates often do not have deep exposure to the organization's environment and will copy current project management practices, such as a bias toward direct execution. Good coaching can also assist to develop the needed soft skills that most of new graduates have not yet developed, but which are skills where the competency development mechanisms in the workplace may contribute more to their development than academic courses or formal training [87].

New graduates could take responsibility for ensuring the development of their competencies in all aspects of project management – not just the technical skills, but also in the soft skills and leadership aspects and the knowledge, skills and ability to follow proven project management methodologies.

6. Conclusion and Study Limitations

During the interviews, several managers reinforced that the performance of new graduates as project managers was a direct reflection of their poor preparation during their college studies. The results of this study show, that while there is good reason for these opinions, that is the not the single cause of the poor performance. New graduates are leaving college demonstrating good skills to execute a basic project preparation and to execute projects, but not executing important project management requirements as risk management, change management and ongoing management of work breakdown structures and schedules. It was pointed out that their projects fail most due to changes of scope and risks that were not planned for. The current environments at the surveyed organizations do not foster good project management practices. Furthermore, they have a strong bias toward direct execution. In this environment, coupled with new graduates' skills for basic project preparation and execution, the new project managers tend to follow this practice of focusing on project execution and reporting.

New graduates may not have enough of the work-life experiences that provide them with the needed soft skills for successful project management. Many of these leadership and soft skills have been found to be correlated with project success [88] and have been perceived as more important skills for project managers than their technical skills [89]. Recent studies indicate that leadership skills have a direct influence on the success of project managers and projects with 66 percent of organizations identifying leadership skills as being most important for the early success of project managers [90].

In their review of Brazilian management studies, Rodrigues et al. [64] explore the role of an inside-out approach to research, learning from indigenous questions and informing global research understanding. This paper, while addressing indigenous project management performance in Brazil, may also contribute to the development of universalistic theory [64] by exploring issues of new graduates in project management roles in Brazilian organizations that may provide insights into similar issues and needs for qualified new graduates in other global organizations. It points out the need for providing, and the consequences of not providing, continued project management competency development in organizations to adequately prepare new graduates for increasing responsibilities. With the projected growth in demand for project managers and project management competencies, need for continued growth in project management competencies as new hires move toward mid-level roles, and continuing difficulties in recruiting sufficient numbers of personnel, investing in competency development for project managers can lead not only to increased success, but also to greater retention of those competencies in the organization through less employee turnover [37],[91].

Regarding study limitations, the data analysis was conducted on a single sample in a single country whose size is limited, but adequate, for this research design. Consequently, no generalizable confirmation of the findings was done, although interviews did confirm our survey results. 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. The focus of the study was on organizations and their experiences with new graduates in project management roles. Future studies may remedy the above noted limitations by addressing these limitations.

The method used to gather survey data may have limited the participants to those individuals of leading firms who engaged in professional development of their employees (through executive education) or to those active in business and trade (through the Chamber of Commerce), and may be biased in several ways. First, the sample may be biased towards larger organizations more capable at selecting and developing its employees. Second, it may be biased towards organizations focused on international trade, neglecting firms with a domestic focus. These biases could influence the results, but the expected direction would be towards greater capability and project performance, which may suggest that with a wider sample it is possible that the picture painted by this study may be too positive, with actual results from a wide census of organizations possibly reflecting lower overall project management performance.

A second limitation to this study lies in the use of a survey research methodology for primary data collection. There is possibility that a potentially sensitive topic as performance (of new graduates and projects in the organization) might cause a social desirability bias in responding to the survey. This potential limitation was offset by securing managers' cooperation and willingness to participate in response to invitations to participate that guaranteed anonymity to respondents. A large percentage (over 50 percent) of those initially contacted completed the online survey. Follow-up interviews with a selected sample of managers and senior managers, drawn from the survey respondents, indicated they had no hesitation in expressing their perceptions about performance of new graduates and projects in their organizations.

A third limitation is the selection of project managers to focus on in this study. This study focused on project managers who are recent graduates, but does this without comparing them with the more senior or more experienced project managers. While we assume that more experienced project managers might perform better because of their experience, we cannot demonstrate that in this study.

Subsequent studies could explore a variety of other factors that may impact the types of results found in our study. These studies could include factors such as the performance of both new and experienced project managers, organizational capabilities, the length of a normal or representative project in the organization, industry sector, focus of the projects undertaken by the organization, size, complexity, or budget of projects, international involvement, project management methodologies in use, or greater examination of soft skills in the project management setting.

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Smart Project Management Information Systems (SPMIS) for Engineering Projects – Project Performance Monitoring & Reporting

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Smart Project Management Information Systems (SPMIS) for Engineering Projects – Project Performance Monitoring & Reporting

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Abstract:
Engineering projects are becoming increasingly complex as projects get larger and as technology improves. Greater competition worldwide has meant that projects are delivered quicker and cheaper. This necessitates sophisticated Project Management Information System (PMIS) technologies to be adopted to improve efficiency and quality on projects. PMIS data and reports can be used to better understand the risk exposure, resource utilisation, profitability, and scheduling of a project. It also informs strategic project decisions and performance monitoring and reporting. Unfortunately, project data is often fragmented and embedded in different systems. This paper investigates several commercially available PMIS, to understand and compare the functionality of these systems. A qualitative study using semi-structured interviews was conducted with purposively selected project systems experts at twelve project-based organisations. Thematic analysis revealed what functions PMIS fulfils, how these systems are integrated and how they facilitate project monitoring and reporting. Moreover, a novel model for the basic architecture of a 'Smart' Project Management Information System (SPMIS) is proposed, which would facilitate software integration and intelligence based on identified industry needs and requirements. The model addresses the shortcomings of existing models by combining models and incorporating system intelligence i.e. the automation of certain project management activities.

Keywords:
Project Management Information System; technology; project performance; monitoring; reporting; Smart Project Management Information System; PMIS.

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1. Introduction

As global competition grows there is ever-increasing pressure on projects to deliver faster and more cost effectively, leading to the necessity to adopt new technologies. These developments will most likely influence the way projects are structured, the way in which project management is carried out and the nature of projects themselves [1]. PMIS can streamline the management of data required for project planning and performance monitoring, to increase competitiveness and the chances of project success [2]. Retnowardhani and Suroso [3] evaluated five case studies which found PMIS to have advantages such as correct decision making based on visibility of accurate project performance data and improved project performance by increasing communication through the aid of PMIS. Software can make project management easier by simplifying and/or automating the execution of various project tasks [4]. New PMIS applications enable project managers (PMs) to spend less time on repetitive rule-based tasks, enabling PM's to spend more time focusing on higher order functions such as innovation, creativity, stakeholder relations and strategy [5].

We are living in a digital era i.e. the 4th Industrial Revolution or Industry 4.0, which is characterized by businesses utilizing digitization, automation and information and communication technology in increasing measure [6]. The recent advances in the creation and storage of big data, provides the foundation to drive the implementation of new digital technologies in projects. To monitor projects, up to date and accurate project data is required. This data should be collected and presented to the project stakeholders for evaluation. The project performance data is usually summarized into a project report or on a digital dashboard. However, to generate these reports tends to be a difficult and time-consuming exercise as data is often fragmented and contained in different software applications. The rapid advances in digital technologies holds promise to create a 'Smart' PMIS (SPMIS) which can consolidate, analyze and interpret numerous data sources to assist PM's to monitor multiple, complex projects. Data is the fuel for analytics that will drive automated project management functions. Project management offices with access to data will be able to make full use of new technologies and will have a competitive advantage over companies who do not have access to data [7].

Projects are becoming increasingly technically complex with more pressure to complete the project in less time and at a reduced cost. This is mainly due to increased competition and stakeholder expectations. Engineering companies generally manage several different projects simultaneously. This makes the task of monitoring and controlling multiple projects difficult. Data from PMIS is generally fragmented because it comes from different software applications and sources. In most cases the data is captured manually, and the data is manually imported and exported between software applications. This is a laborious and time-consuming process which is prone to errors. The lack of quality live data and real-time reporting can negatively impact strategic decisions, risk exposure, resource planning, profitability, and stakeholder relations in projects. The existing commercially available PMIS systems as well as the conceptual models found in the literature do not address all of these issues in one system or conceptual model.

This is an exploratory study which investigates organizations in the construction and engineering industry as well as commercially available PMIS used in these industries. The following premises were used to formulate the research questions for the study:

The degree to which organizations can integrate project data between systems, influences the accuracy and timeliness with which the data can be pulled into project reports for decision making.

- How are companies integrating the PMIS that they use?

By understanding the methods used to monitor project performance provides guidelines for improving PMIS for project reporting.

- How are companies reporting on project performance?

By understanding how the ideal PMIS should function and the shortcomings of existing PMIS, a new conceptual model can be developed.

- What are the main characteristics of the ideal PMIS?

By understanding the functions of the different commercially available PMIS, the strengths and weaknesses of the systems can be identified, and the new conceptual model can incorporate these findings and better align the theory with the existing systems.

- How do the commercially available PMIS functions compare with each other?

The next section of the paper recalls the previous research on PMIS systems, project performance monitoring and reporting. The literature review also compares several existing PMIS conceptual models. We then describe our research methodology, which included numerous industry interviews and PMIS software investigations. We also describe our qualitative study results and discuss the implications. Finally, we propose a new conceptual model for the basic architecture of a Smart Project Management Information System (SPMIS).

2. Literature review

2.1 PMIS Definition and Functions

PMIS can be described as a computer-based information technology software system, which is used by organizations to generate, store and manage project data in pursuit of optimal project performance [7]. PMIS systems are usually made up of several different software packages which enable more efficient resource scheduling, information management and distribution, knowledge repositories and cost management systems [8]. The PMBOK Guide [8] states that, "automated gathering and reporting on key performance indicators (KPI) can be part of this system".

PMIS was introduced to the market in the late 1970's, created by companies such as Oracle, Artemis and Scitor Corporation [9]. However, it was only in the late eighties and the nineties that project management software was more widely used as more and more people started using personal computers. During this time both the software and the techniques for managing projects developed rapidly [9]. Over the last decade PMIS have changed considerably, driven by the advances in new technology and the need for better systems. PMIS have evolved from systems that only manage project scheduling and resources, to comprehensive systems that support many of the other project management functions at a project as well as project portfolio level [2].

The PMBOK Guide [8] provides the following categories and functions of PMIS:

- Scheduling software – assists with planning mapping out project timelines by providing tasks with start and finish dates and provides the links between the tasks. These are commonly known as Gantt charts. The software greatly enhances the speed to create as well as update these charts.
- Cost Control Software – assists with project cost control and includes spread sheets, statistical analysis and simulation tools which can make it easier to estimate costs and evaluate cost estimate alternatives.
- Resource Management Software – assists to optimize resource utilization and highlight where resources are constrained, the software can help manage resource groups, track resource loading, record time sheets and associated resource costs.
- Information (document) Management – assists with project communication enabling stakeholders to source and share documents in a timely way. These systems can be in the form of specialized project information portals, web interfaces, collaborative work management tools and dashboards.

2.2 PMIS project monitoring and reporting

The PMBOK Guide [8] explains that one of the benefits of project monitoring is to allow stakeholders to know the current state of the project in relation to cost and schedule. The actual measurements or observations of project activities is called work performance data. This typically includes percentage work completed, start and finish dates of activities, number of change requests, actual costs, and durations. This data is collected from the different processes or business areas in the project, throughout the lifecycle of the project. The interpretation of the data provides insight into the condition of the project and enables the stakeholders to take corrective or preventative action.

Project performance monitoring has been extensively covered in the existing literature [10].Głodziński [11] developed a conceptual framework to highlight the complexities around project performance drivers, including the interdependency between project performance and project management performance. The research provides a new framework for evaluating project performance by evaluating both the quantitative and qualitative aspects of project performance. The quantitative measures are defined as financial performance which includes all financial data related to income and expenditure. The qualitative project performance measures include aspects like quality and stakeholder satisfaction. The qualitative and quantitative information are combined to produce project performance reports. Díez Silva et al. [10] provide a comprehensive list of the most common project performance measures found in the literature as shown in Table 1.

Table 1. Categories for measuring performance in project management literature [10]

#	**Category**
1	Time
2	Cost
3	Quality
4	Customer satisfaction
5	Organizational – management
6	Staff
7	Efficiency
8	Scope
9	Communication
10	Changes
11	Effort
12	Profitability / Benefits
13	Contracts/ Procurement
14	Risks
15	Safety & Health
16	Conflicts / Arguments
17	Environment
18	Urgency
19	Commitment
20	Successful implementation
21	Relevance / reassessment
22	Diffusion

Several techniques can be used to analyze data, for example cost benefit analysis, earned value analysis, trend analysis and variance analysis. Project performance is usually measured against a project baseline, which is put in place during project initiation [12]. Typically, time, resource, cost and technical variances are measured, however it is cost and schedule variance which is most often analyzed [8]. Project data is communicated in the form of status reports or progress reports. The reports are usually illustrated with charts, trend lines, graphs, color signals and additional written

commentary on project performance and risks is often provided. The project data which is used to compile project reports is often stored in a PMIS.

2.3 Documents and data

Documents can be defined as a set of data or meta data. A document carries information that can be shared and stored. In the case of electronic documents, documents are any source of data which is stored in a database. Some of the document types that exist in a project environment include quotations, invoices, meeting minutes, drawings, forms, emails, specifications, and test results [13]. Many different types of data can be generated by PMIS, including project management data, system management data, model data and meta data. Each of these data types can be broken down further into smaller parts or subsets, each type of data has its own attributes. These attributes typically include start and finish times, duration, and status [14].

Digital documents allow many advantages over other types of documents because each instance of data movement leaves a trace. Most project documents are in a digital format and the generation, sharing and modification of documents is almost all done by computers and computer networks. The traces that these documents leave can be exploited to measure and analyze the activities in an organization or project. Document creation and evolution within projects can reflect or indicate the performance of an enterprise or project. Documentation and project performance are also closely linked; therefore, project performance can be monitored by tracking documents [13].

2.4 PMIS software & evaluation

Kostalova et al. [4] compare different PMIS on the market including several freeware software packages. The software review includes Project Libre, Gantter and Easy Project as well as licensed software such as Microsoft Project and Primavera. Freeware cloud-based tools offer limited functionality and are only suitable for small or simple projects. The more sophisticated software has financial limitations and demands extensive training to use these software applications [4].

Rautenbach and Schutte [15] developed a software application to help organizations select PMIS based on several evaluation criteria broken down into three main criteria as listed below. The tool was tested by several experts and the constancy ratio of the outputs from the different experts were all found to be consistent.

PMIS functional criteria include:

- Integration management;
- Scope management;
- Cost management;
- Time management;
- Quality management;
- HR management;
- Communication management;
- Risk management;
- Procurement management.

Criteria specific to each organization include:

- Perceived usefulness;
- Perceived ease of use.

Software acquisition criteria include:

- Software cost;
- Maintenance and support;
- Implementation and training.

Jaafarit and Manivong [16] also reviewed existing PMIS systems. Their sample consisted of 24 PMIS systems, half of which were commercially available at the time and the other half were in house propriety software applications. They used a scoring system where they scored the software applications against the ideal project management system. The results show that the top scoring software applications fall short of the ideal project management system, the ideal system would result in a score of 100, however the best scoring system only received a score of 39 [16].

2.5 Smart project management information systems (SPMIS)

The concept of a SPMIS was introduced by Jaafarit and Manivong [16]. Their research describes an advanced PMIS to support more complex projects. They use the word smart to highlight additional system intelligence when compared to existing systems on the market. The authors provide some valuable insight on SPMIS. They emphasize that the system should have live real time data which is easily accessible to the project stakeholders. The system should be flexible and able to accept different types of data and information sets. Moreover, it should be extensive in terms of the different functions that the software can perform and intelligent in its analysis and overview capabilities over the project lifecycle. When reviewing the PMIS systems of the day, they stated that micro computers were not powerful enough to create and run a SPMIS. They also noted that most of the PMIS on the market are not designed to "facilitate proactive project management, or even provide integrated evaluation of traditional areas such as cost, time and risks or handle information management, a function which the authors view as an essential, integral part of project management"[16].

Similarly, Braglia and Frosolini [17] proposed an information control tower model which emphasized a PMIS that integrates multiple complex projects into one digital platform. The study found that the platform saved time, reduced errors, and rework and improved document management and overall communication amongst the team members [17].

2.6 Conceptual models

Over the past few decades PMIS have evolved from single project management systems to dynamic multifunctional and multi-project systems that are no longer limited to only project planning and cost control functionality [18]. Several authors have provided models which conceptualize these multifunctional systems. The development of project management theory is beneficial as it can be applied by project managers and organizations for managing projects [19]. Four existing conceptual models [16, 17, 20, 21] are reviewed to gain a better understanding of the basic architecture, functionality, and system characteristics of SPMIS. The focus of these four models are summarized in Table 2. Each model has some unique features as well as common features which are listed in Table 3.

Table 2. Existing conceptual models

Authors	Model description	Main emphasis of model
Jaafarit & Manivong, 1998[16]	Broad Concept Architecture of the SPMIS	System should handle hard and soft project management functions over the entire lifecycle of the project.
Braglia & Frosolini, 2014[17]	Control Tower Application Model	System is characterized by a central control tower, which interfaces with other databases and systems from the different functional areas of the organization and other organizations.
El-Omari & Moselhi, 2011[20]	Proposed PMIS Architecture – Automated Data Acquisition from Job Sites	System emphasizes automated data acquisition from job sites into a centralized database.
Zamani et al., 2017[21]	PMIS – The Interplay Between Communication, Information & Intelligence	System emphasizes an internet-based system which functions over the entire lifecycle of the project, with integral links between communication information and intelligence.

Table 3. Existing conceptual models' characteristics

Main system characteristics	Jaafarit & Manivong, 1998[16]	Braglia & Frosolini, 2014[17]	El-Omari & Moselhi, 2011[20]	Zamani et al., 2017[21]	Total
Centralized data base			✓	✓	**3**
Real-time data	✓	✓	✓	✓	**4**
Project portfolio management		✓			**1**
Automated data inputting			✓		**1**
Intelligence, decision making, future forecasting & scenario planning	✓	✓	✓	✓	**4**
Compatible with other software	✓	✓	✓	✓	**4**
Easy access to information	✓	✓	✓	✓	**4**
Project reporting/tailored information outputs	✓	✓	✓	✓	**4**

2.7 Literature review synopsis

The PMBOK Guide [8] provides substantial theoretical knowledge on how projects are monitored and the role of PMIS in projects. The PMBOK Guide [8] does not advocate or rank existing PMIS in the market nor does it refer to intelligent PMIS systems. It also does not address how project reports, containing extensive data from projects, are generated and presented to stakeholders.

Project performance is well documented in terms of both quantitative and qualitative project performance measures [10]. However, the literature does not provide solutions on how organizations can efficiently create and manage all the performance data and easily integrate it into project reports.

Four different conceptual PMIS models are identified in the literature. There is no distinct or unified conceptual model for the architecture of an advanced PMIS. The existing models have similarities, however, these models also differ quite substantially. Therefore, the opportunity exists to provide a more unified model which combines common as well as unique characteristics of the existing models.

Kostalova et al. [4] compare the capabilities of the different applications by means of a check box table, while Jaafarit and Manivong [16] use a scoring system. Primavera is the only application tested by both authors. Unfortunately, Kostalova et al. [4] PMIS review methods are poorly defined, while Jaafarit and Manivong [16] PMIS scoring results are no longer relevant as most of the software that was reviewed is no longer commercially available.

The literature review revealed the need for a more up to date PMIS investigation of the latest commercially available software applications. The literature review also identified that a more unified conceptual model of advanced SPMIS is required, which has the potential to solve the problem of fragmented data sources from different PMIS in projects. According to Brynjolfsson et al. [22] from MIT, "one thing we've learned about digital progress is never say never. Like many other observers, we have been surprised over, and over again as digital technologies demonstrate skills and abilities straight out of science fiction. In fact, the boundary between uniquely human creativity and machine capabilities continues to change."

3. Research methodology

The research includes two main approaches; semi-structured industry interviews and PMIS software review as shown in Figure 1. The two approaches were used to gain knowledge to develop a new SPMIS conceptual model.

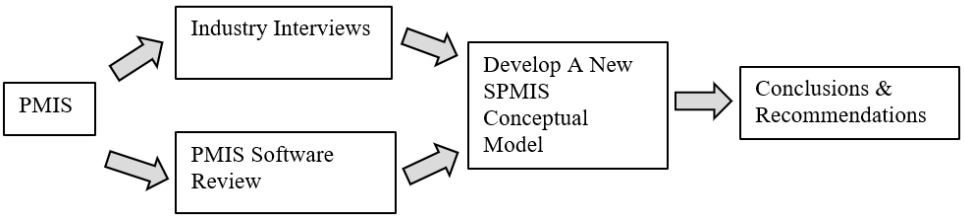

Figure. 1. Research design schematic

3.1 Industry interviews

Guest and Johnson [23] suggest that at least twelve in-depth interviews should be completed where the aim is to understand commonalities between similar types of groups. According to this recommendation and the time constraints of this study, thirteen interviews were completed. The research participants were purposefully chosen from different project-based organisations for the qualitative study. Research participant 10 and 11 were from the same organisation. The selected project-based organisations were all within the South African engineering and construction sector. The selected organisations all manage multiple projects varying in size from smaller feasibility studies to very large engineering and construction projects. Organisations which handle large projects were purposively chosen because more sophisticated software is required to handle the size and complexity of these projects [11].

The designation of the chosen research participants included senior project managers, senior project controllers or director level employees in the organisations. They had job descriptions which included managing, monitoring or controlling multiple large engineering and construction projects.

The semi-structured interview consisted of 25 questions. Further follow-on questions were used in some instances to prompt more feedback regarding certain topics. Each interview took approximately 40-60 minutes, it was voice recorded, transcribed and then coded in Atlas.ti using thematic analysis. The demographics of the research participants and their project-based organisations are provided in Table 4.

Table 4. Participant demographics

Interview	**Job title**	**Industry**	**No of projects in progress**	**Project size in Rands** [1US$=15 Rand]	**Project duration range**
1	Projects director	Construction management - retail & warehousing	30	500K-1G	0.5 - 24 months
2	Senior project manager	Construction management - retail, hospitals, hotels, industrial	50	1M-500M	4 - 24 months
3	Program manager	EPCM - Energy, oil & gas	10-12	10M-2.5G	12 - 120 months
4	Head of projects	Scientific & engineering construction projects	7	2G-3G	60 - 96 months

Interview	Job title	Industry	No of projects in progress	Project size in Rands [1US$=15 Rand]	Project duration range
5	Projects director	EPCM - Mining & mineral processing	10-20	2M-150M	4 -15 months
6	Program manager	EPCM -Water treatment & plant manufacturing	4-5	1M-400M	3 - 96 months
7	Capital planning manager (PMO office)	Mining, mineral processing, schools & hospitals	137	100K-5M	2 - 36 months
8	Senior project manager (Director)	EPCM - Ferro alloy & energy	3	100M-1.5G	16 - 22 months
9	Chief Executive Officer (CEO)	Construction & fabrication of building glass & aluminium facades	25	1M-120M	6 - 18 months
10	Project services hub leader	EPCM - Construction duplexes, simplexes, low cost housing, water & transport infrastructure	1200 (Southern Africa)	500K-1G	1.5 - 72 months
11	Digital practice leader	EPCM - Construction duplexes, simplexes, low cost housing, water & transport infrastructure	1200 (Southern Africa)	500K-1G	1.5 - 72 months
12	Project controls manager	EPCM - Base metals, pyromet & hydromet	600 (Africa, Europe Middle East)	2M-10G	6 - 36 months
13	Contracts director	Construction/building of commercial, industrial and retail buildings	25	100M-500M	12 – 24 months

* K=Thousand M=Million G=Billion

3.2 Software review

An internet search on Capterra, a software review website, revealed that there are at least 500 commercially available software applications that can be used for supporting project management [24]. Therefore, it was not practical to review every commercially available PMIS. Rather the results from a survey by Ilyas, Hassan and Khalifa [25] of approximately 25 project managers in the construction and energy/oil industry in Europe, the Middle East and Africa (EMEA) was used together with the findings from this research to determine a shortlist of five different PMIS to be reviewed in this study, as listed below [25]. Each PMIS was investigated by interviewing software sales consultants, reading product brochures, assessing website content and watching software demonstration videos online.

- CCS Candy;
- MS Projects;
- Primavera;
- Aconex;
- Trimble (Project Sight).

Table 5 lists the main functions of five commercially available PMIS. A scoring matrix which is adapted from Kostalova [4] includes some additional project functions which were used to score the PMIS.

Table 5. PMIS Software Review Matrix

PMIS FUNCTIONS	MS Project Online	Oracle/Primavera	CCS	Oracle/Aconex	Trimble
1. WBS & Gantt chart	✓	✓	✓		
2. CPM (critical path method)	✓	✓	✓		
3. Time sheet system	✓	✓			
4. Task management (social collaboration)		✓		✓	✓
5. Cost and financial control	✓	✓	✓		✓
6. Risk management		✓			
7. Document management		✓		✓	✓
8. Field management		✓		✓	✓
9. Automated data inputs (from field instruments)					
10. Resource levelling or histogram	✓	✓	✓		
11. Project performance data reporting/dashboards	✓	✓	✓	✓	✓
12. Workflow management				✓	✓
13. Customisable project reports	✓	✓	✓	✓	✓
14. Live data reporting/cloud based	✓	✓	✓	✓	✓
15. Project portfolio management (ppm)	✓	✓			
16. Ability to use data from past projects					
17. Compatible with other software applications	✓	✓	✓	✓	✓
18. What if analysis (scenario planning)	✓	✓	✓		
19. Earned value and s-curves	✓	✓	✓		
20. BIM & drawing mark-up interface			✓	✓	✓
SCORE :	12	15	11	9	10

The research results show that according to the criteria in Table 5. Primavera has the most PMIS functions based on the study sample. However, the other applications are not too far behind. Each software application has strengths and weaknesses when compared to the other applications, these are listed in Table 6.

Table 6. PMIS strengths & weaknesses

Software Application	Core Strengths	Weaknesses
MS Projects	▪ Scheduling ▪ Cost effective ▪ Easy to use ▪ Most widely used in industry	▪ Cost management ▪ Risk management ▪ BIM and drawing interface ▪ Field management
Primavera	▪ Scheduling ▪ Resource management ▪ Portfolio management ▪ Risk analyses	▪ Cost management ▪ Workflow management ▪ BIM and drawing interface
CCS	▪ Cost management ▪ Scheduling ▪ Earned value integrator	▪ Portfolio management ▪ Document management ▪ BIM and drawing interface
Aconex	▪ Document management ▪ Workflow management ▪ Field management ▪ BIM and drawing interface	▪ Scheduling ▪ Cost management
Trimble	▪ Cost management ▪ Document management ▪ Workflow management ▪ Field management ▪ BIM and drawing interface	▪ Scheduling ▪ Portfolio management

None of the PMIS used machine learning based on historical project data or had automated data capturing. These shortcomings remain major challenges as well as opportunities for future development.

4. Results

4.1 PMIS utilization

The research results indicated in Table 7 show that many different PMIS applications are used to fulfil multiple project functions. For example, research participant 4 makes use of Primavera for project schedule management, resource management and time sheets. The results also show that the organisations do not use each PMIS application to their full functionality. For example, research participant 3 makes use of an enterprise resource planning (ERP) software called IFS for time sheets rather than using Primavera. Research participant 3 described the organisations approach to software selection as the “best of breed”, for each project management function, where they use the strengths or core functions from different PMIS applications on the market.

Table 7. Utilization of PMIS software

Inter-view	Project Cost Management	Time Sheets	Project Resource Management & Histograms	Document Management & Workflow Management	Project Schedule Management	Drawing & BIM Software
1	MS Excel	None	None	Windows Server Based	MS Project	None
2	PPO	PPO	None	PPO	MS Project	
3	IFS	IFS	Primavera	Aconex & M-Files	Primavera	Autodesk Revit
4	Great Plains	Primavera	Primavera	EB, Google Drive	Primavera	
5	Cispro	SDK	MS Project	DR Pro, Windows, done manually	MS Project, CCS Candy	Autodesk, Smart Plant, Aveva
6	Envisage	Clock o Fi	Asana	EB	MS Project	
7	Prism, SAP, Excel	Saeco	None	Standard Windows Server	MS Project	Autodesk, Pro-Engineer
8	CCS Candy	None	None	Solidworks	MS Projects	
9	MS Excel, Pastel & V6	MS Excel	CCS Candy	Wownet, MS Team Member	MS Projects, CCS Candy	Bentley/Navisworks
10&11	BST Global, Revit, Builder	BST	MS Excel	Share Point, BIM 360	MS Projects	
12	SAP, Trimble, CCS Candy	SAP bolt on, custom built tool	SAP bolt on, custom built tool	Livelink	Primavera & MS Projects	Solidworks/Revit
13	CCS Candy, BuildSmart	SAS (custom in house system)	SAS (custom in house system)	Docwise	CCS Candy	

*MS=Microsoft PPO=Project Portfolio Office CCS=Construction Computer Software

4.2 PMIS integration

The results show that no project management functional area stands in isolation, all the functions worked together to ensure successful project implementation. Therefore, when data is located in different PMIS applications, organisations find it challenging to integrate data across systems. The data is either integrated manually, requiring user interface, or it is automated through the software. The integration enhances the software's capability and provides better information to the users.

In table 8 summarised feedback from the interviews, show that the greater the number of projects being handled by an organisation the more sophisticated the software application needs to be to manage the large amount of data generated. This claim is substantiated by research participants 10, 11 and 12 who's organisations have built a centralised database system to deal with this problem. These organisations were then able to build earned value tools as well as reporting and dashboarding tools from the database. These findings support the new SPMIS conceptual model which is presented in this research.

Table 8. Research participants' comments on PMIS integration

Partici-pant	Research Participants Summarised Comments
1	**MS Excel – MS Project –** "Information is entered manually in the master schedule based on progress from the Quantity Surveyor and other contractors monthly. "
2	**PPO** – "Project cost management, timesheets and document management and workflows are integrated into one system. The integration of schedule and costs are not done in this organisation." **PPO – Autodesk –** "Drawings are uploaded manually into the system."
3	**Primavera** – **"**Project resource management and project schedule are integrated across projects to provide resource histograms. Organization had an application programming interface (API) developed to link the enterprise resource planning (ERP) IFS cost management system to the Primavera schedules, however this created a lot of friction because the planners schedule updates were dominating the information on the cost control system." **IFS – "**Time sheets are integrated with the project cost management sheets." **Primavera - IFS –** "Reverted to having separate systems with manual entry of data between the two systems. Primavera does have its own cost control capability, however IFS is the main company asset, and a substantial investment has been made implementing the system which has a time component capability which the organisation then reverted to." **Aconex – Autodesk – "**Documents are uploaded from Autodesk into Aconex, where they are distributed."
4	**Primavera** – **"**Project resource management and project schedule are integrated across projects to provide resource histograms." **Primavera – Great Plains** – "The progress information and time sheets are fed manually to Great Plains. Participant acknowledged that it could be done better, they are investigating ERP's systems which can do better integration."
5	**SDK-CISPRO – "**Timesheet data from SDK is imported into Cispro cost control software. However, this is a manual process where data is first exported into Excel, where macros are written to import into Cispro. Once data has been imported it must be checked manually to confirm that the data has synced correctly." **MS Projects – "**Data from separate project schedules is collected and then a new schedule is manually developed to understand how the projects overlap at an organisational level." **MS Projects/CCS** – **Bentley/Navisworks – "**In some cases the schedule is linked to the 3D model. This allows you to build construction sequence animation videos. You first need to code each section in the model and group it together, you need to make sure all your coding is correct and it's a complicated procedure, so it is not being utilised on all projects, only where the effort is justified." **MS Projects – Bentley – Cispro –** "In some cases a link is set up where the model can download a bill of quantities (BOQ) based on the progress which can then be manually integrated into the cost reports."
6	**Clock o Fi - Envisage** – "Time sheet data entered manually into the ERP system."
7	**Excel – Prism – "**Base line budget done in Excel and uploaded into Prism." **Saeco – SAP – "**Time sheet directly integrated with cost control system which is SAP." **MS Projects – Prism** – "MS Projects integrates the project schedule into Prism. The schedules sit on the server and are manually uploaded into Prism." **Prism – SAP** – "The project cost sheets in Prism are integrated with SAP, there is a SQL database so there is a live link."
8	**MS Projects** – **CCS Candy** – "MS Project schedules get uploaded into cost control software." **Solid Works** – "Integrates the 3D models with project documentation and workflows."
9	**MS Excel – Pastel** – "Time sheet hours captured in excel against certain cost codes. This information is then manually fed back into Pastel." **CCS Candy** – "Integrates the schedules with resources to do resource management, however the organisation reverted to Excel because the person with the skills to operate the system left the organisation."

Partici-pant	Research Participants Summarised Comments
10&11	**Digital Work Space (Share Point) –** "The organisation developed a digital cloud based workspace, where the different software applications could be easily accessed in one location by clicking on the different project functions which includes an approvals portal, WBS breakdown development portal, the project cost and pricing management portal, the project schedule portal and the business intelligence portal where the data can be pulled into various project performance dashboards. The organisation is also working on integrating BIM360 and ProjectWise into the platform digital workspace, to have full integration and accessibility across all functional areas." **BST Global – Project Time Sheets** – "Are directly linked in the software to the project cost control sheets at a task or activity level." **BST Global – MS Projects Online** – "The different task 'percentage complete' values are manually exported into BST to determine forecasts and earned value measurements." **MS Projects - Navis Works – "**The schedule is linked to Navis Works to create 3D animations of construction sequence. This is not a seamless process so if the model changes the schedule doesn't update automatically. Difficulty in translating schedule to actual site construction sequence." **Autodesk/Bentley – Cost & Pricing Tool** – "The bill of materials which comes from the 3D design models is exported manually into the cost and pricing tool."
12	**Note:** The organisation developed a cloud-based structured query language (SQL) database which, enables data sharing and visibility across all the applications to facilitate extracting data for project reporting, including a custom-built earned value tool. The tool takes the timesheets, schedule, documentation and drawing progress information and automatically correlates it to the project cost codes with SAP to calculate earned value and project performance indices. **CCS Candy – Trimble** – "Budget estimates are done in CCS and budget costs are then manually exported into Trimble to establish the baseline costs." **SAP** – **Trimble** – "Trimble only captures SAP manhour costs as a cost account." **SAP** – **Custom resource tool** – "Pulls data from SAP and into custom built resource tool which compares actual hours versus planned hours." **MS Projects/Primavera – Navis works** – "Integrates schedule with a 3D model, to create 3D simulations of construction sequence."
13	**CCS - BuildSmart –** "CCS captures revenue, budgets, and schedule, BuildSmart captures costs of procurement, BuildSmart is integrated into CCS to compare revenue vs cost. Ledger numbers need to line up on the two software systems to enable integration and do proper comparisons to calculate margins." **SAS (Internal custom-built tool)** – "Integrates time sheets and resource management."

Data generated from PMIS is used by the organisations, to support monitoring and reporting of projects. The research results for project performance monitoring is summarized in Table 9.

Table 9. Project performance monitoring and reporting

Method	Explanation
Fundamental understanding of the project	There is a need to be able to determine if the data received is correct. People can manipulate data to hide things and there is the need to know how to identify erroneous information. There is a need to understand the information behind the data, like the organization's strategic objectives for the project, or where things have gone off track, to really be able to make sense of the data.
Project performance reviews	Regular meetings are required to monitor and control projects. Meetings are an effective way to collectively review project performance data and for managers to get deeper insight on project performance. Typically, project teams meet weekly and senior management or

Method	Explanation
	executives meet monthly to review project performance data.
Project performance measures	The results show that the top three performance measures used by organizations for reporting are, cost, schedule and risks/issues. Other common measures are health and safety (H&S), earned value measurements, forecast 'schedule to complete' and forecast 'cost to complete'.
Project reporting	The results show that project performance data is collected from project managers, contractors, site teams, cost controllers, planners, photos, drone footage as well as from the PMIS. The data is often pulled together into an MS Excel, MS Word or MS Power Point document to compile monthly project reports. Generally, reports contain graphs and colors to illustrate the data. Reports are typically created for management executives or clients.

4.3 The "ideal" SPMIS

This section investigates several of the most important characteristics for the ideal SPMIS based on information obtained from the research participants. The characteristics for the "ideal" system are summarised in the Table 10.

Table 10. Characteristics of the ideal SPMIS

Characteristic	Description
Increasing efficiency and time savings	The system should save the user time so that minimal man-hours are required to manage the system. There is no question that the data generated from PMIS is useful to the organization however it is always a time versus benefit trade-off. The research results show that some organizations purposely choose not to use sophisticated systems due to the time involved to operate them. System functionality is not always the problem but rather the time required to use the systems. Upload and download speeds were also mentioned as a problem.
Accessibility to project information	The system should have all the information in one place which is easy to store and retrieve. The system should provide easy access to good information so that people are empowered to make informed decisions on projects.
Automated data capturing and validation	The system should be able to either capture data automatically or automatically validate any of the data being captured or fed into the system. The systems are only as good as the quality of the data being fed into them. Data capture should be made as easy and seamless as possible, as data capture remains a problematic area in projects due to the human factor where data may be manipulated or entered incorrectly.
Flexibility & adaptability	The reporting system should be easily adaptable to present different information to different stakeholders, even to the extent where the same data can be customized and presented in different formats like tables or graphs. The system should be adaptable to organizational business processes as well as to each project's diverse requirements. Software should also be adaptable as the project is executed and requirements change.
Simplicity of system	The system should be simple enough to be used by the wider organization and not only by specialists who are trained in each specific software application. An integrated system is required, that everyone can interpret. Software functionality is often not the problem but rather the availability of expertise required to use the software to its full functionality.
Intelligence	The quality, quantity and the format of data are three important factors that will enable machine learning in projects. This data can be leveraged through machine learning to monitor the performance of projects as well as automate many project management functions. The challenge however lies in the SPMIS having enough intelligence to understand the complexities of each project, and to let the system operate autonomously with limited human interaction.

4.4 SPMIS conceptual model

A new proposed conceptual model is presented in Figure 2, which was developed using the findings from this research.

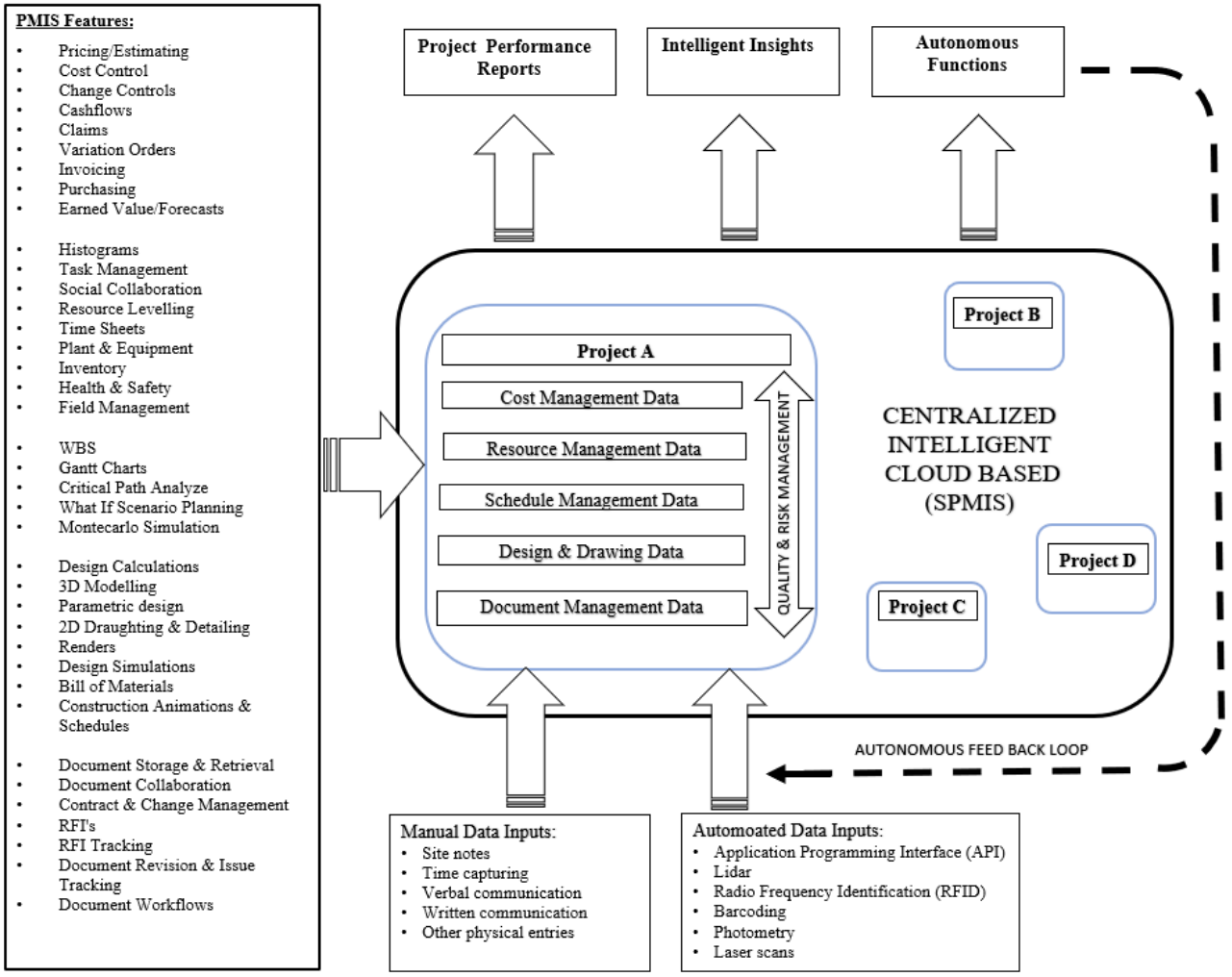

Figure. 2. New proposed SPMIS conceptual model basic architecture

The various PMIS functions are listed in the left-hand column in Figure 2. These functions can be completed by multiple PMIS applications and are categorized into five main categories, namely, cost management, resource management, schedule management, design and drawing, and document management. These categories are aligned with The PMBOK Guide [8]. Except for the category of design and drawings, it was evident from the research that the project organisations who completed engineering in house made use of sophisticated 3D design software which was integral to their operations. These systems often had additional functionality known as building information modelling (BIM) allowing real time data sharing and collaboration over the life cycle of the project. The BIM systems can have a time dimension (4D) and a cost dimension (5D) as well as other relevant project data linked to the model as part of the BIM integrated project delivery approach [26].

The conceptual model is designed to be flexible whereby different software applications can be used for individual projects, depending on the project's requirements. The results from the industry interviews show that typically quality management and risk management are not separate PMIS applications, but rather that use of PMIS helps improve quality and reduce risk. For example, document and workflow PMIS can improve quality on projects by ensuring that documents are reviewed and approved and then distributed to the correct people on the project team. The same could be said for risk management, using PMIS to support and improve the management of projects across the different functional areas naturally leads to risk mitigation.

The sources of data are fed either manually or automatically into the system. Manual data entry requires a user interface to capture and enter data while automated data capture is data that is fed into the system without requiring any external human input. One example could include 3D laser scans that sync with design models and automatically update the project schedules. The autonomous feedback loop should have the intelligence to automatically manage project data and automatically complete administrative tasks to maximise the utilization efficiency of project resources. The autonomous interaction via feedback loop and the automated data entry is unique to the new proposed SPMIS model as well as the emphasis on project reporting at a project and multi project level.

The heart of the SPMIS is the centralized cloud-based data management system. Where data from multiple projects can be fed into the system. The centralized SPMIS is built on the fundamentals of artificial intelligence, which uses artificial neural networks and machine learning algorithms to detect patterns in project performance data and provides these insights to the project stakeholders. The SPMIS should handle many different types of data and make all data easily accessible and visible in one location. Finally, the system should present data as project reports in ways that are meaningful and easy to interpret like graphs, charts, and diagrams to help project stakeholders make more informed decisions while monitoring project performance.

5. Conclusions and recommendations

5.1 Conclusions

The study indicates that there are many different types of PMIS, which fulfil or support various project functions. There is no single application which caters for all the required project functions, nor is there one PMIS solution that fits all types of projects. Most of the organizations' sampled selected PMIS based on the system that they felt best served their needs in each functional area. This is supported by Rautenbach and Schutte [15], who recognized the challenge of PMIS selection and developed a software selection tool to help organizations select the best suited PMIS. Many organizations integrate data manually across applications which is time consuming and open to data manipulation or misalignment. The organizations who manage many large projects use centralized PMIS systems like MS Share Point. The concept of the centralized data management system in this research is aligned with the conceptual models proposed bay El-Omari and Moselhi [20] and Zamani et al. [21].

The research indicates that PMIS functionality is not the real problem but rather the amount of time and skills required to operate the systems and keep the data up to date. In some cases, the effort required to use these systems outweighs the benefits realized from them. There is high variability of PMIS utilization in industry (based on the industry interviews) this may be due to the limited sample size.

It is recommended that larger sample sizes be utilized in future studies and that these studies should primarily focus on large organizations managing mega projects.

The research highlighted the link between project performance monitoring and PMIS integration, as integrated systems help break down information silos and improve the quality and efficiency of project reporting. The finding that organizations produce monthly project reports, containing mainly scheduling, cost, risk and earned value project performance data supports the literature [10].

The research indicates that MS Projects is the most used software application for project scheduling. This corroborates the findings of Kostalova et al. [4] and Raymond and Bergeron [27]. The results show that Primavera has the most

functionality and advanced features, these findings are supported by the Kostalova et al. [4], who came to the same conclusion after doing a similar study. Primavera's strengths include its well-developed project portfolio capabilities where resources can be managed and levelled across multiple projects.

Ultimately a new conceptual model for a SPMIS was developed based on the literature review, industry interviews and PMIS software review. The new model is unique in that it covers more PMIS features than the existing models and includes an automated feedback loop for improving the utilization efficiency of project resources. The model is limited in that it only provides a basic architecture, the complexities of incorporating the many qualitative aspects of project performance and success factors are not incorporated into the model like environmental management and stakeholder relations.

5.2 Recommendations

The pace of digital technological progress is advancing rapidly, driven by the demand from industry as well as governments for better PMIS. Therefore, it is recommended that the model be tested as new PMIS technological breakthroughs occur. The most promising areas for breakthrough technologies lies in the application of AI in PMIS as well as automated data capturing from job sites. The application of these technologies would remove some of the major obstacles that are experienced with current day PMIS. Firstly, AI could be used to process the vast amounts of data generated during a project, identify patterns and anomalies in projects which cannot be comprehended by human cognition. Then it could communicate this information back to project stakeholders and team members, providing insight and actions to follow. This tool could be used by project managers to optimise the allocation of scare resources in the most efficient way. Secondly, new computer vision or scanning technologies could be used to monitor and assess site progress and feed this data automatically into the SPMIS. It is recommended that further study be done in these areas as they relate to practical implementation and integration into the SPMIS.

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