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Key Project Management Practices in Collaborative R&D&I Projects Across Activity Sectors

José M. R. C. A. Santos[a,b,]*, Gabriela Fernandes[c], Pedro Ribeiro[d], Luís Miguel D. F. Ferreira[c], Daniela Barroso[e], Eduardo B. Pinto[d]

[a]*Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia,5300-253 Bragança, Portugal*
[b]*Laboratório para a Sustentabilidade e Tecnologia em Regiões de Montanha, Instituto Politécnico de Bragança, Campus de Santa Apolónia,5300-253 Bragança, Portugal*
[c]*University of Coimbra, CEMMPRE, ARISE, Department of Mechanical Engineering, Polo II, Coimbra, 3030-788, Portugal*
[d]*Centro Algoritmi, University of Minho, Department of Information Systems, Campus de Azurém, Guimarães, 4804-533, Portugal*
[e]*ANI – Agência Nacional de Inovação, S.A., Edifício NET, Rua de Salazares, 842, 4149-002 Porto, Portugal*

Abstract

Collaborative Research and Development and Innovation (R&D&I) projects provide special challenges in understanding and expressing the value of project management (PM) practices to deliver stakeholders' expected benefits. This study aimed to contribute to understanding the relevance of PM practices on collaborative R&D&I projects' success from the perspective of firms, higher education institutions, and other research-performing organizations. It used exploratory factor analysis (EFA) to categorize the surveyed key PM practices initially grouped according to the typical project lifecycle (initiation, planning, execution, monitoring/controlling & replanning, and closure). EFA resulted in the identification of four underlying factors, designated by 'must have' practices that cover the whole PM lifecycle: 'initiation' practices; 'planning' practices; and 'execution, monitoring/controlling & replanning' practices. Significant variance in using key PM practices by respondents from different activity sectors is observed. For example, respondents from Interface Centers use more 'must have' practices than those from firms and use more 'planning' practices than those from firms and higher education institutions. This might be influenced by the reported existence of project management offices, beyond their administrative roles, in the vast majority of Interface Centers, as opposed to other activity sectors. The results suggest that this specific type of project would benefit from team capacity-building programs in PM practices tailored to the identified sector-specific needs of firms and research-performing organizations.

Keywords: Collaborative research; project management; key practices; project success.

* Corresponding author. Tel.: +351 273 330 832.
E-mail address: josesantos@ipb.pt

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1. Introduction

Recent initiatives, such as those promoted in Europe to face the economic crisis resulting from the COVID-19 pandemic are often directly and indirectly supported by public funds to promote a more significant societal impact from collaborative Research and Development and Innovation (R&D&I) projects. Innovations rarely involve a single idea but bring together knowledge from various sources [1]. Engaging with other organizations can stimulate an organization's innovation capabilities by exposing it to the capabilities of collaborating partners. The industry increasingly relies on open innovation, and Higher Education Institutions (HEIs), Interface Centers, R&D&I Labs, and Collaborative Labs (CoLABs) are often the principal repository of such exploratory knowledge.

Collaborative R&D&I projects contribute to developing knowledge-based, innovative products, processes, and services [1]. Typically, a consortium is set up to tackle specific needs and opportunities the business sector identifies. To this end, organizations representing specific value chains, including firms and research-performing organizations, work temporarily to meet predefined objectives, aligned with thematic priorities defined at the public policy-level and, in most cases, with public funding support. The typical diverse nature of these consortia implies that different organizational cultures must be conciliated to manage collaborative R&D&I projects successfully. This includes various levels of project management (PM) practices use. Moreover, project success criteria and perceptions are influenced, among other factors, by differing organizational vocations, such as illustrated by firms and HEIs.

The overall study focused on helping to improve the understanding of how collaborative R&D&I projects are managed in different organizational contexts. The perspectives of HEIs, other research-related institutions (e.g., Interface Centers, CoLABs and R&D&I Labs) and the business sector were considered. It explored the role of PM in this particular type of project, examining PM practices use and usefulness and the link between the use of these practices and project success. The specific research question pursued to answer in this paper is: "Does the use of key PM practices in collaborative R&D&I projects change among co-promotors activity sector?"

The paper begins with a background literature on the research topic, followed by an explanation of the methodology employed to collect and analyze empirical data. The main findings that emerged from the study are discussed, followed by conclusions, limitations, and future work.

2. Background

Collaborative R&D&I projects can bring unique opportunities for knowledge exchange, technology transfer, and societal impact. However, they often fail to meet stakeholders' expected benefits [1]. This type of project faces main challenges, namely uncertainty about research methods and expected results; balance between creative freedom and control; multiple, contradictory stakeholder expectations; role and skill set of project managers, namely limited authority, sharing of functions with the principal investigator; and measurement of project performance [2].

HEIs and industries often have different objectives and priorities that make managing this type of project particularly tricky. While HEIs focus on fundamental research, knowledge dissemination, and academic recognition, industries prioritize commercialization, profitability, and competitiveness [3]. Balancing these diverse objectives can be challenging [4]. There is also a need to bridge cultural gaps and align communication styles, as academia tends to have a more decentralized, collaborative, and slow-paced culture, while industries may have a more hierarchical, result-oriented, and fast-paced culture [3]. Moreover, HEIs often operate on longer-term timelines for R&D&I projects, while industries may have shorter-term expectations for projects to meet market demands [5]. This often leads to a high strain level that must be tackled promptly.

PM practices are the mechanisms by which PM processes are delivered and supported, and that, when managed effectively, can lead to project success [6]. This includes PM techniques (e.g., work breakdown structure or earned value management), various guidelines in which organizational processes are defined (including the use of procedure documents, checklists, job aids, and templates), as well as the use of software packages and various databases [7]. Therefore, PM practices are key to addressing the complexity of collaborative R&D&I projects.

Due to the highly heterogeneous activities and managerial conditions of R&D&I projects König *et al.* [8] argued that, for this type of project, it is challenging to generalize PM practices. Nevertheless, recently, Fernandes and O'Sullivan [9] developed a roadmap of PM practices for major collaborative HEI-industry R&D projects based on a large longitudinal case study. This study was chosen to select the key PM practices surveyed, considering the similitude of context, objectives, and empirical evidence.

3. Method

The research approach adopted is quantitative within a single cross-sectional study (Figure 1). Empirical data was collected using an online questionnaire survey, developed based on the published results of an in-depth large collaborative R&D&I case study between Bosch Car Multimedia and the University of Minho [9]. The survey was sent by email to 5946 potential respondents (from firms, HEIs and other research-performing organizations), that had been involved in collaborative R&D&I projects supported by the Portuguese Innovation Agency (ANI), and posted in ANI's monthly newsletters, website, and LinkedIn page (May - September 2022). In the first part of the questionnaire, the respondents were inquired about using PM practices. A 5-point Likert scale was used, where '1' indicates 'Do not use', '2' - 'Use Seldom', '3' - 'Use Sometimes', '4' - 'Use frequently', and 5 - 'Always use'. The listing of key PM practices followed extant literature [9], and covers the typical four phases of the PM lifecycle ('Initiation', 'Planning', 'Execution, monitoring/controlling & replanning', and 'Closure'). Various demographic and professional data on the respondents were collected in the last part of the questionnaire. This included information on roles, responsibilities, experience level, activity sector, typical project budgets, and demographic data (e.g., age, gender, and highest academic qualifications).

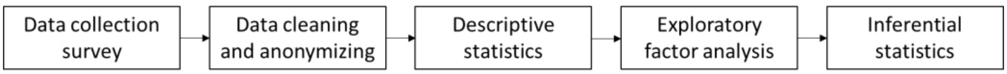

Fig. 1. Diagram illustrating the research process.

Exploratory factor analysis (EFA) was conducted to categorize PM practices. The factors were extracted using the principal component method where the factors are based on the total variance, and Varimax rotation, which is a method of orthogonal factor rotation intending just some factors to have significant loads and the goal is to maximize the variance between loads of each principal component. The data analysis was performed using the SPSS 26 software.

The statistical relationship between the use of PM practices and the activity sector was analyzed using ANOVA. As the sample size was always greater than 30, and according to the central limit theorem [10], the influence of non-normality was minimized. No patterns or similarities in the responses could be identified, so the observations' independence was assured. The dependent variables were measured on an interval scale. The homogeneity of the variances was evaluated using Levene's test. For some variables, deviation from homogeneity of the variances could be identified. Thus, to compare pairs of variables, the Games-Howell post-hoc test was used because it does not assume equal variances and, thus, mitigates the existence of deviations from variances homogeneity. Moreover, it is adequate when the sample sizes of the two groups are different, which was typically the case. The significance level used was $p < 0.05$.

Pearson's Chi-Square test was used to provide the statistical significance of the strength of association between the activity sector and other nominal variables such as the existence of a Project Management Office (PMO). Cramer's V (2-sided) was used as a measure of association to determine the strength of the relationship between nominal variables.

4. Results and discussion

4.1 Data characterization

A total of 465 valid responses were analyzed (ca. 8% response rate). This relatively low response rate is thought to be due to the length of the questionnaire. In fact, a total of 1,304 responses were received, with 59.3% reaching page 3 of 12 of the survey. Thus, 35.7% of the respondents that moved forward into the survey questions actually finished it. A shorter survey could have increased the response rate. The raw data was cleaned by deleting respondents that did not agree to participate, selecting respondents that reached at least the last section, removing unneeded fields, checking and correcting variable attributes, and anonymizing textual responses.

Table 1 – Key respondents' characteristics.

Gender	Age	Academic Qualifications	Years of Experience	Organization Type
57% Men 43% Women	> 49 years: 35.1% 40 - 49 years: 36.3% 31-39 years: 24.1% 25-30 years: 3.7% < 25 years: 0.9%	PhD: 36.1% MSc: 28.6% BSc: 22.4% Post-graduation: 9.2% High school: 3.7%	>15 years: 23.0% 10-15 years: 17.0% 7-10 years: 15.3% 4-6 years: 19.4% 1-3 years: 22.2% < one year: 3.2%	Firms: 58.2% HEIs: 22.8% Interface Centers: 7.8% CoLABs: 5.2% R&D&I Labs: 4.7%

The academic respondents consisted of professors (72.8%), researchers (24.3%), and grantees (2.9%). Of the non-academic respondents, 71.1% hold a director, coordinator, or board member position, 28.6% were technicians, and only one (0.3%) was a trainee. HEIs have the older respondents and CoLABs and R&D&I Labs have the youngest. Respondents from HEIs, R&D&I Labs and CoLABs have the highest academic qualifications, and those from firms the lowest. In all organization types, more than 50% of the respondents have over seven years of experience, leading us to conclude that the respondents have a high level of expertise and are reliable respondents.

The distribution of respondents by economic sector was varied, although firms from the software sector were the most represented. Most of the respondents indicated to be (co)responsible for projects (57.8%), members of the PM team (23.4%), members of the technical/scientific team (13.1%), and members of steering committees (5.6%). The vast majority (75%) of the respondents reported typical project budgets between €50.001 and €1.000.000. The survey results further evidenced that as the typical project budget increases, the proportion of PhDs increases among the respondents, and that of BScs decreases.

PMOs, having beyond administrative roles, were reported to exist in 59.8% of the respondents´ organizations (with 3% not being aware of their existence). There is a moderate association strength between the existence of a PMO and the activity sector [$n= 441$; Pearson Chi-Square $(10) = 34.524$, $p = 0.000$, 2-sided; Cramer´s $V = 0.198$]. The existence of a PMO is reported by 86% of the respondents from Interface Centers, followed by HEIs (72%), R&D&I Labs (68%), consultancy firms (61%), CoLABs (54%) and firms (49%).

4.2 Project management practices categorization

EFA was conducted to infer the categorization of PM practices following a PM lifecycle (Table 2).

Table 2 – Project management practices categorization (exploratory factor analysis results).

		Exploratory Factor Analysis			
		Must Have	Initiation	Planning	Execution, Monitoring/ Controlling & Replanning
Initiation	**Project proposal**: elaborating a document that briefly describes the problem, the objectives, and the implementation proposal (to be used for securing internal or external funding).		0.736		
	Alignment workshops: conducting alignment meetings internally (e.g., Administration, Management, Direction, Leadership) and among partners.		0.620		
	Project charter: elaboration of a document where the benefits, objectives, the general scope of the project, time, cost and resource constraints, among others, are described (e.g., project charter).		0.690		
	Kick-off meeting: holding a kick-off meeting in which everyone involved in the project is informed about the objectives, organization, and goals to be achieved, among others.	0.562			
	Benefits register: elaboration of a document for recording information on the project's expected benefits, and identification of suitable indicators for their respective monitoring (e.g., benefits register).		0.575		
Planning	**Scope management plan**: development of the scope management plan (including deliverables, deliverables quality acceptance criteria, and innovative features).			0.507	
	Work breakdown structure: elaboration of the project's WBS.			0.567	
	Gantt chart: project schedule development (e.g., Gantt chart).	0.672			
	Milestone list: development of the list of milestones (events or important points in the project).	0.676		0.532	

		Exploratory Factor Analysis			
		Must Have	Initiation	Planning	Execution, Monitoring/ Controlling & Replanning
	Responsibility assignment matrix: development of a responsibility matrix (identifies the activities to be performed, the person responsible, to whom reports, informs, and consults to define, develop and execute each activity).			0.573	
	Risk register: developing a risk register (including risk identification, analysis and monitoring, and respective response plans).			0.649	
Execution, monitoring, controlling & replanning	**Dissemination and communication plan**: development of a plan that includes the communication needs of the project, how and in what format all information will be communicated, and who will be responsible for each type of information.			0.598	
	Ongoing delivery: ongoing delivery of interim results generated within the scope of the project (as opposed to delivery only at the end of the project).	0.715			
	Progress meetings: holding periodic follow-up meetings between key project stakeholders from the different partners.	0.760			
	Innovation meetings: holding meetings for the presentation of project results to stakeholders and analysis of exploitation potential.				0.618
	Progress reports: carrying out project progress reports to record the information collected during progress meetings.	0.638			
	Issue log: recording and analysing issues (collecting, assessing, identifying causes, and planning responses to issues/problems identified at follow-up meetings).				0.640
	Quality inspection: to determine whether a result, intermediate or final, meets the project's specified quality criteria.				0.537
	Lessons learned register: registry of lessons learned, such as failures, and mistakes, as well as what went well, in terms of schedule, resources, and cost, among other dimensions, with the aim of improving project performance.				0.646
	New project ideas log: registry of new ideas, to promote future R&D&I projects.				0.561
	Change log: reasoned record of potential changes to the project's scope, schedule, and investments regarding the planned (including rescheduling of delivery dates).				0.562
	Team building: promoting of team spirit (e.g., team building events and milestone parties).				0.629
	Results dissemination: communicating and disseminating interim and final project results to all stakeholders.	0.605			
	Stakeholders' satisfaction survey: periodic evaluation of the satisfaction of key stakeholders (e.g., through surveys).				0.676
	Benefits monitoring: continuous monitoring of project benefits (e.g., using the benefits register).				0.716
Closure	**Closure meeting**: conduct a closing meeting, namely, to record the successes and failures of a project, including recommendations for improving the future performance of other projects.	0.635			
	Closure report: elaboration of a project closure report, including performance summary, objectives and results obtained, benefits achieved, lessons learned, as well as new ideas for future projects.	0.654			
	Transition plan: creating a plan to ensure the effective transfer and exploitation of the project results.				0.616
Variance %		**8.717**	**4.120**	**4.728**	**37.833**
Cumulative %		**46.600**	**55.448**	**51.328**	**37.833**
Cronbach Alfa		**0.893**	**0.749**	**0.831**	**0.874**

The results were slightly different from what was expected. One similarity was that four groups emerged from the analysis, even though they do not fully coincide with the typical PM lifecycle groups. The main difference is that a new component arose which was named 'Must have' PM practices for two reasons: a) that the corresponding practices cover the complete PM lifecycle, meaning that the respondents understand that they should be used from the start until the end of a project, and b) with the exception of "progress reports", all of these practices either appear in the top 10 most used or the top 10 most useful practices or even in both. The remaining practices of the phases 'Execution, monitoring/controlling & replanning' and 'Closure' were grouped into one component. Therefore, the empirical data shows that 'Closure' does not emerge as an independent component. The other two factors were labelled 'Initiation' and 'Planning' because they combined all the other commonly used practices in those phases, respectively. Table 1 shows the factorial loads that indicate the correlation between the PM practices and the four categories described above. In total, these factors explain 55.448% of the variance in the use of PM practices, which is an acceptable value [11]. All the Cronbach's Alfa values are above the 0.7 desired threshold.

4.3 Key project management practices use by different activity sectors

The dependence of the respondents´ reported use of key PM practices on the activity sector was analyzed considering the EFA categorization outcome (Figure 2).

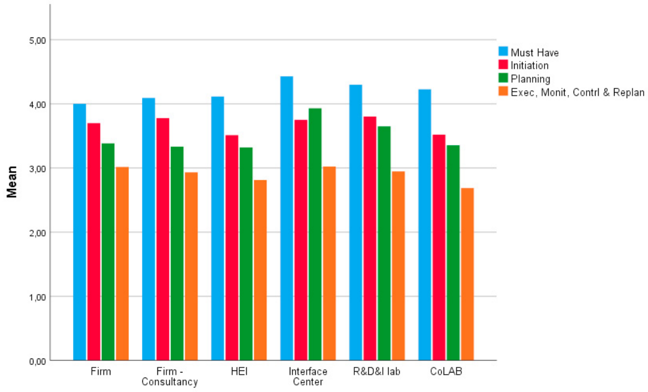

Fig. 2. Use of categorized PM practices per main activity sector.

The ANOVA and Games-Howell tests resulted in statistically significant differences between categorized practices for each activity sector. Generally, it can be observed (Figure 2) that the use of the categorized key PM practices decreases in the following order: 'Must have', 'Initiation' and 'Planning' (no statistically differences exist between these two categories), and 'Execution, monitoring/controlling & replanning'. Thus, 'Must have' practices are the most used (covering the complete typical PM lifecycle).

It can be observed in Table 3 that respondents from Interface Centers use more 'Must have' key PM practices than those from firms, and use more 'Planning' key PM practices than those from firms and HEIs. This is interpreted along with most respondents from Interface Centers reporting the existence of a PMO. The presence of a PMO leads to more structured 'Must have' and 'Planning' PM practices in Interface Centers. These results are corroborated by the analysis of the relation between the activity sector and the use of the individual key PM practices, summarized in Table 4 and illustrated in Figure 3.

Table 3 – p-values for ANOVA and Games-Howell tests on the categorized PM practices (dependent variable) and activity sector.

Practices category	Activity Sector 1	Activity Sector 2	ANOVA	Games-Howell
Must have	Interface Centers	Firms	0.032	0.024
Planning		Firms	0.012	0.008
Planning		HEIs	0.012	0.005

Table 4 – p-values for ANOVA and Games-Howell tests on the PM practices and activity sector.

Category	Practice	Activity Sector 1	Activity Sector 2	ANOVA	Games-Howell
Must have	Gantt Chart	Interface Centers	Firms	0.037	0.006
	Results Dissemination	HEIs	Firms	0.004	0.026
	Milestone List	Interface Centers	Firms	0.007	0.009
		R&D&I Labs	Firms	0.007	0.005
Initiation	Alignment Meetings	Firms	HEIs	0.053	0.045
Planning	Scope Management Plan	Interface Centers	HEIs	0.012	0.019
	Work Breakdown Structure (WBS)	Interface Centers	Firms	0.000	0.005
			Consultancy Firms	0.000	0.048
			HEIs	0.000	0.000
			CoLABs	0.000	0.023

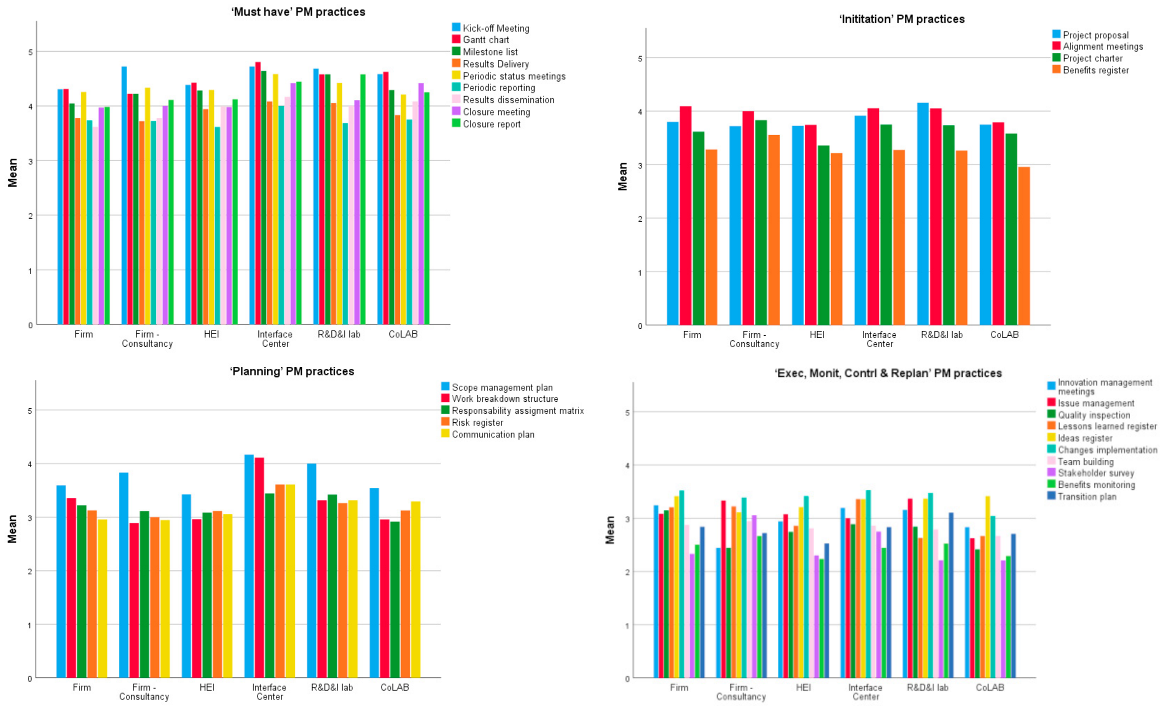

Fig. 3. Use of individual PM practices per category and main activity sector.

Respondents from firms use less the 'Must have' PM practices 'Gantt chart' and 'Milestone lists' than Interface Centers; and use less 'Communication and dissemination of results' and 'Milestone lists' than those from HEIs and R&D&I Labs, respectively. On the other hand, respondents from Interface Centers use more the 'Planning' practice 'Scope management plan' than those from HEIs; and use more 'WBS' than those from Firms, Consultancy Firms, HEIs, and CoLABs. These results correlate with the observation that PMOs are reported by 49% of the firms' respondents and by 86% of the Interface Centers' respondents. Previous studies have found that a PMO drives organization's PM maturity level [12]. PMOs mitigate issues related to project planning, communication and lessons learned practice by acting as the central organizational body for knowledge integration and as a repository of good practices [13]. Therefore, the existence of a PMO is posed to lead to greater use of 'Must have' and 'Planning' PM practices in Interface Centers than in firms.

Conversely, respondents from firms use the 'Initiation' PM practice 'Alignment meetings' more than those from HEIs. This is interpreted as being due to the looser graded relations in HEIs, aligned with the concept of academic freedom [14].

No statistically significant relationships exist between the respondents´ opinion on the 'executing, monitoring/ controlling & replanning' key PM practices and their main activity sector. This is thought to be because this category is the least used (Figure 2).

5. Conclusions

Publicly funded collaborative R&D&I projects are increasingly used to tackle societal challenges. The variety of partners typically involved in this type of projects results in differences in the use of PM practices. EFA was used to categorize surveyed key PM practices. The results show the emergence of a new PM practices category ('Must have' practices) that includes practices from all the typical PM lifecycle phases. This category of practices is reported to be the most used.

The differences in the use of PM practices by firms, HEIs and other research-performing organizations was explored. Respondents from Interface Centers, which largely report the existence of a PMO, use more ‘Must have’ PM practices than those from firms, and use more ‘Planning’ PM practices than those from firms and HEIs. CoLABs and Firms report less frequently having a PMO. Thus, the existence of a PMO is inferred to influence the observed differences in the use level of the key PM practices between partners from different activity sectors. One of the main functions of PMOs is to act as a repository of best practices and enablers of their uptake by project managers [15]. Thus, it is concluded that this type of project would greatly benefit from capacity-building programs in PM practices tailored to the identified sector-specific needs of firms and research-performing organizations. Tailored training programs in PM would provide exposure to specialized knowledge, tools and techniques, increasing the prospects of project success, and foster collaboration among project managers facing similar challenges.

A limitation of this study is the indirect association between the existence of a PMO and the use of key PM practices. To tackle this, future work will involve the use of ordinal logistic regression for modeling the relationship between the PM practices' use level and the activity sector. Another limitation is the fact that the study was carried out only in Portugal, thereby reflecting the national context and not an international perspective.

Future work will also involve the analysis of the influence of the use and usefulness of these key PM practices on the success of collaborative R&D&I projects. By using regression analysis, this will allow also to assess if the existence of a PMO influences significantly the success of collaborative R&D&I projects.

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