Perspectives: Policy and Practice in Higher Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tpsp20

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To cite this article: José M. R. C. A. Santos (2021): Management of public–private R&D projects in Higher Education: key trends and issues, Perspectives: Policy and Practice in Higher Education, DOI: 10.1080/13603108.2021.1894616

To link to this article: https://doi.org/10.1080/13603108.2021.1894616

Published online: 10 Mar 2021.

PERSPECTIVES: POLICY AND PRACTICE IN HIGHER EDUCATION
https://doi.org/10.1080/13603108.2021.1894616

Routledge
Taylor & Francis Group

Management of public–private R&D projects in Higher Education: key trends and issues

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ABSTRACT

Research and Development (R&D) project managers in Higher Education must deal with uncertainty, ambiguity, competition, accountability and different objectives for professors, scientists, firms, users and other stakeholders. Formal project management frameworks are commonly adapted to support this. However, the wide range of challenges related to R&D inhibits truly effective and efficient approaches. In this paper, the R&D project management literature is analysed, chief concepts are examined, and key areas to be considered by any management approach in Higher Education institutions are suggested. This will lead to more realistic management practices, focused on their added-value and on that of the particular project and not on the management framework/methodology *per se*. The particular case of collaborative private–public R&D projects funded by public funds is addressed in view of their increased importance as a key instrument for the implementation of public science policies.

KEYWORDS

Public–private R&D; project management; approaches; challenges

1. Introduction

Governmental mediation is key for advance of new knowledge and technologies that benefit society. Public intervention reduces the risk of research and development (R&D) projects by sharing it among the public funder, partners and other participants. Also, public-funded R&D has the power to (1) catalyse the development of ground-breaking knowledge and technologies, (2) decrease costs and other blockades to large-scale implementation and (3) create trust in the market by effectively validating developments (Kurth et al. 2017). These are fundamental conditions for significant market uptake of latest technologies. At the same time, the development of knowledge and technology is accelerating, requiring shorter response times to capture opportunities, originating an increasing necessity for connecting people and disciplines, and using key abilities from wide sources. This is reflected in the fact that technology-intensive firms increasingly embrace the open innovation model and interact with external interested parties in their innovation efforts, stimulating co-created knowledge exchanges (Secundo et al. 2019). Particularly, companies increasingly engage with public research and technology organisations, namely higher education institutions, in multi-disciplinary, and frequently international, R&D projects. However, private and public organisations have, by definition, differing and sometimes contradictory cultures, incentives and goals for R&D projects. The truth is that this frequently ends up in conflicts and misaligned and underperforming initiatives, that undermine expectations from taxpayers.

The use of public funds for firm-based R&D has been addressed within the literature by several authors, but research addressing R&D projects sponsored by public funds and executed by public entities are rare. The literature covers mostly industry instead of the public sector.

Kuchta et al. (2017) studied R&D projects financed by public funds in Poland. They analysed particularly the connection between the attained and the original goals, project management practices utilised, features of the team, the connection between the planned activities and the work done, and also arising managing issues. They found that for various R&D projects within the public area no project management methodologies are applied (83%), mainly because they're not known to researchers (69.1%) since they favour distinction issues instead of project management (27.2%). Nearly 20% of the study participants specify that instinctive project management approaches are enough, and so they do not value specific management approaches. Not surprisingly, due to the aforementioned lack of incentives, the budget dimension was where the best agreement between plans and actual implementation was observed. An additional issue relates to human resource management (planning, acquisition, shaping), mainly because of the high autonomy and low 'discipline' of team members

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that share other responsibilities like teaching. Naturally, this scenario will vary widely with each country and cultural context, but this can be still typically the scenario e.g. in research-performing higher-education institutions.

Mikulskiene (2014) found that the Lithuanian companies see the public sector researchers as 'high-quality, creating great, inspired basic theories, but, simultaneously, the national R&D system works in "performance" mode, but not in "production" mode'. Conversely, public sector researchers affirm that firms avoid basic research, prefer partnerships only in commercialisation project phases and have a tendency to invest into short-term projects. Also, many R&D team members based on public institutions feel uncomfortable when having to use formal procedures as they typically include hierarchy and detailed structures. As project management adds some formality to R&D activities, researchers tend to think it may hinder their scientific creativity and don't see the worth of using project management techniques. This is often not the case in R&D intensive companies. The authors also found that this strongly influences management practices in collaborative private–public R&D projects and is strongly related with the interpretation of stakeholders' input.

Project termination is another key issue that must be handled but that, typically, lacks due consideration, namely in public–private projects. In the case of public-funded R&D in public institutions usually there aren't any incentives to critically assess the likelihood of cancelling a project. Moreover, in most cases, there are no incentives to ending a project before time or under the contracted budget. Researchers try to achieve the foremost they can within the given time and budget. This is not the case in private firms, where strict schedule and resources monitoring and controlling mechanisms are always put in place for the sake of effectiveness. And where project termination is usually an option.

The choice to end a R&D project before it attains its predetermined goals is still one of the foremost problematic decisions. Among the most predominant though least acknowledged motives is the issue of redirecting the researcher work if a project is ceased (Guan and Liu 2003). In fact, in the case of private R&D projects, it risks to demotivate teams (Balachandra, Brockoff, and Pearson 1996). Gonçalves, De Mello, and Nascimento (2014) found that R&D managers in firms mostly replace decisions to kill projects with project prioritisation. They prefer to keep projects in the pipeline, even in stand-by, rather than terminating them. Conversely, when a public research project is cancelled, the unused budget may be returned to the funding agency (Çağlar and Gürel 2017).

From the previous paragraphs it's clear that unified project management approaches would benefit both private and public entities engaging in collaborative R&D initiatives. The employment of a shared concepts and language would facilitate alignment of attitudes and practices, thus resulting in increased prospects of success. Many project management approaches, frameworks and methodologies have been developed and adapted to R&D projects, and even patented (e.g. US20180330296A1). However, as seen above, their use by public entities remains in its infancy, and hindered by cultural and organisational aspects. Thus, there is a need to search out for a common ground that might conciliate the views, attitudes and practices in private–public R&D endeavours.

Perspectives has addressed project management in higher education mainly on quality management, change management and information technology approach. In particular, McCormick (2006) has addressed project management in higher education, namely from an electronic research administration point of view. Moreover, the existence of a 'project management' domain in higher education has been evidenced by authors such as Whitchurch (2006). In this paper key areas are tentatively identified that, whatever project management approach is employed, should be managed carefully by administrators and managers at the higher education sector, in order to enhance the success odds of R&D initiatives carried out in increasingly complex research and innovation ecosystems.

The corresponding research question forming the basis of this study is: 'which key management aspects must be considered in every R&D project, independently of the methodology or framework utilized to that end?'.

A heuristic framework combining an in-depth literature analysis and phenomena observation forms the premise of the research design. Findings from literature (documentation) were continuously validated by direct, empirical observation and interaction with practitioners. The present study is inductive, exploratory and interpretative in nature. A qualitative research approach was used, because it is suitable for examining questions that are intricate and challenging to measure, along with recognising topics, configurations, conceptions and perceptions that are necessary to tackle such interrogations.

In the next section, the major specificities that characterise R&D projects are addressed, with a focus on key areas that influence decisively their success. The paper ends with the identification of major conclusions and future work.

2. Management of R&D projects

R&D funding requires accurate estimates for projects and, consequently, managers traditionally focus on planning and controlling, disregarding its risky nature, and issues originated in human nature. Also,

processes or products that are technologically complex often require an understanding of both customer technological skills and needs. Thus, stakeholder management is critical. Moreover, since R&D projects usually have long life cycles, large investments and high uncertainty, risk assessment is additionally key to success. In the particular case of international R&D projects other aspects must be considered like effective communication, attention to protection of intellectual rights, need for economies of scale and critical mass, and complex overall coordination. Thus, it can be perceived that the execution of R&D projects calls for exceptional leadership, adequately trained staff, accountable management and operational and organisational simplicity.

In the following sub-sections, the major project management approaches used for R&D initiatives are revised, and a detailed analysis of the influence that key areas have on the management of R&D projects is presented. Together, they constitute a conceptual approach for the effective and efficient management of R&D endeavours.

2.1. Project management approaches

Formal project management approaches were originally developed for projects with relatively low uncertainty (e.g. ISO21500:2012, PMBOK), for the software industry (e.g. Scrum) or for new product development (e.g. Stage-Gate). In the next paragraphs, several examples are given to illustrate efforts being made to adapt formal frameworks or methodologies to the R&D context.

Chin (2012) developed a project management approach to be used in industry-university research environments, using reference industrial standards such as PMBOK, PRINCE2, APMBOK and British Standard BS6079-1:2002. In particular, a project management methodology guidebook was developed to be used in the initiation, planning, execution, monitoring and closing of R&D projects. It includes a collection of tools and techniques, templates and processes, that facilitate management during the course of the whole life cycle of these projects.

Hors et al. (2012) developed an application of PMBOK and Lean Six Sigma values to develop a research management system by employing a particular tool for identification, implementation and later analysis. The procedures were categorised into four groups: organisational culture, systems, processes and people. It was concluded that the solutions enabled the improvement of research management systems.

Simion (2012) adapted and adjusted PRINCE2 to a pre-established project methodology of a science funding agency (ANCS). It was concluded that any research and development project might be guided by the PRINCE2 principles, and that it is a 'guarantee' that time, cost and quality of the project may be effectively controlled.

Kiyota and Kubo (2017) successfully applied R&D project management methodologies based on the PMBOK. The usefulness of tools like the 'responsibility assignment matrix' and the 'work breakdown structure' was demonstrated.

Femenías and Diagonal (2012) developed an agile practice for new process and product development that is a combination of a number of earlier design approaches, best practices from the IT sector (comprising e.g. Scrum), and waterfall project management theory. The methodology includes the following stages: definition, design, development, testing, deployment and closing project.

In addition to formal project management methodologies, specific tool and techniques may be successfully applied to R&D projects, with adaptations whenever necessary. For instance, Creemers, De Reyck, and Leus (2015) devised optimal strategies for scheduling that optimise the expected net present value (NPV) of a project but considering changes in activity durations and costs, created cash flows, activity precedencies and failure probability, and options for alternative technologies. It's meant to be employed in initiatives with difficulty to predict activity durations, where scientific breakthroughs or technological discoveries can correspond to a successful activity completion. Another example of a useful tool is the 'requirements traceability matrix' utilised in waterfall methodologies. It connects requirements to their source and tracks them throughout the project life cycle. Thus, it brings objectivity to the deliverables acceptance process and increases the prospect of final result approval.

From the information presented above, it can be concluded that whatever framework or methodology is employed for managing R&D projects, key areas can be identified that are critical to their successful application: (1) the context surrounding the project, (2) its stakeholders, (3) its knowledge-based nature, (4) its inherent risky setting and (5) the necessity for performance and evaluation indicators. Each of these areas is detailed in the next sub-sections, with a view to highlight critical management aspects of every R&D endeavour.

2.2. The context

The context under which research projects are executed is increasingly complex, including social, economic, political and technical settings. Thus, project management methodologies must be flexible and adaptable to every context. This includes considering aspects like the source of funding, the topic area(s), and also the need for a national or multinational

consortium, just to convey some examples. Priorities for research set by policy making bodies (often themselves research funders) and host institutions must be considered. The impact of the project on technological, economic and social dimensions must be taken into consideration. Also, the scientific context, i.e. the state of the art of the knowledge in the relevant scientific field(s) must be thoroughly addressed for the project success. Moreover, the project manager should be fully responsive to the institutional context, e.g. administrative procedures, key institutional stakeholders, strategic/technologic roadmaps, etc. In inter-organisational, multinational and/or multidisciplinary projects, the project manager must additionally act as a 'knowledge translator', facilitating processes that make it possible for project participants to debate and communicate about research created outside their own academic and institutional contexts (Jansen et al. 2014). In face of above, focusing on constrains and the 'environment' is suggested for successful R&D projects (Farokhad et al. 2019).

2.3. The project stakeholders

A project stakeholder is someone that may influence, or be influenced, positively or negatively by the project. Thus, stakeholder identification and management must be a priority for every project manager. For instance, activities not relevant to the requirements of the project results' users, nor geared to producing technologies easily adopted by them, are typical issues. Frequently, researchers tend to focus on the scientifically most stimulating issues. The technologies emanating from such research might not be very relevant to the actual end-users. In another example, policy makers responsible for defining legislation relevant to the market introduction of new technologies should be involved, if relevant, in R&D projects developing those technologies. Otherwise the project may produce wonderful papers but have no impact on society. A further example corresponds to 'internal' stakeholders. For instance, the cost and also the budget of every project need to be conciliated to ensure that needed funds will be available at the proper time. Thus, it may be a good idea to define approaches to 'manage' appropriately the financial director, or similar role.

Elias, Cavana, and Jackson (2002) performed a detailed review of literature on stakeholders and mapped the evolution of the stakeholder concept from 1963 to 2002. Moreover, they devised a method for the analysis of stakeholders in R&D projects, comprised of the following steps: (1) stakeholder map development, (2) definition of a stakeholders' chart, (3) stakeholders' stakes documentation, (4) stake vs. power graph development, (5) process-level stakeholder analysis, (6) perform stakeholder analysis at transactional level, (7) decide the stakeholder management capability and (8) examine the stakeholders' dynamics. Also, García-Valderrama and Mulero-Mendigorri (2005) utilised the stakeholder concept for creating validation points that allow to evaluate R&D effectiveness. These examples illustrate well the key importance of stakeholder management in the context of R&D projects.

2.4. R&D knowledge-based nature

Knowledge is the own fabric of any R&D initiative. It's the alpha and the omega of every R&D project. It's management involves both tacit and explicit knowledge. Explicit knowledge can be easily documented and explained (e.g. reports). However, researchers seldom feel that the documents they generate are used and, thus, document preparation is usually seen as a tedious, unproductive requirement. Thus, 'flexible' information collection strategies must be formatted. Conversely, tacit knowledge is problematic to transfer. Goffin and Koners (2011) found that the majority of the knowledge generated in new product development projects (that may include R&D stages) is tacit, being hard to convey, dependent on teams' interaction, and linked with problem-solving. The authors analysed five case studies concerning German firms, and concluded that four lessons learnt seem to be mostly connected to tacit knowledge: solving deviations in specifications of products, managing schedules, solving issues and tackling budgets. It was found that learning connected to tacit knowledge wasn't successfully captured for dissemination. The results also showed that managers of R&D projects and the organisation itself should use mentoring to capitalise on created tacit knowledge. The authors suggest that current and potential R&D project managers should attend post-project reviews so as to pass on lessons learnt. The major points should subsequently be discussed during project kick-off meetings.

2.5. Risky by nature

A risk is an event characterised by a specific probability of occurrence. It may be a threat or an opportunity. Its consequences to the project may vary in severity. Typically, research managers tend to concentrate on scientific and technological risks only. But in fact other key categories must be considered, such as organisational risks (e.g. a team member leaves the firm), societal risks (e.g. an NGO strongly opposes the project), competition-related risks (e.g. a competing team achieves the project goals first), etc. Also, in order to obtain innovative results, researchers should have a risk-taking behaviour, increasing the probability of failure. Thus, typical uncertainty of R&D projects demands

robust project risk management (Baccarini and Melville 2011). As an example, Bodea and Dascalu (2009) proposed a risk evaluation model for research projects supported by fuzzy inference. Although this might not be adequate for every project, proactive and robust risk management approaches should be implemented in all R&D initiatives.

2.6. R&D project metrics

Accountability of project results is of the utmost importance. This is the case not only for privately funded R&D projects but also for initiatives funded by tax payers' money. Metrics, or indicators to be more precise, are essential for both success and performance evaluation. A project success must be assessed once the project is ended, but a project performance can be evaluated during the course of its entire life cycle. Therefore, a scorecard of project indicators involves both performance and success metrics (Fernandes et al. 2019).

The assessment process selected should be a way for focusing R&D proposals on those aspects that the organisation wishes to highlight and that it will most likely reward. Public funding organisations usually favour non-financial aspects like added-value to society and scientific worth (Çağlar and Gürel 2017). Does the project outcome lead to longstanding benefits to the funder? Is it expected to deliver new basic knowledge? For fundamental research, by definition exploratory, where the criteria are tough to quantify and also the conclusion is highly indeterminate, selection methods that allow for qualitative assessment tend to be more recognised by managers. Also, selection processes that include peer review are more readily accepted by researchers themselves (Henriksen and Traynor 1999). On the other hand, companies measure R&D performance with other purposes in mind, such as stimulating organisational learning, motivating staff and for profitability analysis (Chiesa et al. 2009). Other reasons include rating of technical capabilities by costumers, measures of product quality and reliability, R&D projects distribution by portfolios and strategic alignment with the business (Schwartz et al. 2011).

Elmquist and Le Masson (2009) investigated how R&D projects can be assessed when specifications are not known at the beginning. They observed that the standard quality–cost–time framework cannot be used because it considers that (1) when the project begins the correct specifications are made and (2) projects are independent units, ignoring both how knowledge is transferred between projects and the way projects produce knowledge. The authors suggest the following metrics: (1) use of financial resources, (2) support to strategic vision expansion, structuring and refinement, (3) development of competences and (4) identification of knowledge gaps. Nonetheless, when the criteria are defined, they must also be implemented so as to replicate the favoured organisational perspective. The utilisation of balanced scorecard (BSC) concepts for R&D projects has been studied by Eilat, Golany, and Shtub (2008), with the aim of supporting the assessment process along its entire life cycle. Several other authors have addressed the use of BSC in this context, such as Yang et al. (2010), focused on technology maturity and competitive advantages.

3. Conclusions

R&D initiatives are key to the evolution of society in all of its dimensions (social, economic, technological, environmental, etc.). This has been increasingly acknowledged by firms, national governments and supranational authorities (e.g. the European Commission) and is reproduced in the mounting volume of R&D projects executed regularly, namely involving higher education institutions. Increased accountability for investment in R&D, and its intrinsically uncertain, risky and intricate nature, demand specific and robust management methodologies. Professional R&D project management has been evolving as a 'branch' of traditional project management. Specific frameworks, methodologies and tools have been developed, namely in the last few years, and applied to the higher education context. However, each R&D project has its specificities and, thus, irrespective of which framework or methodology is employed, tailor-made approaches need to be adopted. This can be a herculean task, if not managed adequately. A way to ease the project manager hurdle, and increase his/her efficiency and effectiveness, is to stress the need to focus on key management areas. In this paper, we revised the specialised literature, and incorporated the views of subject matter experts on this topic. This resulted in the definition of five key management areas for a R&D project: its context, its stakeholders, its knowledge-based nature, its risks and performance/evaluation indicators. It's the author's opinion that, whatever framework or methodology is employed, R&D project management approaches should be centred around these areas. Consequently, future advances on this subject are expected to emphasise new tools and techniques that at the same time simplify and make R&D project management more realistic. Ultimately, the project manager should manage the project and not the other way around.

Acknowledgements

The author is grateful to the Foundation for Science and Technology (FCT, Portugal) and FEDER under Programme PT2020 for financial support to CIMO (UIDB/00690/2020).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author is grateful to the Foundation for Science and Technology (FCT, Portugal) and FEDER under Programme PT2020 for financial support to CIMO [UIDB/00690/2020].

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