The Journal of Technology Transfer
https://doi.org/10.1007/s10961-021-09915-9

Project management practices in major university-industry R&D collaboration programs – a case study

Gabriela Fernandes[1] · **David O'Sullivan**[2]

Accepted: 23 December 2021

Abstract
University-industry collaboration (UIC) projects are complex undertakings, that can involve multiple parties or stakeholders. Effective management of UICs can mean the difference between success and failure, in terms of technology transfer and research commercialization. This research paper focuses on the micro-level analysis of UICs and in particular the project management practices that can help major UICs deliver benefits and broader societal impact. PM has been evolving toward more hybrid approaches involving both traditional and agile practices. A conceptualization of a hybrid approach is presented based on a literature review. This conceptualization is then used as a starting point for exploratory empirical research. Participant observation, document analysis, and thirty semi-structured interviews were conducted in a large UIC case study to help identify PM practices and check their relevance. Data analysis led to a framework comprising 29 transversal or *must-have* practices distributed throughout the project lifecycle and 30 contingent or *optional* practices, divided into traditional, agile and common. This research extends the existing knowledge on UICs by giving a micro-level perspective on managing UIC projects and providing evidence of the adoption of hybrid approaches to assure the overall governance of significant inter-organizational endeavors. The framework provides a roadmap for future major UIC projects.

Keywords University-industry collaborations · Project management practices · Hybrid project management · Agile project management · Transversal and contingency practices

1 Introduction

Companies are more open to collaborative innovation and investment in research and development (R&D), and this positively influences university-industry collaborations (UICs) (Galan-Muros and Davey 2017). Industry recognizes the value of collaborating with universities for enhancing their own internal innovation capabilities (Kobarg et al.

✉ Gabriela Fernandes
gabriela.fernandes@dem.uc.pt

[1] Department of Mechanical Engineering, CEMMPRE, University of Coimbra, Polo II, 3030-788 Coimbra, Portugal

[2] National University of Ireland Galway, Galway University Road, H91 TK33, Galway, Ireland

Published online: 11 March 2022

2018). R&D collaboration is now regarded as one of the essential ingredients for innovation (Hernández-Trasobares and Murillo-Luna 2020). In recognition of this, the European Union has made innovation the central theme of the Horizon 2020 research funding program (Spalek 2016). Collaboration between universities and industries is also encouraged by governments for enhancing national competitiveness and wealth creation (Barnes et al. 2002; Hernández-Trasobares and Murillo-Luna 2020). Given the grand challenges of the 21st Century, UICs are expected to play a key role in developing new products, technologies, and processes for industry, that create value for customers and broader societal impact through employment and economic growth (Faria et al. 2020). The current Covid-19 pandemic, for example, has demanded an unprecedented number of UICs, and their success has never been more important for society. This increasing prevalence of UICs also means potential increases in failure to meet stakeholder expectations (Brooke and Lippe 2015; Nsanzumuhire and Groot 2020), often a consequence of lack of partner trust; lack of clarity regarding objectives, poorly assigned responsibilities and planning; and lack of flexibility and agility within the management structure (Oliver et al. 2020; Rybnicek and Königsgruber 2019).

Research literature concerning UICs has focused on the macro-level of UIC implementation namely, the key channels of interaction between universities and industry, the implementation mechanisms of building trust or boundary spanning, and the barriers and challenges faced by partners, the dynamics of triple helix infrastructure, the economic and societal impact of UIC activities (Nsanzumuhire and Groot 2020, Skute et al. 2019). An inherent criticism made on these studies is that they are too focused on the outputs of UICs rather than on the mechanisms or practices deployed during execution (Albats et al. 2018). A more micro-level analysis of practices deployed during the lifecycle of the UIC project is needed (Albats et al. 2018; Morandi 2013).

Some researchers have emphasized the adoption of project management (PM) practices as a critical factor for the success of UICs (Barnes et al. 2006; Fernandes et al. 2020a; Huang and Chen 2017). Nevertheless, the value of PM is a function of what is implemented and how well it fits the organizational context (Cooke-Davies et al., 2009). Through extensive and complex contracts, funded by an external entity, the specific context of UICs has several specificities that require attention (Nishimura and Okamuro 2018). There are additional challenges around the UIC consortium structure (Peterson 1995), that demand effective guidelines. As argued by Brocke and Lippe (2015, p. 1022), UICs *"present specific challenges, demanding of adaptations and adjustments to existing project management approaches"*.

UICs are usually funded and regarded as projects by the funding entities but often are organized as programs by partners (Fernandes et al. 2015a). A program is constituted by a set of related projects. A program is more than a sum of its projects and aims to achieve a planned set of benefits (Pellegrinelli 2011). A collaborative UIC program is here defined as a temporary organization with a collaborative work environment, with a set of projects related in a specific context, with heterogeneous partners who have collective responsibilities, and, in most cases, with public funding support. UICs are associated with high uncertainty and risk, significant pressure in terms of creativity and innovativeness, individually oriented collaborators, and project members often resident in different locations (Brocke and Lippe 2015; König et al. 2013).

With the growing tendency of more agile management, three distinct PM approaches used in projects are emerging, the traditional, agile and hybrid approaches (Azenha et al. 2021; Gemino et al. 2021). Azenha et al. (2021) argue that hybrid approaches are fundamental for developing technology-based products and services and deal with distinct

organizational cultures, processes and contractual requirements. Papadakis and Tsironis (2020) recently identified the challenges and best practices to implement in-house hybrid PM in organizations. However, PM research studies in the micro-level practices in UICs are limited (Skute et al. 2019). The key main objective of this research was to find the PM practices that may be adopted in major UIC programs involving a high number of projects. The research question adopted was: *How to deploy key PM practices for effectively managing major university-industry R&D collaborations?*

To address this research question, researchers delved into a large case study between the University of Minho (UMinho) and Bosch Car Multimedia (Bosch) in Portugal. This UIC involved an investment of 54.7 million Euros, from 2015 to 2018, and over five hundred researchers. The case study allowed the discovery of crucial knowledge of micro-level PM practices and evidenced the adoption of a hybrid PM approach for assuring the overall governance of one significant inter-organizational endeavor.

This paper begins with a review of research literature on managing UIC leading to a conceptual 'initial framework' of PM practices. This is followed with an explanation of the research methodology and the steps taken to collect and analyze primary data through a cross-sectional case study. The results of thirty semi-structured interviews, coupled with observation and document analysis, lead to presenting a final framework of PM practices for managing UIC projects within major programs. The main findings emerging from the study are discussed, followed by conclusions, limitations and future work.

2 Literature review

2.1 Managing university-industry R&D collaborations

Rajalo and Vadi (2017, p. 42) argue that "*Knowledge and technology transfer between academia and industry is expected to spur innovation, as this kind of collaboration combines not only heterogeneous partners, but more importantly, heterogeneous knowledge*". UIC projects are one of the main channels of university-industry interactions (De Fuentes and Dutrénit 2012). UIC projects are a way for firms to obtain expertise that cannot be generated in-house through knowledge transfer (Becker and Dietz 2004), promoting economic progress, innovativeness, and competitiveness fostered by a continuous research engagement (Skute et al. 2019).

There are several critical success factors for why UIC projects succeed. One well-recognized success factor is a high level of trust (Bellini et al. 2019; Hemmert et al. 2014; Pertuzé et al. 2010; Plewa et al. 2013), at the level of both individuals and organizations along the multiple stages of the collaboration (Oliver et al. 2020). However, how to increase the level of trust among participants is complex. Oliver et al. (2020) found that the reputation of scientists and their shared values helped build trust at the individuals level, while at the organizational level, trust is focused on efficiency and time commitment to the collaboration. Another important success factor argued by Bellini et al. (2019) is the collaborative know-how, drawn from previous collaboration relationships. Other success factors include: clarity regarding objectives, assigned responsibilities and planning, and flexibility and agility within the management structure (Oliver et al. 2020; Rybnicek and Königsgruber 2019). These critical success factors are all addressed by an effective PM approach (Brocke and Lippe 2015).

There are several differences among the parent organizations within a UIC that arise from their diverse intentions, motivations, and responsibilities (Nomakuchi and Takahashi 2015). Collectively, these are coined as a 'cultural gap' between universities and industries (Barnes et al. 2006). The cultural factors identified include conflicts over intellectual property, academic freedom to publish, differences in priorities, time horizons, and topics of research. Barnes et al. (2006) suggest that many of the adverse effects associated with the 'cultural gap' can be attenuated by good PM. However, understanding how to manage inter-organizational UIC projects within major programs and their particular issues appears limited (Ankrah and AL-Tabbaa 2015; Nsanzumuhire and Groot 2020), and there are few reference models that guide the practice of PM within UICs. Most UIC literature focuses on macro issues (e.g., key channels of interaction, barriers and challenges faced by partners) with only a light focus on micro-level management including PM practices.

Chin et al. (2011) have developed a model of PM best practices among universities and SME (small and medium-sized enterprise) industrial partners. The PM² Project Management Methodology Guide, developed by the European Commission, is a lean methodology and promoted as suitable for any type of project (European Commission 2016). Fernandes et al. (2015a) suggested a program and project management lifecycle approach in the context of large-scale UIC. Program management provides a link between the execution and the specific strategies of the collaborating partners and their need to integrate the deliverables and the workflows of multiple interdependent projects that deliver an integrated product, service or capability (Milosevic et al. 2007). Program governance is responsible for spurring creative and proactive synergies between partners and contributing to the final success of the program (Frederiksen et al. 2021). Programs provide UICs with the most potential to realize strategic benefits, find creative solutions and operate effectively (Pellegrinelli 2011). Programs usually cover a group of related projects that can generate greater benefits than projects may do individually (Thiry 2002). Programs achieve this through improved exposure, prioritization, more efficient use of resources, and greater alignment with other related projects (Pellegrinelli, 2007). Program management thrives where there is ambiguity and uncertainty among individual project management (Rijke et al. 2014).

The program manager strives to coordinate efforts between projects and typically does not directly control the individual projects (PMI 2017). An inappropriate degree of project control by program management is unproductive (Rijke et al. 2014). Excessive control can force too much bureaucracy on project management, resulting in distracting resources from achieving what is important – i.e., project objectives (van Buuren et al. 2010), and in the diversion of program management resources away from their strategic role (Rijke et al. 2014). Yet, limited control may lead to loss of synergies among projects, and therefore reduced quality, cost overruns, delays, and limited benefits on the overall UIC program. Nonetheless, program and project management have to consider the contextual aspects (Besner and Hobbs 2013; Pellegrinelli et al. 2007) and the need for adaptations and adjustments to PM practices. Morandi (2013) found that the selection of mechanisms, exploited to coordinate and control collaborative R&D activities, is affected by task uncertainty, equivocality, and the interdependence of partners. UICs need to select and practice an appropriate PM approach (Azenha et al. 2021) and introduce and adjust the PM practices that comply with the established strategic objectives.

2.2 Project management approaches and practices

PM approach is here defined as a high-level outline of guiding principles, perspectives, and characteristics of how a project is managed and governed (PMI 2017; Špundak 2014). A PM approach describes how a project will be manged and governed (Gemino et al. 2021). Lappi et al. (2018) argue that a PM approach is related to the internal aspects of project governance.

PMI (2017) states that PM approaches can be predictive and adaptive. In a predictive approach, usually referred to as traditional, the project scope, time, and cost are determined in the life cycle's early phases. Any changes to the scope need to be carefully managed. In situations where projects have a high degree of volatility, uncertainty, ambiguity and complexity, PM approaches need to be able to respond quickly to changes (Serrador and Pinto 2015). These changes may sometimes lead to conflicts among collaborators (Bennett and Lemoine 2014). In such scenarios, the adaptive approach, usually referred to as 'agile', can be considered (Böhmer et al. 2015). In agile PM, the scope of the project is defined and approved before each iteration. However, the adoption of agile approaches brings its own challenges, such as the project manager relinquishing some authority (Nerur et al. 2005). Several agile frameworks have been studied and developed such as the *Dynamic Systems Development Model* (Agile Business Consortium 2014), *eXtreme Programming* (Fernandes and Almeida 2010; Flora and Chande 2014), *Scrum* (Santos et al. 2016; SCRUMstudy 2016), *Crystal* (Cockburn 2004) and *Kanban* (Ahmad et al. 2013; Flora and Chande 2014). These studies helped to identify the key PM practices that are increasingly dominant in the software development industry, but are also increasingly used in other contexts, such as in R&D projects. Serrador and Pinto (2015) demonstrated a positive co-relationship between agile use and project success. However, other research argues for a combination of traditional and agile approaches (Gemino et al. 2021; Špundak 2014). One must value the specificities of each approach and, if possible, work with both at the same time.

Cooke-Davies et al. (2009) argue that PM value is created or destroyed depending on the extent of fit or misfit between the organization's strategic drivers and the characteristics of its PM system. They criticize the unconditional use of PM standards and a misfit between specific project characteristics and the chosen management approach. Therefore, this research is based on the contingency theory (Drazin and Van de Ven 1985; Lawrence and Lorsch 1968), used in PM for the last two decades (Sauser et al. 2009). The contingency approach investigates the extent of fit or misfit between project characteristics and the PM approach adopted (Sauser et al. 2009). Engwall (2003) emphasizes the importance of a contingency approach and argues that projects are open systems dependent on history and organizational context. All different project types would benefit from a contingency theory perspective. A study developed by Hanisch and Wald (2012) shows that construction, R&D and IT projects benefit from this approach. R&D UIC projects in particular are comprised of highly heterogeneous activities and managerial conditions. Therefore, as König et al. (2013) argued, it is challenging to generalize PM practices, advocating instead for a contextual PM approach (Brocke and Lippe 2015).

PM practices are the mechanisms by which PM processes are delivered and supported, and that, when managed effectively, can lead to project success (Barbosa et al. 2021). 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 (Fernandes et al. 2013). Searching for tools and techniques is

a tangible way to study PM practices because they represent how managers execute PM processes. They are also concrete and specific ways to apply rules and principles that must be selected according to the context of the organization where they fit (Besner and Hobbs 2008). Tools and techniques are closer to the day-to-day practice, closer to the things people do and closer to their tacit knowledge (Besner and Hobbs 2006). Therefore, in this research study, PM practices are simply seen as those tools and techniques that practitioners use to 'do the job' and execute a PM process. Several investigations have identified the most used and useful PM practices (tools and techniques). Some studies refer to tools and techniques in general, for example, Besner and Hobbs (2006) and Fernandes et al. (2013), while others refer to specific contexts such as the studies of Tereso et al. (2019) and Besner and Hobbs (2008, 2012, 2013).

2.3 Conceptual framework for project management practices in major UICs

Understanding context is essential for identifying the most helpful PM practices for a major UIC. As such, a conceptual framework for managing R&D projects within a major program grounded on the contingency theory is proposed (see Fig. 1). The framework conceptualization identifies a set of transversal or *must-have* PM practices used by all projects within an overall major program. It also conceptualizes contingent practices that may be voluntarily adopted by individual projects within the program.

Transversal PM practices are distributed throughout the PM lifecycle to assure the governance of the overall program. Governance is a way to define the structures to develop the organization's objectives, providing means of obtaining those objectives and the standards to monitor the progress of the project (Turner and Müller 2017). As argued by Fernandes et al. (2015b), the standardization and tailoring of PM tools and techniques are critical initiatives to improve PM practice in organizations.

Contingent PM practices may or may-not be adopted within individual projects. Adoption depends on the PM approach embraced by the project team i.e., traditional or agile. It is also dependent on the knowledge and experience of the project teams involved since the value of using PM practices is also reliant on the teams maturity (Shi 2011; Fernandes et al. 2015b). Contingent practices are divided into traditional, agile, and common practices, which can be used either in traditional or agile approaches. Depending on selection, contingent PM practices are then integrated into the PM lifecycle phases of the project.

Each project team needs to understand the differences between traditional and agile approaches and analyze the project context in order to better understand which one better fits with and serves the individual UIC project (Papadakis and Tsironis 2020). The

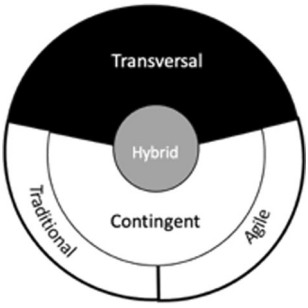

Fig. 1 Conceptual framework for PM practices in major UICs

specificities of each one must be valued and, where necessary, work with both simultaneously if each one adds value (Gemino et al. 2021). When applied together, they can counteract the weaknesses of each other. Project teams can introduce and adjust the contingent PM practices so that the projects can meet the established objectives and benefits since each project within a program is unique and has its own strategy.

The following Tables 1 and 2 identify specific transversal and contingent PM practices and key literature sources. The main studies used were from Besner and Hobbs (2006, 2008, 2012, 2013), Fernandes and Almeida (2010), Fernandes et al. (2013), Flora and Chande (2014), Tereso et al. (2019), among other bibliographic references such as PMBoK® (PMI 2017) and PM² Project Management Methodology Guide (European Commission 2016). The studies were selected, considering the similarity of objectives, robustness, empirical evidence obtained, and diverse organizational contexts.

Table 1 presents the transversal PM practices grouped according to the PM lifecycle (Fernandes et al. 2015a), composed of four phases 'initiation', 'initial planning', 'execution', (including monitoring/controlling and replanning), and 'closure'. Twenty four transversal PM practices are identified, with most of them in the top 20 most useful PM practices presented by one or more studies of Besner and Hobbs (2006), Fernandes et al. (2013) and Tereso et al. (2019). Although some practices have slightly different designations than those attributed by the referred authors, they can be considered equivalent to those 20 most useful practices. Although very useful and common in several contexts, some of the practices found in the literature were understood as contingent in the UIC program context (e.g., 'work breakdown structure', 'Gantt chart'). On the other hand, the in-depth analysis of the UIC program context allowed the identification of some more specific PM practices (e.g., 'project idea paper', 'new project ideas log', 'audits').

Table 2 presents the selected contingent PM practices divided into traditional, agile, and common. Many of the PM practices identified are mentioned by different authors using other similar terminologies.

Within the sub-category of contingent – traditional, only three PM practices were identified: 'Work breakdown structure (WBS)', 'Gantt chart' and 'PM software for monitoring schedule'. Although Besner and Hobbs (2006) and Fernandes et al. (2013) had identified them as among the twenty most essential tools and techniques, in the UIC program context, they were identified as contingent for the individual projects. The low level of PM maturity in the particular context of UIC (Chin et al. 2011) and the typology of R&D projects, which requires a high level of creativity (Davies 2014; Brocke and Lippe 2015), leads to identifying them here as contingent PM practices. It is worth of mentioning, if a project team decided to use the 'WBS' (more detailed planning), the 'PM software for monitoring' is an essential tool for supporting schedule management. In the agile category, fifteen practices were identified and fourteen practices in the common category which can be used independently of the approach adopted, traditional or agile e.g., 'project communication room'.

3 Research methodology

The research followed a single case study design of a major UIC, aiming to depart from existing knowledge and then learn from the experience of the program and project stakeholders. The UIC program was named IC-HMI. Using the case study approach, researchers can focus on a particular phenomenon and discover crucial knowledge (Yin 2018).

Table 1 Transversal PM practices

Phase	PM Practice	Sources
Initiation	Project idea paper	Besner and Hobbs (2006, 2008); Fernandes et al. (2013); PMI (2017)
	Project charter	Agile Alliance (2018); Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
	Kick-off meeting	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); PMI (2017)
	Stakeholder register	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); PMI (2017)
Initial Planning	High-level project scope plan	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); Morandi (2013); PMI (2017)
	Project procurement plan	PMI (2017)
	Project staff plan	PMI (2017), Bellini et al. (2019)
	Dissemination and communication plan	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); PMI (2017)
	Milestone list	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
	Responsibility assignment matrix	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
	Risk register	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
Execution, Monitoring/Controlling and Replanning	Project issue log	Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
	Benefits register	Fernandes et al. (2017); PMI (2017)
	New project ideas log	PMI (2017)
	Quality inspection	Besner and Hobbs (2006, 2008, 2012); Tereso et al. (2019)
	Progress report	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); Morandi (2013); PMI (2017); Tereso et al. (2019); Bellini et al. (2019)
	Progress meetings	Fernandes et al. (2013); Morandi (2013); PMI (2017); Tereso et al. (2019)
	Change log	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
	Re-baselining	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); Morandi (2013); PMI (2017)
	Audits	European Commission (2016); PMI (2017)
	Lesson learned register	Besner and Hobbs(2006, 2008, 2012); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
Closure	Project closure report	European Commission (2016); PMI (2017); Tereso et al. (2019)
	Project closure meeting	European Commission (2016); PMI (2017)
	Transition plan	European Commission (2016); PMI (2017)

Table 2 Contingent PM practices

Appr.	PM Practice	Source
Traditional	Work breakdown structure (WBS)	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); Morandi (2013); PMI (2017); Tereso et al. (2019), Bellini et al. (2019)
	Gantt chart	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017); Tereso et al. (2019)
	PM software for monitoring schedule	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017), Bellini et al. (2019)
Agile	Planning for iteration-based agile	Fernandes and Almeida (2010); Flora and Chande (2014); PMI (2017)
	Product backlog	Agile Alliance (2018); PMI (2017); Santos et al. (2016); SCRUMstudy (2016)
	Release planning schedule	European Commission (2016); PMI (2017); SCRUMstudy (2016)
	Daily standups	Agile Alliance (2018); Cockburn (2004); PMI (2017); SCRUMstudy (2016)
	Sprint backlog	Fernandes and Almeida (2010); Flora and Chande (2014); PMI (2017); Santos et al. (2016); SCRUMstudy (2016)
	Sprint reviews	PMI (2017); SCRUMstudy (2016)
	Sprint retrospective	Agile Alliance (2018); PMI (2017); SCRUMstudy (2016)
	Continuous integration	Agile Alliance (2018); Fernandes and Almeida (2010); Flora and Chande (2014); PMI (2017)
	Self-directed work teams	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017)
	Burn charts - burndown or burnup charts	Agile Alliance (2018); Cockburn (2004); Fernandes and Almeida (2010); Flora and Chande (2014); PMI (2017)
	Kanban board	Agile Alliance (2018); Ahmad et al. (2013); Flora and Chande (2014); PMI (2017)
	Simple design	Agile Alliance (2018); Fernandes and Almeida (2010); Flora and Chande (2014)
	Process miniature	Cockburn (2004)
	Essential interaction design	Cockburn (2004); Flora and Chande (2014)
	System metaphor	Fernandes and Almeida (2010); Flora and Chande (2014)
Common either to traditional or agile	Requirement analysis	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017)
	Activity list	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017)
	Effort estimation	Fernandes and Almeida (2010); Flora and Chande (2014); Santos et al. (2016)
	Meeting minutes	European Commission (2016)
	Project communication room	Agile Alliance (2018); Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017)
	Social media	Fichtner (2015); PMI (2017); Yates and Paquette (2011)
	Team-building event	Besner and Hobbs (2006, 2008, 2012); Fernandes et al. (2013); PMI (2017)

Table 2 (continued)

Appr.	PM Practice	Source
	Information radiator	European Commission (2016); PMI (2017)
	Decision log	Besner and Hobbs (2006, 2008, 2012); European Commission (2016); Fernandes et al. (2013); PMI (2017); Sulaiman et al. (2006)
	Earned value management	Agile Business Consortium (2014); Santos et al. (2016)
	MoSCoW method	Agile Business Consortium (2014)
	Modelling	Agile Business Consortium (2014)
	Demonstrations	PMI (2017)
	Testing	Agile Business Consortium (2014); European Commission (2016); Fernandes and Almeida (2010); Flora and Chande (2014); PMI (2017)

Several recent studies on UICs have used case study research strategy, e.g., Albats et al. (2018) studied the key performance indicators of UIC success, Rantala and Ukko (2018) the implementation practices and challenges of performance measurement in UICs, and Steinmo (2015) the cognitive social capital as a facilitating factor in collaborative university-industry relationships.

IC-HMI was a collaborative R&D program between the University of Minho (UMinho) and Bosch Car Multimedia Portugal (Bosch) that comprised 30 collaborative projects, aiming to create innovative solutions for mobility-related to automobiles in the future. The IC-HMI program involved an investment of 54.7 million euros, between July 2015 and July 2018, with around 500 researchers and Bosch collaborators, working interdependently. IC-HMI was the most extensive UIC program conducted in Portugal. With this program, Bosch expected to increase its international accumulated sales volume and diversify business and products and consolidate its reputation among customers and within Bosch Group. On the other hand, UMinho expected to improve its recognition in the scientific community and strengthen the scientific and technological knowledge transfer into the industry (Fernandes and O'Sullivan 2021). UMinho and Bosch have perceived the value of PM to support the management of such collaboration and, therefore, have established a governance model based on a purposely developed approach devoted to program and project management of UIC funded contracts, named PgPM (Fernandes et al. 2015a).

Figure 2 summarizes the research process adopted. An initial attempt at the PM practices framework was based on literature review, which was used to guide a subsequent exploratory study, resulting in the final PM.UIC framework. The unit of analysis was the PM practices used on the management system of a major R&D endeavor jointly carried out by academic and industrial researchers. As well recognized in literature, a new PM practice is unlikely to deliver the desired results if it does not fit within the organization or its competitive environment (Cooke-Davies et al. 2009). To address this issue, the case study sought to understand the set of essential PM practices, traditional and agile, that are suitable to the context of major UICs.

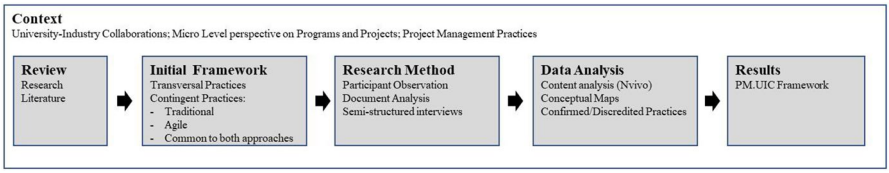

Fig. 2 The research process

3.1 Data collection

The research followed a qualitative multimethod, where the chosen research methods applied to the case study were participant observation, document analysis, and semi-structured interviews (Saunders et al. 2019). Observation played a crucial role in the context of this research by driving the researchers to have closer contact with the object of study in its natural environment, helping them to grasp the organizational context (Angrosino 2005). Participant observation provided the researchers with experiential and observational access to the actualities of the world of meaning (Alvesson and Sköldberg 2017). Since the beginning of the program, the insider researcher observed IC-HMI stakeholders in naturally occurring situations, namely during regular management and technical meetings, workshops, and celebrations. Therefore, through participant observation, it was possible to realize and perceive the UIC context and identify the potentially essential PM practices.

The analysis of several IC-HMI documents was also crucial to better understand the case study context, namely the case study efforts on improving PM practices and the PM practices effectively adopted (e.g., 'Project Charter', 'Progress Reports', 'Risk Register').

Semi-structured interviews were performed among individuals involved in the program environment at different levels of the organization hierarchy. These individuals included program and project managers, PgPMO members, and project team members. The university program manager was professional manager, however university project managers (project leaders) were academic principal investigators.

A total of 30 semi-structured interviews were conducted between April and May 2018. Each interview lasted between 21 and 95 min. Interviews were conducted in-person at the interviewee's organization headquarters. The researcher explained, in advance and by email, the scope of the research study and the purpose of the interviews through a briefing document, which clarified the research scope, anonymity and confidentiality, and the critical PM terms adopted by the study, to assure that the interviewees perceived these terms consistent with the researchers' understandings. Nevertheless, each interview started with an outline of the research objectives.

The data produced by the semi-structured interviews were collected by using tape recordings and by taking contemporaneous notes. Only one interviewee did not allow the use of tape recording. The notes taken during the interviews were enriched after carefully listening to the audio recording, and interviewees were asked to validate and possibly add information to these notes if they were willing to do so. Of the 30 interviewees, 26 have validated the notes, and only one interviewee made essential additions to the notes. Table 3 presents key characteristics of the participants.

Table 3 Interviewee characterization

Current role		UIC experience (years)	
Program manager	2	Less than 3	9
Project manager	10	Between 3 and 5	8
PgPMO	11	Between 5 and 10	9
Team member	7	More than 10	4
Organization		PM experience (years)	
University	18	Less than 3	7
Bosch	12	Between 3 and 5	7
		More than 5	7
		More than 10	9
Qualification			
Graduation	7	PM Training	
Postgraduation	13	Yes	19
Doctorate	10	No	11

3.2 Data analysis

Qualitative content analysis was used for data analysis. This approach is commonly used when conducting qualitative studies for measuring the frequency of different concepts and themes and allowing, with caution, indications of significance (Vaismoradi et al. 2013). Commercially available software packages support content analysis. In this study, NVivo software was used. This software allows to measure the presence of categories and themes and facilitates editing of data concepts, attributes and codifications (Miles et al. 2014).

We followed the coding procedure suggested by Strauss and Corbin (1998). Based on the identified PM practices in the 'initial framework' (see Tables 1 and 2), we created a list of first-order codes. These served as the basis for deductive reasoning, where we grouped our first-order codes into two distinct categories that were previously identified as transversal and contingent PM practices. We then clustered the transversal practices into the PM lifecycle (i.e., initiation; initial planning; execution, monitoring/ controlling and replanning; and closure), and the contingent practices into traditional, agile or common PM practices (second-order codes).

Data from the thirty interviews were revisited several times by the researchers. Given this process and the fact that all interviewees approved the interview notes produced, the qualitative results are considered reliable (Gray 2004). This process allowed researchers to identify PM practices included in the 'initial framework' that should be eliminated or added or moved from transversal to contingent PM practices and vice versa.

4 Findings

The interview responses regarding PM practices, coupled with participant observation and document analysis, were compared with those identified from the literature review (Tables 1 and Table 2). The final set of practices in the 'initial framework' were then modified to reflect:

- *Confirmed* practices already identified in the 'initial framework', although in some cases prompting some slight rephrasing to the practice or even inside the category. For example, specific transversal practices simply moved from a different phase of the PM lifecycle to another phase, or inside the category contingent, the practice moved from one subcategory, traditional, agile or common to another.
- *New* identified practices that emerged from the answers of participants.
- *Moved* practices from contingent to transversal or vice versa.
- *Reformulated* practices that were substantially rephrased to broaden or to narrow their scope. For example, the 'MoSCoW method' is renamed to 'method for requirements prioritization' (e.g., 'MoSCoW'). 'MoSCoW' is just one of the methods for requirements prioritization, narrowing down its scope. The reformulated practices can also be moved inside the category transversal practices or the category contingent.
- *Discredited* practices as interviewees put a slight emphasis on them or even proposed explicitly to deny it.

Tables 4 and 5 summarize the results of this analysis, namely the % of interviewees that prompted each practice as a percentage of the total of participants (30 interviewees). The tables also indicate if each PM practice was identified during participant observation (*) and document analysis (**). Finally, the table indicate if the PM practice is confirmed, new, moved, reformulated or discredited. Most of the PM practices were confirmed, and a few discredited.

4.1 Transversal project management practices

Table 4 summarizes the results of the study into transversal PM practices within the case study, divided into project phases. Overall, interviewees discredited none of the 24 PM practices identified in the 'initial framework' and identified a few new practices. The final PM.UIC framework resulted in 29 transversal PM practices. Nevertheless, several practices can be used in combination. For example, the 'progress report' might include the registers of 'project issue log', 'change log', or 'new project idea log'. Note that, although each practice only appears once, most practices are updated from the beginning to the closure of the project, for example, the: 'stakeholder register', 'dissemination and communication plan', 'risk register', 'benefits register', 'lessons learned register', among others.

Both university and industry members agreed that the PM practices that must be transversal to all projects within the program. Nonetheless, university members placed more emphasis on the importance of using the 'project idea paper' than industry members. The reasons behind this difference may be that these documents are usually perceived by industry members as being overly theoretical, and so mostly only accessible to members with academic competencies. Nevertheless, this PM practice was regarded as critical for promoting the interaction between industry and academic members. UIC projects are driven by both industry and scientific challenges, therefore industry member engagement was crucial. Workshops, brainstorming sessions, or simply meetings for discussion of the problem, objectives, and potential solutions for each initial project idea helped to support the preparation of the 'project idea paper'.

Industry members had put more emphasis on the importance of the 'transition plan' to facilitate the ongoing project benefits realization. This included a list of members, within each organization, accountable for the exploitation, and the handover of all the necessary information to allow for the proper exploitation of the project's results. This had

Table 4 Transversal PM practices

Ph.	PM Practice	%	Comments
Initiation	Project idea paper	77 *	***Confirmed.*** 17% of the interviews referred that using the 'project idea paper' is before the 'project initiation'. However, the 'project idea paper' and the funding application are the main inputs for the 'project initiation' phase. Usually, there is a significant temporal gap, more than one year, between the 'program preparation' and the 'project initiation' (Fernandes et al. 2015a).
	Project charter	87 *	***Confirmed.*** Respondent 25 stated, *"one of the most important practices and greatest concern for the program coordination must be the 'project charter'"*. He argues that 'Project charter' must be a dynamic tool and not just an initial formalization tool of the start of a funded, approved project". The gap between the 'program preparation' and the 'project initiation' could be alleviated through the attempt to align the 'project charter' with the 'project idea paper' and the funding application.
	Kick-off meeting	87 **	***Confirmed.*** 'Kick-off meeting' aims to communicate the project objectives, generate a common understanding among all the parties involved about the project, obtain the commitment of the team members and explain the roles and responsibilities of each stakeholder established in the program governance model.
	Stakeholder register	83% *	***Confirmed.*** Interviewee 23 referred *"that members should better know all participants in the project since its initiation and the 'stakeholder register' might contribute to this"*. 'Stakeholder register' should be updated during the whole PM lifecycle.
	Benefits register	70 *	***Moved.*** The expected project benefits should be identified even during the project strategic planning, i.e., during the 'program preparation' (Fernandes and O'Sullivan 2021).
	Alignment workshops	3 **	***New.*** Although only stated by interviewee 28, *"include at the beginning of the project a practice that portrays the alignment of expectations and only then we should move to planning"*. The workshop aims to align the expectations and objectives of the involved stakeholders because the process of obtaining funding is lengthy. The negative influence of this long-term temporary gap between the project ideas (previously to the funding application development) and the effective 'project initiation' were mitigated through these alignment workshops that are central to establish a strong communication linkage between both partners (Pertuzé et al. 2010).
	Project competencies list	13	***New.*** According to interviewee 19, it is essential "*to identify the required project competencies, namely the PM competencies. In cases where required competencies are not fulfilled, it is necessary to define alternative ways of filling the lack of competencies.*" It is therefore critical to consider not only technical but also management competencies.
Initial Planning	High-level project cope and schedule plan	80 *	***Reformulated.*** The decision was to join the 'schedule plan' with the 'high-level project scope' because, in practice, the list of deliverables and the respective deadlines are usually in the same document, as it was observed at the IC-HMI program. The gap between the 'program preparation' and the 'project initiation' could be alleviated through the attempt to align the three practices: 'high-level project scope and schedule plan', the 'project charter' and the 'project idea paper'.

Table 4 (continued)

Ph.	PM Practice	%	Comments
	Project procurement plan	83 *	***Confirmed.***
	Project staff plan	83 *	***Confirmed.*** It allows to better understand the team member's availability to the project, and a commitment of the program coordination with the necessary resources to the project.
	Dissemination and communication plan	87 *	***Confirmed.*** It should include the different communication channels selected for the project, namely newsletters, emails, magazines, brochures, including a 'social media' tool. The 'social media' was presented as a 'contingent' practice but when questioned directly was eliminated by three (10%) of the total interviewees. It was considered reductive to put 'social media' and not put the remaining communication channel mentioned above. Therefore, the 'dissemination and communication plan' might integrate a 'social media' tool.
	Milestone list	73% *	***Confirmed.*** Interviewee 22 referred that it is essential a well-clarified 'milestone list'. All 'project charters' of IC-HMI program included a 'milestone list'.
	Responsibility matrix	77 *	***Confirmed.*** Interviewee 23 mentioned the importance of having a well-defined 'responsibility assignment matrix'. He pointed out that *"an improvement could come from better knowledge of the roles of each of the project actors…"*. The responsibility matrix was established at the IC-HMI program governance model.
	Risk register	87 *	***Confirmed.*** While some interviewees affirmed that risks are identified at the planning stage, qualitative analysis and risk response plans should also be carried out (Fernandes et al. 2019). All 'project charters' have included an initial list of risks identified.
Execution, Monitoring/ Controlling and Replanning	Project issuelog	77% *	***Confirmed.*** This practice assumes the 10th position of the top 20 PM practices of the study by Fernandes et al. (2013). Interviewee 5 stated, *"issues of personal interest that override the interest in projects are common, which become important issues to the project"*. Interviewee 28 claimed that *"the university's objectives are different from the company's objective which, in certain projects, generated some conflict of interest between members"*. Thus, the 'project issue log' allows registering and formalizing the problems resulting from conflicts of interest that facilitate their resolution.
	New project ideas log	70 *	***Confirmed.*** Identifying new project ideas leads to the development of future R&D collaborations between the partners, which help keep the new jobs created, helping in capturing and maintaining talented human resources (Scandura 2016). Keeping talented resources was one of the main difficulties in managing the IC-HMI program because most human resources are contracted in fixed-term and so not attractive to researchers.
	Quality inspection	83 *	***Reformulated.*** The researchers decided to eliminate the part that discriminated 'quality inspection' as the 'level of fulfilment of deliverables' because it was considered, for example by interviewee 23 "'*Quality inspection' should not focus only on the fulfilment of deliverables. Still, also it should be concerned with the quality of the development of all project work "*.

Table 4 (continued)

Ph.	PM Practice	%	Comments
	Progress reports	83 *	***Confirmed.*** Respondent 10 states that "*it must also include the recording of financial status and HR"*, which were not included in the 'progress reports' of the IC-HMI case study.
	Progress meetings	83 **	***Confirmed.*** It was noted by interviewee 10 that *"'Progress meetings' should be upgraded to include human resources (HR) issues and budget execution so that financial monitoring and HR monitoring can be done."*
	Change log	73 *	***Confirmed.*** A project change might also result in the use of the practice 're-baselining'. Interviewee 12 concluded that *"in a project of innovation there are several uncertainties, and so many changes occur during the project"*. Therefore, it is essential to record the changes that occur throughout the project as observed in IC-HMI program.
	Re-baselining	77 *	***Confirmed.*** Interviewee 28 emphasized that *"there are relevant issues today, but that in the course of the project may see their relevance change, which is one of the great difficulties of innovation; to innovate is to take risks"*. Attending to the quick scientific-technological changes, it is common to make a re-baselining of this typology of projects. Morandi (2013) argues that updated project plans are needed to coordinate partners' activities when partners are bounded by reciprocal interdependence, as it happens in IC-HMI program.
	External audits	83 **	***Reformulated.*** In the 'initial framework', 'audits' were identified and understood as 'external audits' conducted by the funding entity. However, interviewee one suggested adding 'internal audits' as a 'contingent' PM practice. Therefore, here, the transversal practice was clarified as 'external audits'.
	Lessons learned register	80 *	***Confirmed.*** The interviewees understood that this practice should be better performed; at IC-HMI, the 'lessons learned' were, unfortunately, being collected mainly during the project closure, as referred by interviewee 6 and observed in IC-HMI program.
	Requirements analysis	40 *	***Moved.*** 40% of the interviewees considered that this practice should be transversal. Usually, this practice arises in the 'project initial planning' phase, but given the typology of the project, typically, the detailed 'requirements analysis' happens during the 'project execution' phase, as observed in IC-HMI program.
	Ongoing delivery	17 **	***New.*** Since most of these project types are funded, it is even more crucial the 'ongoing delivery' of the project outputs. According to interviewee 28, usually the management of deliverables *"is guided by four modules: Scope (scope; defines what will be done and what works and meets the expectations of the Bosch side and the university side); As-Is (current situation of the projects, justifies the existence of the projects, what will be done, the analysis of requirements and clarification of the same); To-Be (a future situation, it is the prioritization of the requirements and the very clarification of what will be the result of the project and how to achieve this result) and Development (what was done and how it was done) and finally the pilot"*.

Table 4 (continued)

Ph.	PM Practice	%	Comments
	Innovation meetings	10 **	***New.*** Regular meetings occur in project development sites to present to the different project stakeholders the project results achievements and discuss how both partners can explore them. It is also a useful practice to surpass the difficulties in managing the integration of the different projects of the program, as it involves stakeholders from the different levels.
Closure	Project closure meeting	77 **	***Confirmed.*** The 'project closure meeting' allows the systematization of the project lessons learned. As mentioned by interviewee 6, *"the 'project closure meeting' allows balancing if all project objectives have been achieved or, if they have not been, understand why"*.
	Project closure Report	80 *	***Confirmed.*** 'Project closure report' includes a summary of the project performance, the objectives, the results obtained, the benefits achieved, the lessons learned, as well as the new project ideas for future collaborations.
	Transition plan	67	***Confirmed.*** 'Transition plan' is assumed as a practice for setting objectives, prerequisites, activities, and responsibilities for a smooth transition from the project context to project results' operationalization. This PM practice is critical for therealization of all project benefits (EuropeanCommission 2016). According to interviewee 20, *"the 'transition plan' can be seen as putting into practice what is being developed in the project."* However, this practice was not observed in IC-HMI or identified during document analysis.

* Document analysis

** Participant observation

longer-term impacts, such as economic growth and wealth creation, resulting from new product development and increases in process efficiency (Ankrah and Al-Tabbaa 2015).

Program managers from both university and industry emphasized the importance of the 'project charters' and 'progress reports' to assure the effectiveness of overall program governance. Interviewee 25 stated *"the most critical tool and that requires greater attention and quality is the project charter. This document should be used throughout the project lifecycle."* They also highlighted more the significance of the 'lessons learned register' and 'new project ideas log'. The main reason behind this is that program managers are focused on long-term collaboration objectives that can create a sustainable university-industry partnership. At time of writing, Bosch and UMinho are presently in the closing phase of yet another major UIC program, involving an investment of above €100 million euros; and it is in the strategic planning phase of the following UIC program.

Program managers placed less emphasis on the importance of the 'high-level project scope and schedule plan'; 'project staff plan project' and 'procurement plan' than project managers. The university project managers (all academic principal investigators) were focused on managing individual projects and saw these PM practices as critical to pursue daily the project objectives, i.e., knowing what to do, when, and with what human and other resources available.

Table 5 Contingent PM Practices

App.	PM Practice	%	Comments
Traditional	Work breakdown structure	67 **	***Confirmed.*** 'Work Breakdown Structure (WBS)' was the practice perceived by interviewees as the most useful but not used by most project teams. Interviewee 4 referred *"a more detailed planning for some projects would make sense. How would it be done and how much it could be detailed is something that has been discussed"*. However, according to interviewee 21, this detailed planning may be challenging to implement because *"often the project is presented in a rather general way and as it is an R&D work, everything is not well defined from the outset"*.
	Gantt chart	63	***Confirmed.*** Interviewee 9 considers that *"the project team internally could have its own 'Gantt chart' more detailed"*.
Agile	Planning for iteration-based agile	47 **	***Confirmed.*** *"The use of the 'planning for iteration-based agile' is essential when choosing for an agile approach to the internal planning of the project team"* (interviewee 11).
	Product backlog	47 **	***Confirmed.***
	Release planning schedule	50	***Confirmed.*** Interviewee 16 states that *"this practice may sometimes not be possible to apply when sprints are very small and what is decided in 'sprint planning' is to perform well-identified tasks which are to be done"*.
	Daily standups	47	***Confirmed.*** Interviewee 10 stated, *"our team does 'daily standups' with usually a duration of 5 minutes, at the beginning of the day, to allocate the daily tasks and discuss some tasks that are not progressing as intended"*.
	Sprint backlog	50 **	***Confirmed.***
	Sprint review	50 **	***Confirmed.*** *"Usually, after the 'sprint review', the 'sprint planning' is performed on the same day"* (interviewee 16).
	Sprint retrospective	50	***Confirmed.*** 'Sprint retrospective' helps the team learn from the previous work on the product and its process. Interviewee 16 refers that *"it is a good moment to register lessons learned"*.
	Continuous integration	50 **	***Confirmed.*** 'Continuous integration' often incorporates the entire project work to test it to subsequently deliver a suitable version of the product to be launched on the market at any time (Fernandes and Almeida 2010; Flora and Chande 2014).
	Self-directed work teams	47 **	***Confirmed.***
	Burn charts	47	***Confirmed.*** It was decided not to detail in the final PM.UIC framework what types of 'burn charts' exist to respect the level of detail of the remaining PM practices identified.
	Kanban board	43	***Confirmed.*** 'Kanban board' facilitates management as it allows project teams to keep up to date tasks and still know what was done, what is being done and what remains to be done.
	Simple design	0	***Discredited.***
	Process miniature	0	***Discredited.***
	Essential interaction design	0	***Discredited.***
	System metaphor	0	***Discredited.***

Table 5 (continued)

App.	PM Practice	%	Comments
	Sprint planning	7	***New.*** Understood in the 'initial framework' as an integral part of the 'planning for iteration-based agile', but from the interview analysis, it was clear that 'planning for iteration-based agile' is more higher-level planning, while 'sprint planning' is considered detailed planning. As interviewee 29 stated, "*the existence of 'sprint planning' is an important practice to plan the next sprint"*.
Common either to traditional or agile	PM software	63	***Reformulated.*** In the 'initial framework' 'PM software' was focused on 'monitoring schedule'. However, it was observed that, although it aims at monitoring the schedule, it is also essential for scope management, among other aspects related to PM. It is a 'contingent' practice because not all projects require the same PM software; it also depends on the adopted traditional or agile PM approach, thus being reformulated as a 'contingent' practice (either traditional or agile). Interviewee 8 referred that *"we use Excel, but I believe that it is not the best tool to manage projects of this dimension. The use of other software would be interesting"*. Interviewee 20 stated that *"MS Project could be used to define better what has to be done and when to do it"*.
	Requirements prioritization	53 **	***Reformulated.*** During the interview analysis, it was clear that it is essential to prioritize requirements, but it does not necessarily require using the MoSCoW method. The name of the practice was restructured to 'method for requirements prioritization', and MoSCoW was given as an example.
	Activity list	47	***Confirmed.***
	Effort estimation	50	***Confirmed.***
	Meeting minutes	50 *	***Confirmed.*** Five respondents considered that it should be a transversal practice. However, the researchers understood that those involved in the projects could not be 'forced' to keep minutes of their meetings. The researchers understand this to be a useful practice and should be valued and used but should not be imposed.
	Communication room	53 **	***Confirmed.*** A specific space was created in the UMinho campus dedicated to the Bosch and UMinho partnership to allow the project teams co-allocation. Several team-building events were also developed to bring people together, establish good relationships, trust, and create a collaborative and cooperative working environment and address the communication difficulties. According to interviewee 10, *"it would be very interesting to have a space available for the project teams to be together also at Bosch. It is a practice that would promote team spirit and facilitate understanding of what each team member is developing. It is complicated that there are three different spaces and not all in the same building for the project teams, which forces the members to move from one place to another"*.
	Social media	0	***Discredited.***
	Team-building event	47 **	***Confirmed.*** Interviewee 10 highlighted that the *"implementation of team-building activities are important to gain team spirit and to increase the project team motivation, helping team members to remain in the project"*.
	Information radiator	40	***Confirmed.***
	Decision log	50	***Confirmed.***

Table 5 (continued)

App.	PM Practice	%	Comments
	Earned value management	0	***Discredited.***
	Modelling	50	***Confirmed.*** 'Modelling' includes visual representations of concepts as well as prototypes and mockups. In the context of the IC-HMI projects, this practice is considered essential for most projects.
	Demonstrations	50 **	***Confirmed.***
	Testing	47 **	***Confirmed.*** It was considered, for instance, by interviewee 23 that *"the 'Test Plan, Test Driven Development, Independent Testing, Test at All Levels' included in the practice 'testing' is very specific and technical"*. Therefore, at the final PM.UIC framework, it was referred to as 'testing'. 'Testing' in the context of R&D projects are very common. However, they are not necessarily used in all projects. Not all projects at the IC-HMI program used it; therefore, it was understood as a contingent practice.
	Shared Portal	17	***New.*** Interviewee 9 stated that "*it would be interesting to have a collaborative platform in which it would be possible to have an integrated management of the projects of the program by all entities involved because at any moment of the project any entity and anyone who had access to this information could see the projects' current status, which is currently difficult given the dispersion of information"*.
	Open points list	7	***New.*** Although only interviewees 12 and 11 referred to the importance of maintaining a list with all project issues opened and with the need for intervention, it was decided to include the 'open point list' because of its importance not only to manage at the project level but also at the program level.
	Internal audits	7	***New.*** Although it was suggested by only two interviewees the inclusion of 'internal audits', it was decided to include it in the final PM.UIC framework as a contingent PM practice, because, as interviewee 2 mentioned, *"internal audits are very critical namely to be better prepared for the external audits"*.
	Milestone party	3	***New.*** Only interviewee 6 stated the importance of a milestone party. However, it was included in the final PM.UIC framework to encourage extended personnel exchange between the university and industry members, as is suggested by Pertuzé et al. (2010). Nevertheless, this kind of practice should not be imposed, and therefore is a *nice-to-have* practice.

* Document analysis

** Participant observation

4.2 Contingent project management practices

Table 5 summarizes the results of the contingent practices. Most of the practices were confirmed, only six were discredited: 'system metaphor'; 'essential interaction design'; 'simple design'; 'process miniature'; 'social media'; and 'earned value management'. The first four PM practices listed were considered by some interviewees as very specific and more related to the project technical management and product development, except for 'social media' and 'earned value management'. 'Social media' was considered just a particular communication channel included in the 'communication and dissemination plan' as a

communication method. As for 'earned value management' interviewee four stated, *"the level of maturity of people concerning PM is not appropriate to the use of certain practices, such as earned value management, and also makes difficult its application given the fact that, in these projects, more than one organization is involved, within a university with no culture in producing timely updated timesheets"*.

The structure of the PM.UIC framework includes the contingent PM practices, i.e., practices used by project teams who understand them as useful for their projects. At the 'initial framework,' all the contingent PM practices were understood as non-essential at the program level and *optional* practices at the project level depending on the teams PM approach i.e., traditional or agile. Many interviewees did not offer opinions regarding the agile PM practices due to their lack of knowledge and experience in its use. Thus, the confirmation percentages of these practices are lower in comparison to the transversal PM practices.

Both university and industry members also agreed on the contingent PM practices with industry members placing particular emphasis on agile PM practices, such as 'planning for iteration-based agile', 'product backlog', 'sprint backlog', 'sprint review', 'sprint retrospective', 'daily' standups, and 'burn charts'. The reason for this emphasis by industry members may be the prevalence of agile practices within their New Product Development (NPD) process. If a PM practice has been already adopted by one partner of the collaboration, it will be more easily adopted in the context of new R&D UIC projects (Jiménez et al. 2020). On the other hand, academic members put more emphasis on 'modelling' and 'testing' practices, and this might happen because these practices are very common in academic R&D projects in general

It is worth mentioning that the PgPMO members stressed the importance of 'PM software'. The reason behind this is perhaps not surprising, since the PgPMO team is very close to the operational management of both the program and its constituent projects. Therefore, PgPMO members naturally have a perception of higher importance of software tools to support them in dealing with the vast amount of information to manage. In fact, as argued by several authors, PM software plays a major role in supporting the management of projects (Kock et al. 2020)

5 Discussion

Analysis of the interviews resulted in a new framework of PM practices in major UICs presented in Fig. 3. In summary, the framework offers the transversal PM practices for all projects in a major program, as the program management level must be assured. It identifies seven practices in the 'initiation' phase instead of four in the 'initial framework' (Table 1). In the 'project initial planning' and 'project closure' phases, there were no changes. In the 'project execution, monitoring/controlling and replanning' phase, twelve practices were indicated instead of the five initially proposed, so two practices were added: 'ongoing delivery' and 'innovation meetings'.

In the contingent practices of the final PM.UIC framework, a total of 30 practices are identified: two practices related to traditional approach against three considered in the 'initial framework', 12 agile practices instead of the 15 initially identified, and 16 common (either used in traditional or agile) – two more than the 14 initially identified.

The PM.UIC framework developed through this research, divides PM practices into two groups – transversal and contingent. Transversal practices are *must-have* PM practices

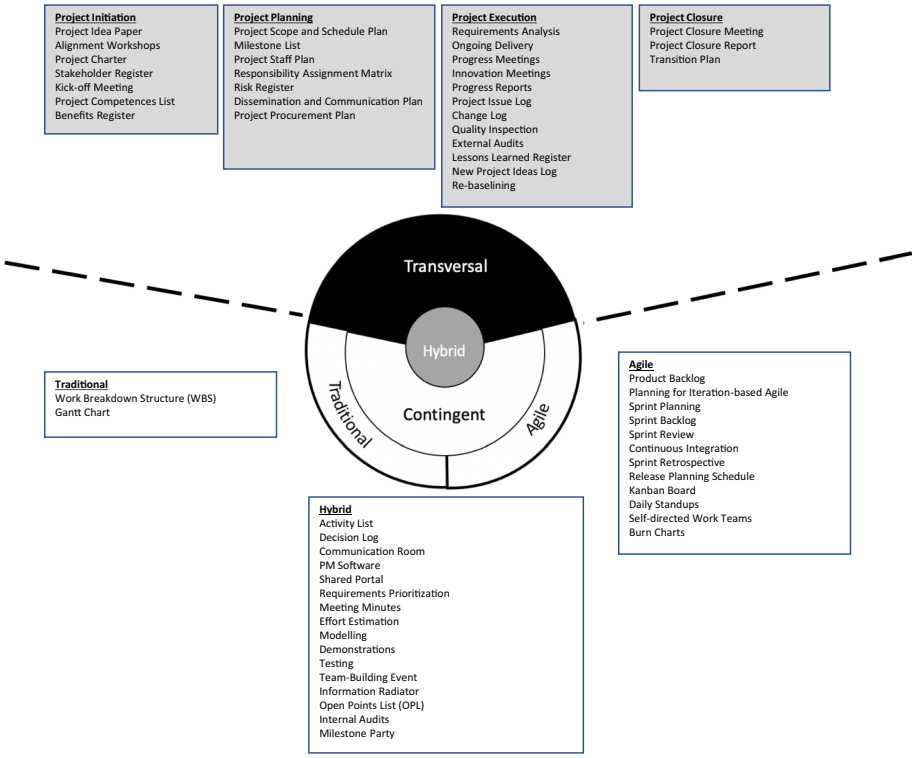

Fig. 3 The PM.UIC framework for PM practices in major UIC programs

distributed throughout the PM lifecycle to assure effective governance of the overall UIC program. Contingent means *optional* practices that project teams can decide to use. These contingent PM practices are divided into traditional, agile and common, i.e. used either by traditional or agile PM approaches. The contingent practices would allow the use of the 'optimized' model that emphasizes planning and formal processes based on phases, and the 'adaptive' model that recognizes that the goals to be achieved and the path to achieving them are fundamentally uncertain and are based on intuitive judgment, informal processes, and learning acquired through trial-and-error experience (Davies 2014; Shenhar and Dvir 2007). While the transversal practices would allow the engagement of all the stakeholders involved, as well as a more significant alignment and proximity between them, and a better vision of the major program objectives to lead to the success of the projects within the program, maximizing the program benefits realization (Coombs 2015; Fernandes and O'Sullivan 2021).

The contribution of this study is twofold. Firstly, this research builds knowledge of UICs by having a micro-level perspective on managing collaborative R&D projects for which there is limited understanding (Brocke and Lippe 2015; Nsanzumuhire and Groot 2020). The paper presents a PM.UIC framework proposal to manage UIC projects within a major program. The framework gathers current knowledge on critical PM practices (tools and techniques) for the particular context of UIC, which can guide other UICs to create greater balance between creative freedom and control (Brocke and Lippe 2015). The framework attends to recent calls on UIC literature for studies to investigate types of governance

mechanisms, requiring a balance between control and more open heterarchical governance to fit the expectations and needs of both university and industry partners (Skute et al. 2019). Academic researchers tend to have a high need for creative freedom, and therefore autonomy for establishing research directions and managing their UIC projects (Zalewska-Kurek et al. 2018). While firms need to assure the alignment of goals, as well as commitment among collaborator partners (Morandi 2013; Pertuzé et al. 2010).

Secondly, the research improves our theoretical understanding of how to combine in the management of a major program two different PM approaches: traditional and agile, to assure the overall program governance of a funded UIC, independently of the PM approach adopted by each project. The research results also highlight that several PM practices are common either to traditional or agile approaches (see Fig. 3). Additionally, the research supports both the image of PM as a field with relatively uniform generic practice and shows some differences across a different organizational context, as found by the study of Besner and Hobbs (2008) and more recently by Tereso et al. (2019). The PM.UIC framework identifies some critical PM practices specific to the UIC context, such as the 'project idea paper', the 'alignment workshops' or the 'transition plan'. However, other essential PM practices in the PM.UIC framework are common or generic to any project, such as the 'project charter', 'kick-off meeting' or 'milestone list' (Besner and Hobbs 2008; Tereso et al. 2019).

At the beginning of the research conceptualization, it was hoped that the research might come up with a relatively short list of relevant PM practices on which stakeholders involved in the management of UICs should focus their attention. However, the results of the empirical work show that managing such initiatives is a complex issue and cannot be reduced to a small list of PM practices. It may be argued that even the current list of PM practices is not detailed enough.

6 Conclusions

This study investigates the key PM practices for the context of major university-industry R&D collaboration (UIC) program. The first stage of the research involved developing an 'initial framework' derived from the literature. The framework conceptualization was based on the contingency theory (Drazin and Van de Ven 1985; Lawrence and Lorsch 1968; Sauser et al. 2009), which comprised 24 transversal PM practices (Table 1), and 32 contingent PM practices (Table 2). The contingent PM practices are divided into three subsets; 15 of the 32 are agile PM practices, three traditional and 14 remaining common to both agile and traditional approaches. The transversal PM practices are presented according to the PM lifecycle, divided into four phases: 'project initiation', 'project initial planning', 'execution, monitoring/ control and replanning', and, lastly, 'project closure'. In R&D projects, traditional or agile approaches might also be used (Barbosa et al. 2021). However, in the case study, the traditional approach was the most adopted by the project teams.

Subsequently, a final PM.UIC framework was constructed following an exploratory study consisting of thirty semi-structured interviews with stakeholders in different levels of the program organization, program managers, project managers, PgPMO members and team members of the case in study, participant observation and document analysis. The framework incorporates the initial essential PM practices listed in the 'initial framework' (Tables 1 and 2), suitably modified to reflect the alterations suggested from the interview responses, coupled with participant observation and document analysis. Analysis of

data served to: identify four new transversal (e.g., 'alignment workshops') and five new contingent PM practices (e.g., 'internal audits'); confirm twenty-one transversal (e.g., 'stakeholder register') and twenty contingent PM practices (e.g., 'product backlog'); move one contingent PM practice to transversal ('requirements analysis'); reformulate three transversal (e.g., 'external audits') and two contingent PM practices (e.g., 'PM software'); and discredit six contingent PM practices (e.g., 'earned value management'). Overall, these modifications resulted in a PM.UIC framework with 29 transversal and 30 contingent PM practices (Fig. 3). This micro-level perspective on UIC practices during the complete lifecycle of an endeavor (Albats et al. 2018) provides valuable guidelines for managing project and program success.

Deploying the PM.UIC framework in future UICs can be done using a simple five-step method. The first step involves engaging UIC stakeholders with all the potential PM practices outlined in the PM.UIC framework. The consortium can then assess the relevance of PM practices for their own particular context, by for example giving each practice a weight between 0 and 100%. The third step may involve selecting the PM practices based on the assessment for each of the major stakeholders i.e., program, project, and PgPMO team. Key stakeholders should then agree on the main tools and templates necessary to operationalize the PM practices selected, e.g., WORD or EXCEL templates of collaboration software. Finally, a simple traffic lights system might also be used to illustrate progress or otherwise of various program and project management activities.

Deploying the PM.UIC framework might also require particular attention to several PM embedding factors (Fernandes et al., 2015b), such as giving specific training to key players on PM practices, the PM.UIC framework might be even used to direct training requirements for university and industry project leaders; identifying opinion leaders mandated to promote PM practices at key meetings; demonstrating the value of PM practices through continuous communication; and raising awareness of PM practices that would increase the probability of program success so further collaborations may be funded in the future (Fernandes et al., 2020a).

6.1 Management implications

Brocke and Lippe (2015, p. 1023) identified eight key challenges for partners involved in UICs that included: *"Balance between creative freedom and control"* and *"uncertainty about working methods"*. By developing a hybrid management approach and identifying key PM practices within a large UIC, this research presents new insights that can help to address these two challenges. Addressing these two challenges can lead to the identification of new ideas and behaviors that can help to reduce the 'cultural gap' between collaborating partners. The adoption of PM practices leads to UICs project success (Barnes et al. 2006; Fernandes et al. 2020a; Huang and Chen 2017). However, as Brocke and Lippe (2015) also argue, there is a need to have a contingency approach to identifying practices that match specific project needs.

Implementing transversal PM practices in all projects within a major program is key to in inter-organizational endeavors, such as UICs. As well-recognized in literature, successful UICs require high trust and commitment between partners (Bellini et al. 2019; Hemmert et al. 2014; Oliver et al. 2020; Pertuzé et al. 2010; Plewa et al. 2013); and the transversal PM practices aims to contribute to increasing the level of trust among partners. Hemmert et al. (2014) argue that trust at the organizational level is centered on efficiency, including alignment with contract provisions and time commitment to the project that PM

practices would promote. For instance, the conduction of regular 'progress meetings' in the Bosch-UMinho case study allowed continuous communication among members of both partners, reducing misunderstandings between partners during the collaboration (Bruneel et al. 2010), namely related to ownership of intellectual property and academic freedom to publish (Bellini et al. 2019), and developing trust (Canhoto et al. 2016). Bellini et al. (2019, p. 1939) argue that "*effort is needed to build channels and tools enhancing trust between industry and university"*, thus emphasizing trust as a key facilitator of knowledge transfer among collaboration partners (Santoro and Bierly 2006).

The emphasis and focus on appropriate PM practices in the Bosch and UMinho collaboration has contributed to enhanced communication among partners (Fernandes et al. 2020a), leading to greater technology and knowledge transfer (Ankrah and AL-Tabbaa 2015; Santoro and Bierly 2006), as well as the continuous search for new project R&D ideas, through the use for example of the PM practice 'new project ideas log' and keeping the search for new projects on the R&D agenda. The focus on identifying appropriate PM practices also contributed to the sustainability of the Bosh-UMinho partnership over three collaboration periods 2013-2015, 2015-2018 and 2018-2021 and currently proposed again between 2022 and 2024 comprising an investment of over 60 million euros.

It is anticipated that embedding the PM.UIC framework within collaborative projects will positively affect the success and, consequently, the sustainability of the university-industry collaborations (Pinto and Fernandes 2021). As shown by Bellini et al. (2019) collaborative know-how is one of the main factors for enhancing intangible benefits, such as knowledge transfer and learning, that is also identified as one of the most important anticipated benefits of UIC stakeholders (Fernandes and O'Sullivan 2021).

However, embedding PM practices is dependent on both university and industry levels of PM maturity (Fernandes et al. 2014). Due to the large investment, UMinho and Bosch partners anticipated the need for Program and Project Management Office (PgPMO) structure to support the implementation of PM practices that would help to maximize program benefits. The PgPMO had a serving role (Fernandes et al. 2020b) since its main objective was to support both the program management and project teams during the program and project lifecycle. From the case study, it was clear that the PgPMO played a significant role in embedding transversal PM practices particularly where there is a high interdependence between partners (Morandi 2013). Project managers usually played the role of management and research, i.e., there is a *"diversity of coordinator function"* (Brocke and Lippe 2015). Therefore, the PgPMO not only supported program management but also the management of individual R&D projects, which is critical to the overall program success (Artto et al. 2011).

The emergence of the PgPMO aimed to provide PM practices that fostered the translation of program objectives into project objectives and to develop skills and competencies for project teams through training, workshops, and seminars. During the 'project initiation' phase, the PgPMO main aim was to translate program strategies into project strategies and to ensure the evolution of project ideas into projects, by using for example the practices of 'project idea paper' and 'project charter'. At the 'project initial planning' phase, its aim was to assure proper support for project leaders, using for example the practices of 'high-level project scope and schedule plan', 'procurement plan', and 'project staff plan'. During 'project execution, monitoring/controlling and replanning' phase, the PgPMO assured that the objectives were met and the expected stakeholders' benefits were realized (Derakhshan et al. 2020), using for example the practices of 'progress meetings' and 'progress reports'.

Identifying, selecting, and deploying PM practices played a role in increasing the transparency among partners (Fernandes et al. 2020b) and reducing the effect of different and

sometimes competing expected benefits from industry and university members (Fernandes and O'Sullivan 2021). The PgPMO promoted systematic knowledge sharing and effective communication between participants, through for example, the use of the 'alignment workshops', 'innovation meetings' and 'progress meetings', building trust and narrowing the so called 'cultural gap' among university and industry participants (Barnes et al. 2006). Moreover, the PgPMO acted as a repository of learning and a vehicle for enabling knowledge transfer across projects and therefore achieving greater project synergies (Artto et al. 2011). The 'lessons learned register' for each project, and the 'project closure meeting' promoted the systematization of the collected lessons to be adopted in future UICs.

6.2 Limitations and future research

The research was performed using a single case study. We acknowledge this as a research drawback, as it limits the generalizability of the findings. Moreover, the PM.UIC framework suggested is based on a major program of projects. This context may have had an influence on the selection and deployment of various PM practices. In this regard, this case study may reduce the generalizability of the findings when compared to more typical single project collaborations.

Project and program management is highly dependent on the organizational context (Besner and Hobbs 2013; Pellegrinelli et al. 2007; Rijke et al. 2014), and like any framework, it portrays a simplification of reality and should be used cautiously when university and industry partners adopt it to successfully manage their own R&D collaborations. Therefore, exploring more UIC cases would result in expanding the outcome of this research by namely comparing the effects of task uncertainty, equivocality, and the interdependence of partners (Morandi 2013).

The research here presented has a technical perspective on managing UIC projects, however future studies on social aspects would help to retain the plurality of perspectives (Hernes 2014) and to capture the complexity found in the phenomenon of managing inter-organizational collaboration programs and projects. It is well-recognized in literature that UIC projects are built on social relationships that require considerable trust and commitment between partners to create reciprocal benefits over time and make a UIC sustainable (Plewa et al. 2013; Skute et al. 2019). Skute et al. (2019) argue for more investigation into the factors that promote long-lasting strategic alliances between universities and industries.

We note that most UICs are operationalized at the level of individual research centers, academic departments, or principal investigators rather than the level of a school or an entire university, as what happened in this case study. Literature points to the need for the existence of individual 'champions' who help bridge the gap between different organizational levels within the university and between the university and its industrial partners (e.g., Santoro and Chakrabarti 2002). In fact, 'champions' promote an important role in promoting trust between partners, specially where there is limited experience with UIC (Hemmert et al. 2014). However, at the case study, a whole PgPMO structure was created and was found critical to promote communication among stakeholders and fostering trust. Future research is needed in PgPMO or similar structures in other UIC contexts to be able to generalize this finding. During case analysis we also found some evidence that different organizational levels interfere with the perceived usefulness of PM practices. Some PM practices are more important for the leadership and governance, while others are primarily for project managers or team members. Future research might also explore this avenue.

Acknowledgements This research is sponsored by national funds through FCT – Fundação para a Ciência e a Tecnologia, under the project UIDB/00285/2020 and LA/P/0112/2020.

References

Agile Alliance (2018). Subway Map to Agile Practices and Agile Glossary | Agile Alliance. Available at: https://www.agilealliance.org/agile101/subway-map-to-agile-practices/. Accessed on December 2018

Agile Business Consortium (2014). The DSDM Agile Project Framework. Available at: https://www.agilebusiness.org. Accessed on December 2018

Ahmad, M., Markkula, J., & Oivo, M. (2013). Kanban in Software Development: A Systematic Literature Review. *Proceedings of 39th Euromicro Conference on Software Engineering and Advanced Applications*, 9–16

Albats, E., Fiegenbaum, I., & Cunningham, J. (2018). A micro-level study of university-industry collaborative lifecycle key performance indicators. *The Journal of Technology Transfer*, 43, 389–431

Alvesson, M., & Sköldberg, K. (2017). *Reflexive Methodology: New Vistas for Qualitative Research* (3rd ed.). United Kingdom: SAGE Publications

Angrosino, M. (2005). Recontextualising observation: Ethnography, pedagogy, and the prospects for a progressive political agenda. In Denzin, N., & Lincoln, Y. (Eds.), *The Sage Handbook of Qualitative Research* (3rd ed., pp. 729–745). Thousand Oaks: Sage

Ankrah, S., & AL-Tabbaa, O. (2015). Universities-industry collaboration: A systematic review. *Scandinavian Journal of Management*, 31(3), 387–408

Artto, K., Kulvik, I., Poskela, J., & Turkulainen, V. (2011). The integrative role of the project management office in the front end of innovation. *International Journal of Project Management*, 29(4), 408–421

Azenha, F. C., Reis, D. A., & Fleury, A. L. (2021). The role and characteristics of hybrid approaches to project management in the development of technology-based products and services. *Project Management Journal*, 52(1), 90–110

Brady, T., & Hobday, M. (2011). Projects and Innovation: Innovation and Projects. In P.W.G. Morris, J.K Pinto, & J. Söderlund (Eds.), *The Oxford Handbook of Project Management* (pp. 273–294).

Barnes, T., Pashby, I., & Gibbons, A. (2002). Effective university-industry interaction: A multi-case evaluation of collaborative R&D projects. *European Management Journal*, 20(3), 272–285

Barnes, T., Pashby, I., & Gibbons, A. (2006). Managing collaborative R&D projects development of a practical management tool. *International Journal of Project Management*, 24(5), 395–404

Barbosa, A., Salerno, M., Nascimento, P., Albala, A., Maranzatoa, F., & Tamoschus, D. (2021). Configurations of project management practices to enhance the performance of open innovation R&D projects. *International Journal of Project Management*, 39, 128–138

Becker, W., & Dietz, J. (2004). R&D cooperation and innovation activities of firms—evidence for the German manufacturing industry. *Research Policy*, 33(2), 209–223

Belderbos, R., Carree, M., & Lokshin, B. (2004). Cooperative R&D and firm performance. *Research Policy*, 33(10), 1477–1492

Bellini, E., Piroli, G., & Pennacchio, L. (2019). Collaborative know-how and trust in university–industry collaborations: Empirical evidence from ICT firms. *The Journal of Technology Transfer*, 44, 1939–1963

Bennett, N., & Lemoine, G. J. (2014). What a difference a word makes: Understanding threats to performance in a VUCA world. *Business Horizons*, 57(3), 311–317

Besner, C., & Hobbs, B. (2013). Contextualized project management practice: A cluster analysis of practices and best practices. *Project Management Journal*, 44(1), 7–34

Besner, C., & Hobbs, B. (2012). An empirical identification of project management toolsets and a comparison among project types. *Project Management Journal*, 43(5), 24–46

Besner, C., & Hobbs, B. (2008). Project management practice, generic or contextual: A reality check. *Project Management Journal*, 39(1), 16–33

Besner, C., & Hobbs, B. (2006). The perceived value and potential contribution of project management practices to project success. *Project Management Journal*, 37(3), 37–48

Böhmer, A., Beckmann, A., & Lindemann, U. (2015). Open Innovation Ecosystem - Makerspaces within an Agile Innovation Process. In Huizingh, I., Conn, E., & Bitran, S. (Eds.), *ISPIM Innovation Summit* (pp. 1–11). The International Society for Innovation Management.

Brocke, J. V., & Lippe, S. (2015). Managing collaborative research projects: A synthesis of project management literature and directives for future research. *International Journal of Project Management*, 33(5), 1022–1039

Bruneel, J., D'este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university-industry collaboration. *Research Policy*, 39(7), 858–868

Canhoto, A. I., Quinton, S., Jackson, P., & Dibb, S. (2016). The co-production of value in digital, university industry R&D collaborative projects.*Industrial Marketing Management*, 56,86–96

Chin, C. M., Yap, E. H., & Spowage, A. C. (2011). Project management methodology for university-industry collaborative projects. *Review of International Comparative Management*, 9(2), 121–135

Cockburn, A. (2004). *Crystal Clear: A Human-Powered Methodology for Small Teams*. Including The Seven Properties of Effective Software Projects

Cooke, J. L. (2016). *Prince2 Agile An Implementation Pocket Guide Step-by-Step Advice for Every Project Type*. Cambridgeshire, United Kingdom: IT Governance Publishing

Cooke-Davies, T. J., Crawford, L. H., & Lechler, T. (2009). Project management systems: Moving project management from an operational to a strategic discipline. *Project Management Journal*, 40(1), 110–123

Coombs, C. R. (2015). When planned IS/IT project benefits are not realised: A study of inhibitors and facilitators to benefits realisation. *International Journal of Project Management*, 33(2), 363–379

Davies, A. (2014). Innovation and Project Management. In M. Dodgson, D. M. Gann, & N. Phillips (Eds.) *The Oxford Handbook of Innovation Management*

De Fuentes, C., & Dutrénit, G. (2012). Best channels of academia-industry interaction for long-term benefit. *Research Policy*, 41(9), 1666–1682

Derakhshan, R., Fernandes, G., & Mancini, M. (2020). Evolution of governance in a collaborative university–industry program. *Project management Journal*, 51(5), 489–504

Drazin, R., & Van de Ven, A. H. (1985). Alternative forms of fit in contingency theory. *Administrative Science Quarterly*, 30(4), 514–539

Engwall, M. (2003). No Project Is an Island: Linking Projects to History and Context. *Research Policy*, 32(5), 789–808

European Commission. (2016). *PM² Project Management Methodology Guide*. Open Access

Faria, J. R., Ferreira, J. J., Johnson, K. H., Mixonc, F. G., & Wankee, P. F. (2020). Agglomeration economies and university program creation in the knowledge economy. *Socio-Economic Planning Sciences*, 72, 100800

Fernandes, G., & O'Sullivan, D. (2021). Benefits management in university-industry collaboration programs. *International Journal of Project Management*, 39(1), 71–84

Fernandes, G., O'Sullivan, D., Pinto, E. B., Araújo, M., & Machado, R. J. (2020a). Value of project management in university-industry R&D collaborations. *International Journal of Managing Projects in Business*, 13(4), 819–843

Fernandes, G., Pinto, E. B., Araújo, M., & Machado, R. J. (2020b). roles of a programme and project management office to support collaborative university-industry R&D. *Total Quality Management and Business Excellence*, 31(5-6), 583–608

Fernandes, G., Martins, A. R., Pinto, E. B., Araújo, M., & Machado, R. J. (2019). Risk Response Strategies for Collaborative University-Industry R&D Funded Programs. In Machado et al. (Eds.) *Innovation, Engineering and Entrepreneurship* (pp. 522–529). HELIX 2018, LNEE 505

Fernandes, G., Pinto, E. B., Araújo, M., & Machado, R. J. (2017). Planning Benefits Realisation in a Collaborative University-Industry R&D Funded Program. In *Proceedings of International Conference on Engineering, Technology and Innovation (ICE/ITMC)*, 1037–1045.

Fernandes, G., Pinto, E. B., Machado, R. J., Araújo, M., & Pontes, A. (2015a). A program and project management approach for collaborative university-industry R&D funded contracts. *Procedia Computer Science*, 64, 1065–1074

Fernandes, G., Ward, S., & Araújo, M. (2015b). Improving and embedding project management practice in organisations — A qualitative study. *International Journal of Project Management*, 33(5), 1052–1106

Fernandes, G., Ward, S., & Araújo, M. (2014). Developing a framework for embedding useful project management improvement initiatives in organisations. *Project Management Journal*, 45(4), 81–108

Fernandes, G., Ward, S., & Araújo, M. (2013). Identifying useful project management practices: A mixed methodology approach. *International Journal of Information Systems and Project Management*, *1*(4), *5*–21

Fernandes, J., & Almeida, M. (2010). Classification and Comparison of Agile Methods. In *Proceedings of 7th International Conference on the Quality of Information and Communications Technology*, 391–396.

Fey, C. F., & Birkinshaw, J. (2005). External sources of knowledge, governance model, and R&D performance. *Journal of Management*, 31(4), 597–621

Fichtner, C. (2015). How to Successfully Use Social Media on Your Projects. in *Proceedings of PMI® Global Congress 2015—EMEA*, London, England. Newtown Square, PA: Project Management Institute.

Figueiredo, N. L., & Ferreira, J. J. M. (2021). More than meets the partner: a systematic review and agenda for University-Industry cooperation. *Management Review Quarterly* (*in press)*.

Frederiksen, N., Gottlieb, S. C., & Leiringer, R. (2021). Organising for infrastructure development programmes: Governing internal logic multiplicity across organisational spaces. *International Journal of Project Management*, 39(3), 223–235

Flora, H. K., & Chande, S. V. (2014). A systematic study on agile software development methodologies and practices. *International Journal of Computer Science and Information Technologies*, 5(3), 3626–3637

Galan-Muros, V., & Davey, T. (2017). The UBC ecosystem: Putting together a comprehensive framework for university-business cooperation. *The Journal of Technology Transfer*, 44(4), 1311–1346

Gemino, A., Reich, B. H., & Serrador, P. M. (2021). Agile, traditional, and hybrid approaches to project success: Is hybrid a poor second choice? *Project Management Journal*, 52(2), 161–175

Gray, D. E. (2004). *Doing Research in the Real World*. London: Sage

Hanel, P., & St-Pierre, M. (2006). Industry-university collaboration by Canadian manufacturing firms. *The Journal of Technology Transfer*, 31(4), 485–499

Hanisch, B., & Wald, A. (2012). A bibliometric view on the use of contingency theory in project management research. *Project Management Journal*, 43(3), 4–23

Hemmert, M., Bstieler, L., & Okamuro, H. (2014). Bridging the cultural divide: Trust formation in university-industry research collaborations in the US, Japan, and South Korea. *Technovation*, 34(10), 605–616

Hernández-Trasobares, A., Murillo-Luna, J. L. (2020). The effect of triple helix cooperation on business innovation: The case of Spain. *Technological Forecasting and Social Change*, 161, 120296

Hernes (2014). *A Process Theory of Organization*. Oxford: Oxford University Press

Huang, M. H., & Chen, D. Z. (2017). How can academic innovation performance in university-industry collaboration be improved? *Technological Forecasting and Social Change*, 123, 210–215

Jiménez, V., Afonso, P., & Fernandes, G. (2020). Using agile project management in the design and implementation of activity-based costing systems. *Sustainability*, 12(24), 10352

Kobarg, S., Stumpf-Wollersheim, J., & Welpe, I. (2018). University-industry collaborations and product innovation performance: The moderating effects of absorptive capacity and innovation competencies. *The Journal of Technology Transfer*, 43(4), 1696–1724

Kock, A., Schulz, B., Kopmann, J., & Gemünden, H. G. (2020). Project portfolio management information systems' positive influence on performance – the importance of process maturity. *International Journal of Project Management*, 38(4), 229–241

König, B., Diehl, K., Tscherning, K., & Helming, K. (2013). A framework for structuring interdisciplinary research management. *Research Policy*, 4(1), 261–272

Lappi, T., Karvonen, T., Lwakatare, L. E., Aaltonen, K., & Kuvaja, P. (2018). Toward an improved understanding of agile project governance: A systematic literature review. *Project Management Journal*, 49(6), 39–63

Lawrence, P. R., & Lorsch, J. W. (1968). Organization and environment: Managing differentiation and integration. *Administrative Science Quarterly*, 13(1), 180–186

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative Data Analysis* (3th ed.). Sage Publications, Inc. All.

Milosevic, D. Z., Martinelli, R. J., & Waddell, J. M. (2007). *Program Management For Improved Business Results*. New Jersey: Hoboken

Morandi, V. (2013). The management of industry–university joint research projects: How do partners coordinate and control R&D activities? *The Journal of Technology Transfer*, 38, 69–92

Nomakuchi, T., & Takahashi, M. (2015). A study about project management for industry-university cooperation dilemma. *Procedia Computer Science*, 64, 47–54

Nsanzumuhire, S. U., & Groot, W. (2020). Context perspective on university-industry collaboration processes: A systematic review of literature. *Journal of Cleaner Production*, 258, 120861

Nerur, S., Mahapatra, R., & Mangalaraj, G. (2005). Challenges of migrating to agile methodologies. *Communications of the ACM*, 48(5), 72–78

Nishimura, J., & Okamuro, H. (2018). Internal and external discipline: The effect of project leadership and government monitoring on the performance of publicly funded R&D consortia. *Research Policy*, 47(5), 840–853

Oliver, A. L., Montgomery, K., & Barda, S. (2020). The multi-level process of trust and learning in university-industry innovation collaborations. *The Journal of Technology Transfer*, 45(3), 758–779

Papadakis, E., & Tsironis, L. (2020). Towards a hybrid project management framework: A systematic literature review on traditional, agile and hybrid techniques.*The Journal of Modern Project Management*, *8*(2).

Pellegrinelli, S. (2011). What's in a name: Project or programme? *International Journal of Project Management*, 29(2), 232–240

Pellegrinelli, S., Partington, D., Hemingway, C., Mohdzain, Z., & Shah, M. (2007). The importance of context in programme management: An empirical review of programme practices. *International Journal of Project Management*, 25(1), 41–55

Pertuzé, J. A., Calder, E. S., Greitzer, E. M., & Lucas, W. A. (2010). Best practices for industry-university collaboration. *MIT Sloan Management Review*, 51(4), 82–91

Peterson, S. (1995). Consortia partnerships: Linking industry and academia. *Computers & Industrial Engineering*, 29(1-4), 355–359

Pinto, E. B., & Fernandes, G. (2021). Collaborative R&D the key cooperation domain for university-industry partnerships sustainability – position paper. *Procedia Computer Science*, 181, 102–109

Plewa, C., Korff, N., Baaken, T., & Macpherson, G. (2013). University-industry linkage evolution: An empirical investigation of relational success factors. *R&D Management*, 43(4), 365–380

PMI. (2017). *A Guide to the Project Management Body of Knowledge (PMBoK Guide)* (6th ed.). Newtown Square, Pennsylvania: Project Management Institute

Rajalo, S., & Vadi, M. (2017). University-industry innovation collaboration: Reconceptualization. *Technovation*, 62-63, 42–54

Rantala, T., & Ukko, J. (2018). Performance measurement in university – industry innovation networks: Implementation practices and challenges of industrial organisations. *Journal of Education and Work*, 31(3), 247–261

Rijke, J., van Herk, S., Zevenbergen, C., Ashley, R., Hertogh, M., & Heuvelhof, E. (2014). Adaptive programme management through a balanced performance/strategy oriented focus. *International Journal of Project Management*, 32(7), 1197–1209

Rybnicek, R., & Königsgruber, R. (2019). What makes industry–university collaboration succeed? A systematic review of the literature. *Journal of Business Economics*, 89(2), 221–250

Santoro, M. D., & Bierly, P. E. (2006). Facilitators of knowledge transfer in university-industry collaborations: A knowledge-based perspective. *IEEE Transactions on Engineering Management*, 53(4), 495–507

Santoro, M. D., & Chakrabarti, A. K. (2002). Firm size and technology centrality in industry–university interactions. *Research Policy*, 31(7), 1163–1180

Santos, N., Fernandes, J. M., Carvalho, M. S., Machado, R. J. (2016). Using scrum together with UML models: A collaborative University-Industry R&D software project.*Springer International Publishing Switzerland*,480–495.

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Edinburgh: Pearson Education Limited

Sauser, B. J., Reilly, R. R., & Shenhar, A. J. (2009). Why projects fail? How contingency theory can provide new insights - a comparative analysis of nasa's mars climate orbiter loss. *International Journal of Project Management*, 27(7), 665–679

Scandura, A. (2016). University-industry Collaboration and Firms' R&D Effort. *Research Policy*, 45(9), 1907–1922

SCRUMstudy (2016). A Guide to the Scrum Body of Knowledge (SBOK™ Guide), 2016 ed. SCRUMstudy™.

Serrador, P., & Pinto, J. K. (2015). Does Agile work? —A quantitative analysis of agile project success. *International Journal of Project Management*, 33(5), 1040–1051

Shenhar, A. J., & Dvir, D. (2007). *Reinventing Project Management: The Diamond Approach to Successful Growth and Innovation*. Boston: Harvard Business School Press

Shi, Q. (2011). Rethinking the implementation of project management: A value-adding path map approach. *International Journal of Project Management*, 29(3), 295–302

Skute, I., Zalewska-Kurek, K., Hatak, I., & Weerd-Nederhof, P. (2019). Mapping the field: a bibliometric analysis of the literature on university–industry collaborations. *The Journal of Technology Transfer*, 44, 916–947

Spalek, S. (2016). Innovative Vs. Innovation Projects in Organisations. *Innovativeness of Modern Organisations, TNOiK* (April).

Špundak, M. (2014). Mixed agile/traditional project management methodology – reality or illusion? *Procedia - Social and Behavioral Sciences*, 119, 939–948

Steinmo, M. (2015). Collaboration for innovation: A case study on how social capital mitigates collaborative challenges in university – industry research alliances. *Industry and Innovation*, 22(7), 597–624

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory* (2nd ed.). London: Sage

Sulaiman, T., Barton, B., & Blackburn, T. (2006). AgileEVM-Earned Value Management in Scrum Projects. In *Proceedings of the Agile Conference*, 10–16.

Tereso, A., Ribeiro, P., Fernandes, G., Loureiro, I., & Ferreira, M. (2019). Project management practices in private organisations. *Project Management Journal*, 50(1), 1–17

Thiry, M. (2002). Combining value and project management into an effective programme management model. *International Journal of Project Management*, 20, 221–227

Turner, R., & Müller, R. (2017). The Governance of Organizational Project Management. In Shankar, S., Müller, R., & Drouin, N. (Eds.), *Cambridge Handbook of Organizational Project Management*. Cambridge University Press

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, 15(3), 398–405

van Buuren, A., Buijs, J., & Teisman, G. (2010). Program management and the creative art of coopetition: Dealing with potential tensions and synergies between spatial development projects. *International Journal of Project Management*, 28(7), 672–682

Yates, D., & Paquette, S. (2011). Emergency knowledge management and social media technologies: A case study of the 2010 Haitian earthquake. *International Journal of Information Management*, 31(1), 6–13

Yin, R. (2018). *Case Study Research: Design and Methods*. sixth. California: Sage Publications

Zalewska-Kurek, K., Egedova, K., Peter, A. T. M., & Roosendaal, H. E. (2018). Knowledge transfer activities of scientists in nanotechnology. *The Journal of Technology Transfer*, 43, 139–158