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Roles and Responsibilities of Project Coordinators: A Contingency Model for Project Coordinator Effectiveness

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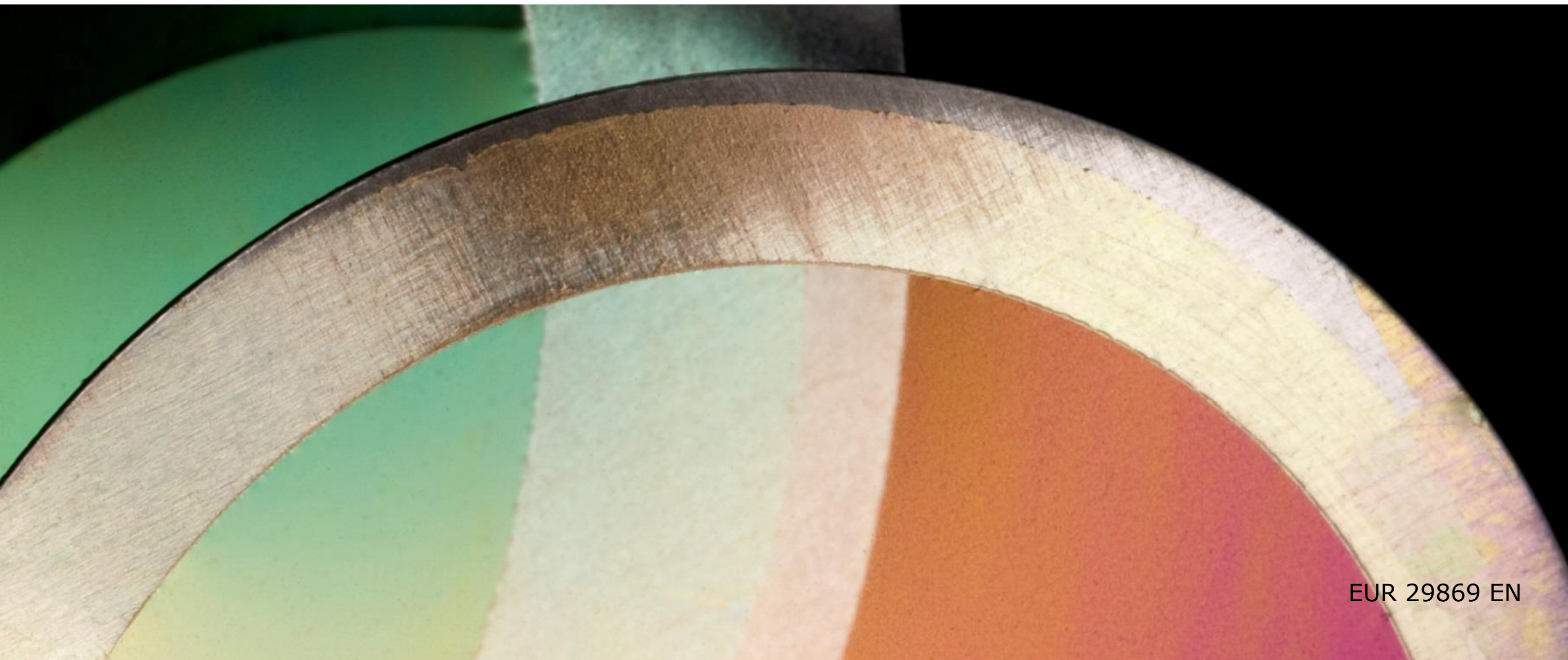

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Title: Role and Responsibilities of Project Coordinators: A Project Contingency Model for Project Coordinator Effectiveness

Abstract

Project coordinators fulfil several roles and responsibilities alongside their primary scientific focus. As boundary spanners between science and industry they have an invisible central role in the delivery of innovation from publicly funded science through technology transfer. In this report we review present empirical literature relating to the role and responsibilities of principal coordinators and we propose a contingency model for studying the effectiveness of project coordinators. The roles, responsibilities and activities of the PC are identified. In our contingency model the threshold roles and responsibilities are identified in the PC as: (i) research leader, (ii) research allocator and controller, (iii) innovation facilitator, (iv) boundary spanner, and (v) project coordinator and manager. These are developed into expanded PC role capabilities that include: (i) research strategist, (ii) economic agent, (iii) technology and knowledge transfer enabler, (iv) collaboration and value creation leader, and (v) manager and governor.

Contents

Foreword

This report is prepared in the context of the three-year research project on Research on Innovation, Start-up Europe and Standardisation (RISES), jointly launched in 2017 by JRC and DG CONNECT of the European Commission. The JRC provides evidence-based support to policies in the domain of digital innovation and start-ups. In particular:

- Innovation with the focus on maximising the innovation output of EC funded research projects, notably building on the Innovation Radar;
- Start-ups and scale-ups – providing support to Start-up Europe; and
- Standardisation and IPR policy aims under the Digital Single Market priorities.

This research builds on the work and expertise gathered within the EURIPIDIS project.

This report synthesises a review of empirical literature relating to the role and responsibilities of project coordinators (PC) and their influence on research projects. Based on this literature review, a contingency model for PC effectiveness is proposed. The model addresses the individual and project factors that influence the PC in their choices and practices. PCs are engaged in the different practices at different levels, and their engagement shapes their roles, from that of project manager (mostly focusing and innovating) to that of scientific entrepreneur (shaping new models and paradigms and brokering science). In the proposed model, the practices of PCs are translated into five roles, each with specific responsibilities for which additional learning is required in order to assess and measure the necessary thresholds for PC effectiveness: (i) research leader, (ii) research allocator and controller, (iii) innovation facilitator, (iv) boundary spanner, and (v) project coordinator and manager. These are developed into expanded PC capabilities that include: (i) research strategist, (ii) economic agent, (iii) technology and knowledge transfer enabler, (iv) collaboration and value creation leader, and (v) manager and governor. The report concludes that the PC has an invisible centrality in delivering different types of project impact, and supports micro-level investigations of the challenges involved in the leadership of publicly funded research projects.

Acknowledgements

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Executive Summary

In the European Union context, the project coordinator has a key role in responding and shaping large-scale publicly funded framework projects, and in leading the delivery of such projects that they have scientific, commercial and societal impacts. This report synthesises a review of empirical literature relating to the role and responsibilities of principal coordinators (PC) and their influence on research projects. Our review focused on three main themes:

- Roles and Responsibilities of PCs
- Antecedent Individual Factor
- Project Organisation Factors

From our review outside of their primary scientific responsibilities we identified several **roles, responsibilities and activities of PCs** as:

- Research strategist
- Agent of economic and policy
- Knowledge and technology transfer
- Collaboration and value creation
- Managerial and governance

The **antecedent individual factors** that influence PCs that we observed in our review are:

- Motivation and faculty interest
- Networks
- Individual knowledge and knowhow
- Incentives
- Policy environment
- Career trajectory, experience and professional development
- Other relevant and discrete factors – scientific domain, time allocation and gender

The PC is required to bring together different actors in an effective manner and the **project organisation factors** that we identified include:

- Diversity of discipline
- Size of consortia
- Diversity of institution context
- Boundary spanner
- Research collaboration management capabilities

For our final theme of our review we focused on **effectiveness and impact**. Measurement of PC effectiveness is intrinsically tied to the success or otherwise of the overall research project and or research programme. We identified the following effectiveness and impact factors as:

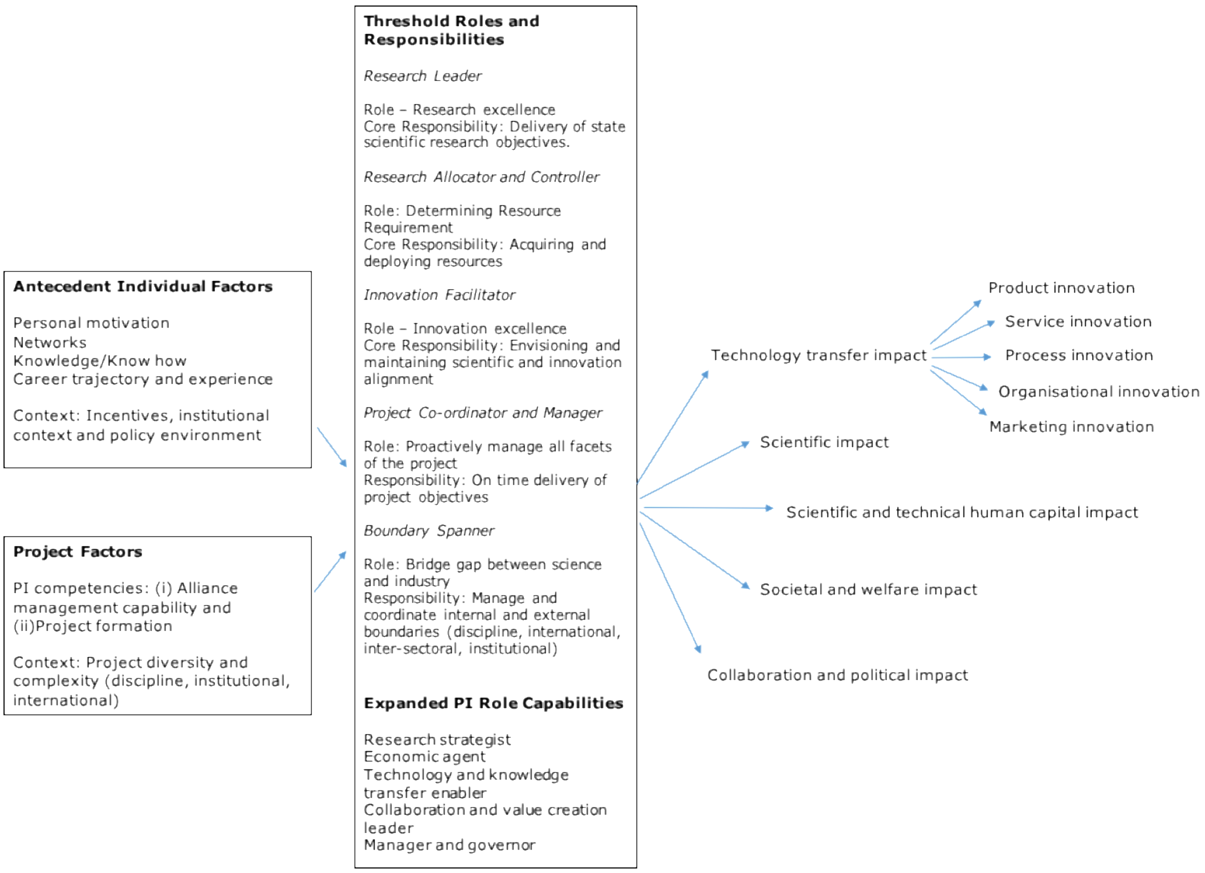
- Scientific impact

- Technology transfer impact and project innovation
- Scientific and technical human capital impact
- Economic impact
- Societal and social welfare impacts
- Collaboration and political impacts

The PC role brings with it **tensions** that individual scientists have to deal with including, *scientific versus economic activities, balancing governance and fiduciary responsibilities and managing market shaping expectations*.

Based on our review we propose a model for studying the effectiveness (see Figure 1). The model suggests that a number of factors affect the approach of the PC. These include imposed conditions but, more importantly, **are contingent on the PCs interpretation of their role and the impact of the PC's previous experience, including training**.

Figure 1 Contingent Model of Project Coordinator Effectiveness



The report concludes that the PC has an invisible centrality in delivering different types of project impact and it is essential to enhance our understanding of exact role they play in shaping and delivering innovation from publicly funded research.

1 Introduction and Context

The requirements for academic research and the management of academic research have undergone important changes since the beginning of the 1990s. These changes have seen funded research increasingly organised as part of large projects and programmes, with an increasingly diverse base of participants and funding structures. Much of this development has been accelerated by strong adherence to the paradigm of mode 2 knowledge production (Gibbons et al, 1994) and to multi-stakeholder models for research and economic development such as the triple helix model (Etzkowitz and Leydesdorff, 1997), with an emphasis on problem-focused, interdisciplinary and collaborative research.

There has been an extensive study of issues relating to research collaboration and technology transfer in the literature, but limited attention has been given to studying the lead researchers who coordinate and direct extensive research projects and indeed programmes – often identified as project coordinators (PCs) or principal investigators (PIs)[1]. Through national and cross-country research programmes (e.g. Framework Programme, Horizon 2020), these lead researchers, henceforth referred to as project coordinators (PCs), have for over a decade been the agents of science policy. As an outcome of a sharper focus on the knowledge economy, their responsibilities have extended to PCs becoming agents of economic policy and presiding over the investment of substantial public monies in research consortia.

In the EU context, the PC has a key role in responding and shaping large-scale publicly funded framework programmes, and in leading the delivery of such projects that have scientific, commercial and societal impacts. These projects, often led by academics, involve consortia that have varying degrees of diversity in terms of institutional context, size, nationality and discipline. In academic and other contexts, these academics are typically known as principal investigators rather than project coordinators.

For EU framework programmes, it is commonly understood that the PC, when awarded a research grant through an EU framework programme, agrees to standard and project-specific contractual requirements based on a project proposal. In turn, the PC takes on very specific roles and responsibilities in order to fulfil the contractual requirements of the funded project (Cunningham et al, 2017).

European Commission research programmes, such as Horizon 2020, have been the main organisational and funding mechanism within the EU that mobilises diverse collaborative research teams to respond to predetermined research topics in priority areas for the EU. Coad et al (2017) state that "one of the main instruments to foster knowledge transfer between research institutions and industry across Europe has been the promotion of research consortia between firms, universities, research centres, and public entities through the framework programmes for research and technological development". Such EC framework programmes are structured in such a way that a PC, usually from an academic institution, takes a lead in assembling, organising and coordinating the scientific, dissemination and impact aspects of proposed projects for the project proposal development and for the implementation phase. For the project development and writing stage, this means that the PC's role is to organise those scientific, dissemination and impact aspects of the proposed project into work packages that are typically allocated to consortia partners (academic, industry, policy, government), based on their expertise and capabilities. After the review process and when a project proposal has been successful, the PC role changes to negotiating with the relevant desk officer the final budget and other contractual requirements of the specific framework programme. For the implementation phase of EC framework-funded programmes, the PC leads and coordinates the delivery of all work packages against an agreed project plan, and also reports to the relevant agency as to the progress of the project. During the proposal

[1] For the purposes of this report we are using the EU term of Project Coordinators to describe Principal Investigators (PIs).

development and implementation phases, PCs access support for their own institution with respect to costing the research programmes, intellectual property issues, etc.

In the environment that PCs operate in, they are facing significant drivers of change that influence their role as PCs. Universities and public research organisations are undergoing transformation in terms of how research is managed at an institutional level (see Kang, 2004, Park et al, 2010). Universities have responded to these changes by investing in signature research centres, thereby concentrating research and scientific activities as well as resources to support transformation and impact-orientated research. Technology transfer offices (TTOs) have seen their mission, role and influence expanded beyond protecting university intellectual property (Fitzgerald and Cunningham, 2015; Gubitta et al, 2015). TTOs are involved in the marketing and promoting of technology, supporting the creation of start-up and spin-off firms, and encouraging faculty to exploit technology (see Friedman and Silberman, 2003; Muscio, 2010). This means that TTOs have to develop and shape dual identities (scientific and business), and building such legitimacy for TTOs can be challenging with academics (O'Kane et al, 2015). Funding agencies and governments are expecting greater returns on their research investment (see Bessette, 2003; Hertzfeld, 2002; Link and Scott, 2004). They now need to demonstrate to society the economic value of public investment in science, innovation and technology.

These contextual drivers and changes have implications for publicly funded PCs as they seek to develop research programmes that exploit EU framework programmes that seek to generate economic prosperity. This means that scientists taking on a publicly funded PC role need to have an ambidextrous mindset to move between scientific and commercial environments, and the capabilities to translate transformative intent into action and measurable outcomes. Ambos et al (2008: 1425) describe this as an extraordinary challenge, where researchers are "not simply required to switch from one (single-handed) activity to another, but to develop the simultaneous capacity for two activities (academic rigour and commercialisation)". Casati and Genet (2014) identify four sets of practices for principal investigators: focusing in scientific discipline (scientific production); innovating and problem-solving (bridging academia and industry to solve problems); shaping new paradigms and models (implementing the principal investigator's vision of the evolution of science) and brokering science (implementing vision through leveraging new networks and forming new organisations).

Ambos et al (2008) note that few studies have examined the capacity of researchers to handle what they describe as conflicting demands and the tensions created by this requirement. Among many scientists, there is a firm conviction that academic research and commercial research are fundamentally different. Some scientists highlight that engagement in technology transfer is insufficiently valued in their institutions, particularly in relation to scientific publishing activity (Markmann et al, 2005). Indeed, some senior faculty may even be reluctant to alter a system that has provided the basis for their own success. Other scientists simply lack the competence to undertake commercial activities or engage in technology transfer initiatives (Clarysse and Moray, 2004). For publicly funded PCs, the new paradigm is that they are transformative scientific and economic agents for public-sector entrepreneurship policy programmes. This requires an ambidexterity and effective boundary-spanning abilities to influence and shape scientific and economic directions that generate economic prosperity (Cunningham et al, 2017).

For any consideration of the role of the PC in publicly funded research, it is necessary to distinguish the differences between public and private research. Public researchers are primarily driven by an urge to expand knowledge frontiers, and to make this knowledge publicly available through scientific publication, while their private counterparts are influenced by profit motivations, which means that any new, commercially applicable knowledge that the firm develops is kept confidential for competitive reasons (Drejer and Jørgensen, 2004). The distinction between science and technology is also relevant. Science is often viewed as a non-market allocation mechanism where knowledge is treated as a pure public good. In science, the assumption is that findings must be made known completely and speedily. For technology, however, results may not be entirely disclosed. Science aims to increase the stock of knowledge by promoting originality, while technology seeks the rents that can be secured from this knowledge (Rausser, 1999). Science has become expensive, and seldom contributes to near-term profitability in a direct sense. University research rarely involves the scale, breadth or timeliness that suit industrial needs. Fundamental science has a long-term generic perspective on what is important, and scientists are motivated by achievement of scientific fame. Technology has a shorter-term view, focused on solving a particular problem; and technologists are motivated by the satisfaction of solving a problem and being rewarded by commercial and financial success (Betz, 1996).

The purpose of this paper is to report on a review of the relevant literature pertaining to the work and context of the PC. The paper defines the role and responsibilities of the PC and proposes a conceptual framework for assessing the effectiveness of the PC in the delivery of research and innovation outcomes from research collaborations.

2 Review Process

This review of the role and influence of PCs in publicly funded research projects focuses chiefly on empirical research, including qualitative research. It addresses the following areas, which in turn set out the structure of this report:

(a) Understanding of the role and activities of the PC in funded research context

(b) Antecedent individual factors of project coordinators affecting effectiveness and the impact of project technology transfer and innovation outcomes

(c) Project-level organisation factors affecting project coordination and effectiveness and the impact of projects for delivering innovations

(d) Effectiveness and impact criteria relevant to project delivery and the PC

The review emphasises a European orientation and in particular seeks to gather pertinent observations from research conducted in the context of European-funded research. The emphasis is on post-2000 published scholarly articles except in a few instances where an allusion to previous literature is required for clarifying our understanding of research trajectories.

Initial searches were carried out using key search themes including "project coordinator" and "principal investigator". Such search terms did not prove useful due, in the first instance, to a general dearth of research on PC, but also, more importantly, the lack of a consistent definition in relation to PCs reflected in the academic literature. Taking guidance from literature review papers published by Bozeman et al (2015) and Perkmann et al (2013), we focused on those scholarly journals most concerned with research management, research policy, and technology transfer. These include *Journal of Technology Transfer, Research Policy, Technovation, Research Evaluation, Technological Forecasting and Social Change, R&D Management, Regional Studies, International Journal of Technology Management, Science and Public Policy, Industry and Innovation, and Scientometrics*.

3 Definitions and Core Responsibilities of PCs

3.1 Definition of PC

Becoming a PC is a career milestone and brings prestige to the individual scientist (see Cunningham et al, 2014; Romano et al, 2017). Definitions of the role of PCs tend to be set by funding agencies and higher-education institutions, and their emphasis typically centres on scientific leadership, governance and administrative responsibilities (see Table 1). In the context of public funding, such as Horizon 2020, the PC is the person charged with direct responsibility for completing a funded project, directing the research and reporting directly to the funding agency.

Table 1: Definitions of PCs

Agency/Organisation	Definitions
European Research Council	Principal investigators are expected to be active researchers who have a track record of significant research achievements in the last 10 years. The Principal investigators should be exceptional leaders in terms of originality and significance of their research contributions.
National Institute of Health (US)	The individual(s) judged by the applicant organisation to have the appropriate level of authority and responsibility to direct the project or program supported by the grant.
European Commission[2]	The Principal Investigator (PI) is the researcher applying for the ERC grant. By creating a proposal in the Funding & Tenders Portal, the PI gets the role of "Primary Coordinator Contact (PCoCo)". As the host organisation, the PI should encode the organisation (via its Participant Identification Code – PIC) that would host the future project in case the proposal is successful (i.e. if the PI plans implementing the project at an institution different from its current employer, the PIC of the future host institution must be used, not the one of the current employer).
	The ***Primary Coordinator Contact*** is nominated for each project as the main contact point between the consortium and the Commission for a particular grant. By default this is the proposal initiator in the submission phase. The PCoCo can nominate or revoke an unlimited number of Coordinator Contacts (CoCos), who will then have the same rights - except the right to revoke the PCoCo. All Coordinator Contacts can: • nominate/revoke Participant Contacts for other

[2] *Source http://ec.europa.eu/research/participants/docs/h2020-funding-guide/user-account-and-roles/roles-and-access-rights_en.htm*

	organisations in the consortium Coordinator - for this reason, it is important to give all your partner organisations access to the proposal on the Funding & Tenders Portal as soon as possible. • nominate/revoke Task Managers and Team Members in their own organisation • assign Legal and Financial Signatories in their organisation to their projects • make changes to project documents on the Funding & Tenders Portal • submit proposals and project documents to the Commission
The Engineering Physical Science Research Council UK	The Principal Investigator should be the individual who takes responsibility for the intellectual leadership of the research project and for the overall management of the research. He/she will be the Council's main contact for the proposed project.

In general, such definitions used by universities and funding agencies to explain the role and responsibilities of PCs tend to be designed from a contractual perspective and do little to reflect the complexity and strategic importance of the role in the context of the implementation of EU framework programmes that are carried out in a multi-layered institutional setting and involve industrial partners across international research systems (Cunningham et al, 2017).

In the growing body of academic research on PCs, some definitions have emerged to capture the totality of the role. Cunningham et al (2016) define PCs as: 'scientists who orchestrate new research projects, combine resources and competencies, deepen existing scientific trajectories or shape new ones that are transformative in intent, nature and outcome that can be exploited for commercial ends and or for societal common good'. O'Kane et al (2017) simply define PCs as 'lead researchers on successful programme and project grants', while Kidwell (2013) suggests that PCs are at 'the forefront of new scientific knowledge'. Boehm and Hogan (2014) suggest in their study of PCs that they have an important role in building networks, and Feeney and Welch (2014) describe the PC key responsibility as: 'The primary responsibility for the conduct, completion and reporting on the research outlined in the proposal'.

In our research on the title project coordinator, it is clear that this is understood in the research context to be orientated towards the project management role.

3.2 Role and Responsibilities of PC

The literature identifies a number of roles, responsibilities and activities of PCs that are outside their primary scientific responsibilities. These roles are:

- Research strategist
- Agent of economic policy
- Knowledge and technology transfer
- Collaboration and value creation
- Managerial and governance

The following sub-sections summarise observations from the literature on each of these PC roles.

3.2.1 PC Research Strategist Role

In the evolving research environment, PCs are key strategic and transformation actors who engage in boundary-spanning activities. As scientists, they design and orchestrate new research projects and take a proactive and reactive strategic posture in doing so. This involves combining resources and competencies with other researchers, research organisations and enterprise partners (Kidwell, 2014). To varying degrees they seek to deepen scientific trajectories and shape new areas (Casati and Genet, 2014). Despite this important strategic aspect to their roles, surprisingly little is understood about the strategic orientation of researchers, or indeed their approach to strategising in relation to their role as leaders in national and international research systems. One study has specifically focused on this; and O'Kane et al (2015) identified four categories of strategic behaviours that adopted research designers, research adapter, research supporter and research pursuer. They also found proactive PCs are consistently strategising to realise their long-term scientific mission and are open to different forms of collaboration to realise their mission.

3.2.2 PC Economic Agent Role

Policy direction relating to public research has also imposed new demands on academic researchers. The Triple Helix model is based on the assumption that industry, university and government are increasingly interdependent. In most countries there is a tendency towards a knowledge infrastructure in which these three institutional spheres overlap (Etzkowitz and Leydesdorff, 1997). In this configuration, the spheres can take each other's forms, and hybrid organisations emerge at the interfaces. The linear model of utilisation of scientific knowledge is replaced by new organisational mechanisms that integrate market pull and technology push. Basic research is linked to utilisation through a series of intermediate processes such as government-initiated programmes that facilitate university–industry interaction. The rise of this configuration is mainly due to the enhanced role of knowledge in our economy and society. The role of universities in this configuration is often referred to as its 'third mission'. Making a contribution to economic growth is becoming a central task, next to teaching and research. In their 1997 book, Slaughter and Leslie introduced the concept of Academic Capitalism to describe their case study-based observations on the increasing market (for profit activity, patenting, licensing, spin-off enterprises and university–industry partnerships with profit components) and market-like activities at universities (competition for external funding, university–industry partnerships, and institutional investment in spin-off companies) (Slaughter and Leslie, 1997).

Whether PCs accept they are part of a triple helix model or not, the reality for most is that there is an expectation attached to most publicly funded research that their efforts contribute to such a system's economic and social objectives. This is normally realised through the technology transfer of the research outputs, with many studies highlighting that the research leader's involvement in this process is critical to determining success. This requires a completely new set of competencies that are often outside the scientific training of scientists, including IPR management, business acumen and commercial awareness. A number of authors have commented that the process of technology transfer is a complex topic and one that is not fully comprehended (Bozeman, 2000). In essence, the PC is now viewed as a key economic actor in the exploitation of publicly funded research.

3.2.3 PC Technology and Knowledge Transfer Role

When scientists take on the role of PC for publicly funded projects they become agents of technology and knowledge transfer. Nearly all publicly funded research programmes require PCs to proactively disseminate their project outcomes through traditional knowledge transfer mechanisms such as scientific papers, conferences, etc. They now also require PCs to be actively involved in technology transfer based on project outcomes through licensing, material transfer agreements, and spin-out and spin-in companies.

PCs have become agents of technology and knowledge transfer. In essence, they have to contribute to scientific and economic environments and, where appropriate, society. The most prevalent knowledge transfer activities among publicly funded PCs in an Irish study (Cunningham et al, 2017) were peer publications, research symposiums, end-of-project reports, collaborative research with industry, and industry- workshops. Notably, all of the commercially orientated activities (licensing, spin-offs, consulting and contractual research) are less prevalent than the other technology transfer activities. Cunningham et al (2016) also found that, when technology transfer activities are broken down by institution type and ranged in their order of prevalence, collaborative research with industry, licensing of intellectual property and consulting are more likely to happen at universities.

Given their role as agents of technology transfer, the limited literature on PCs highlights certain factors that enable or create barriers with respect to technology transfer and exploitation of scientific discovery for innovation and entrepreneurship purposes. Personal relationships, asset scarcity and proximity are enablers and barriers of technology transfer for PCs in collaborating with SMEs (see O'Reilly and Cunningham, 2017). Cunningham et al (2014) found that broader barriers related to political, environmental, institutional and project-based factors also inhibit PCs. In particular, their study highlighted barriers with respect to technology transfer, institutional support for technology transfer and the power of industry partners. In a study set in New Zealand among healthcare PCs, O'Kane et al (2017) found that the personal preparedness of PCs with respect to commercialisation also acted as a barrier.

3.2.4 PC Collaboration and Value-Creation Role

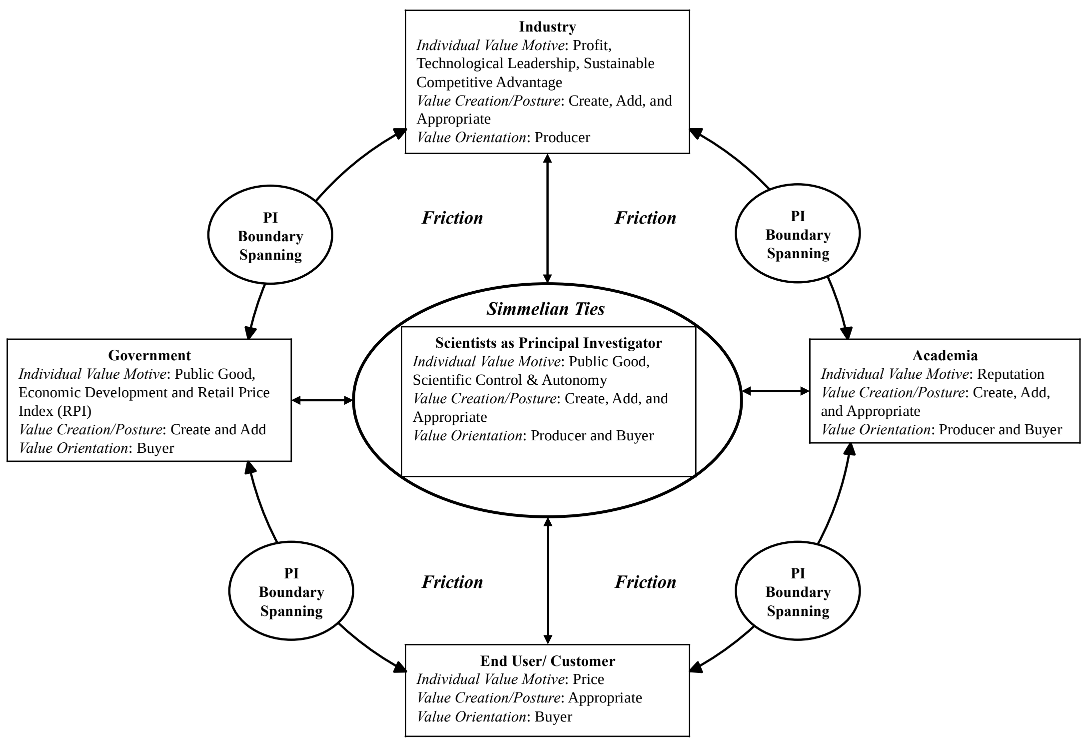
The nature of public science means that collaboration with academic, industry and other relevant stakeholders is an integral part of how it is organised. While various authors use different concepts when considering the collaboration in science, such as 'Mode 2' (Gibbons et al, 1994), 'Academic Capitalism' (Slaughter and Leslie, 1997), 'Post-Academic Science' (Ziman, 2000) and 'Triple Helix of government, university and industry' (Etzkowitz and Leydesdorff, 1997), they all highlight a trend towards such research organisation. Indeed it has been posited that policymakers take for granted that collaboration is the appropriate instrument for public research funding as they expect collaboration to increase the quantity and quality of research. This is particularly evident in the design and structure of EU framework programmes where collaboration is mandatory. This sometimes leads to a positive valuation of collaboration without justification (Duque et al, 2005).

Collaborations occur for a range of reasons, which include: access to expertise or particular skills, access to equipment or resources, cross-fertilisation across disciplines, improved access to funding, learning tacit knowledge about a technique, pool knowledge for tackling large and complex problems, increasing specialisation of science, obtaining prestige, visibility or recognition, enhancing student education and fun (Bozeman and Corley, 2004). Most of these reasons can be reduced to one overarching consideration: that the point of working with someone else is that they have a perspective, skills, resources or some other attribute that contributes something relevant to addressing the research problem, either in improving understanding about it or in implementing that understanding in decisions and action (Bammer, 2008).

The partners in a research partnership can come from either the public or private sector. Given these parameters, research partnerships can be public, they can be private, or they can be public-private (Hagedoorn et al, 2000). From a literature and technology policy perspective, public-private partnerships have attracted the greatest attention because they represent a relationship that directly embodies government intervention in the innovation process and hence are scrutinised more carefully. In terms of organisational structure, research partnerships can be formal or informal. A drawback of the research regarding science collaboration is that it is dominated by a macro perspective, addressing the trends on a high aggregation level without taking into account the position of individual scientists (Van Rijnsoever et al, 2008). There is a need for increased concentration of the study of research collaborations at an individual rather than institutional or systems level. A university is a professional organisation, for which success depends to a large extent on the work of its individual researchers. These institutions can be regarded as coalitions whose members and stakeholders seek to maximise their personal goals. Therefore, it makes sense to view these collaborations at the individual level.

In addressing this imbalance, Cunningham et al (2018) have taken a micro-level perspective using the quadruple helix to conceptualise how PCs are value creators and through their boundary spanning create value for multiple stakeholders (see Figure 2). They argue that the simmelian ties of PCs enable them to create the collective value that is necessary to develop and implement publicly funded research programmes. Cunningham et al (2018) reinforce this by arguing that PCs 'building strong simmelian ties with other quadruple helix actors shape and drive public science value creation'. Moreover, Cunningham et al (2018) suggest that PCs can create but also destroy value for quadruple actors and conclude that PCs 'that have created strong simmelian ties with other helix actors mobilise resources, capabilities and actors to address such public science calls. The informal activities that PIs have done such as networking and bridging activities with other helix actors such as the sharing of knowledge and expertise contributes to building strong simmelian ties and enables them to assemble the best possible group of helix actors to respond effectively to meeting the envisaged outcomes of public science research calls'.

Figure 2: A Conceptual Model of Principal Investigators as Quadruple Helix Value Creators



Source: Cunningham et al (2018)

3.2.5 PC Managerial and Governance Role

From the definitions of PCs, it is clear that, while there might be a common and tacit understanding in practice of what they do, different organisations have different interpretations. In addition to their scientific excellence, PCs have to be effective managers in order to deliver multi-environment transformation. PCs often acquire managerial skills on the job (Kidwell, 2013). One recent study of research centres established by the US National Science Foundation found that some PCs demonstrated managerial capabilities and some did not (Boardman and Ponomariov, 2014). Boardman and Ponomariov (2014) suggest that managerial capabilities matter with respect to how research gets done effectively. Managerial capabilities are also essential in dealing with inter-organisational relationships such as industry collaborators (Boehm and Hogan, 2014). What emerges for the various definitions of PCs and the emerging literature is that PCs have managerial and governance roles and associated challenges. From our review of definitions of principal investigators, it is both implicit and explicitly clear that the scientist, in taking on the publicly funded PC role, takes on managerial and governance roles and responsibilities (see Cunningham et al, 2014). The PC assumes all the managerial responsibilities that are associated with the successful delivery of a funded project. From a managerial perspective, PCs have to manage budgets, select and recruit the research team, set up the governance management structure for the project, engage with stakeholders and provide scientific leadership to the whole project team. For large-scale multi-partner projects, there is considerable complexity in managing and leading for the publicly funded PC.

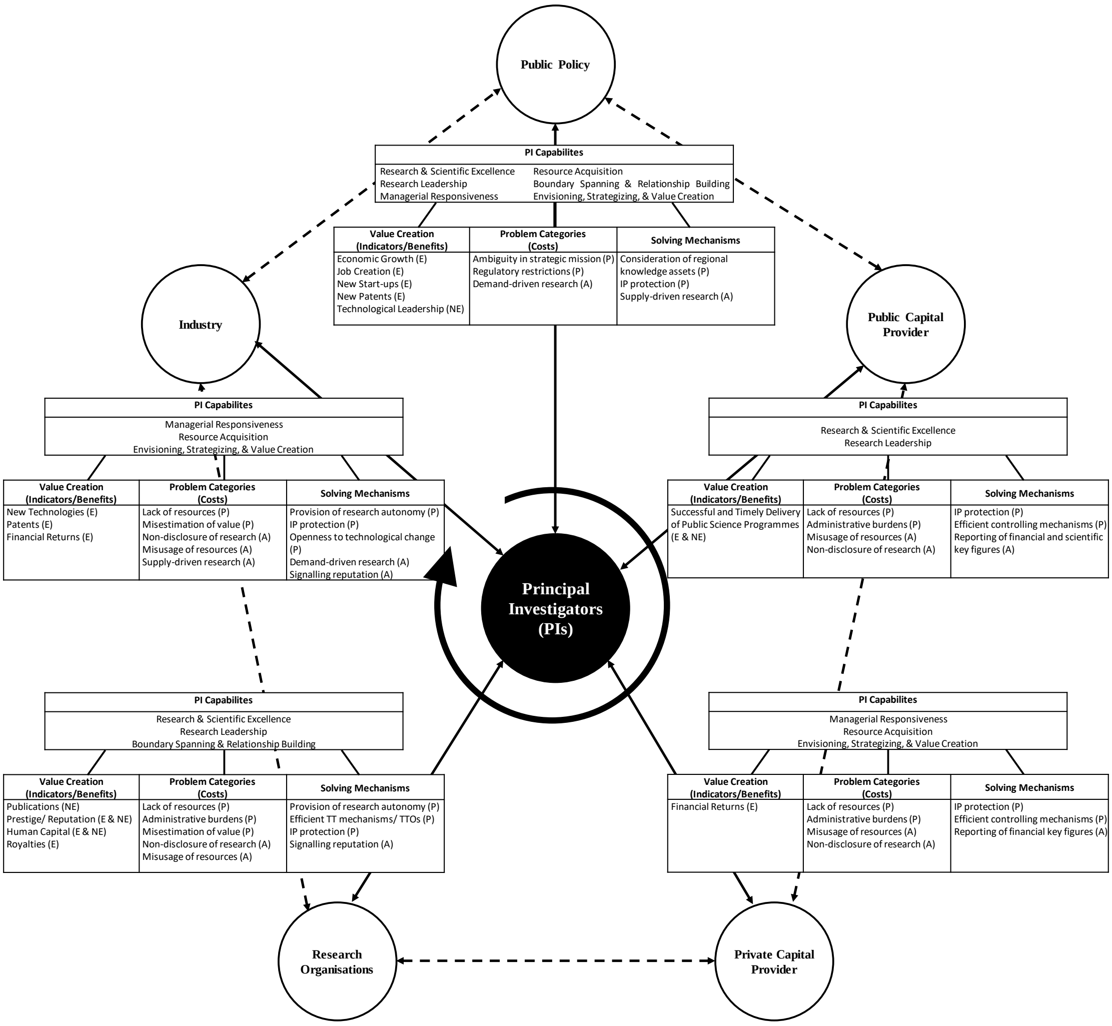
Despite the increased emphasis by policy and funding agencies on the role of the PCs and the diverse roles required of this individual, the literature offers limited consideration of the managerial challenges that PCs face. Research on successful research environments has pointed to the importance of management and leadership for good research output (Peltz and Andrews, 1976), but surprisingly little has been published on different approaches and their relevance in different settings. The only specific study to date on the managerial challenges of PCs found that they centred on project management, project adaptability and project network management (see Cunningham et al, 2015) and concluded that PCs were heavily committed to the operational management of publicly funded awards.

The role of the PC is to lead researchers from multiple disciplines, often from different public/private research centres and different countries, and often dedicating only part of their time to the specific research project or programme. The PC also has to manage multiple stakeholders, all with different expectations and driven by different value-creation motives. Key stakeholders can include (but are not restricted to) research team members (including doctoral research students), public research centre partners, industry, the employing academic institution (including its technology transfer office), the academic department, the funding agency, potential technology transfer recipients, national and local government, as well as the general public. This poses both managerial and governance challenges. Moreover, in reality, successful scientists in the PC role tend to coordinate the management of a series of interconnected projects and other non-project work, and their work can be organised as a chain, portfolio or network of activities (Maylor et al, 2006). The management of multiple projects creates a set of issues that extends beyond the challenges associated with managing a single project, the major constraint relating to resources and in particular the management time available to the PC.

One of the key governance challenges that PCs need to balance is the 'allocation of and benefits to relevant entrepreneurial ecosystem actors' (see Cunningham et al, 2018). One of the most challenging aspects of the PC's role is to build and maintain positive and meaningful relationships with key stakeholders, but also to harness their ideas, resources and capabilities that deliver the multiple intended outcomes. In the context of research project leadership, it is the responsibility of the PC to devise and implement mechanisms to maintain positive and beneficial relationships with key stakeholders through appropriate governance structures. Governance structures are imposed by the funding bodies and host institutions, with technology transfer arrangements being influenced by a combination of university and industry policies. The PC host country's legal environment also influences the type of legal frameworks that are used to support such consortia and for technology transfer purposes. In summary, there been a dearth of empirical studies that examined PCs and governance. However, Cunningham et al (2018) developed a PC-centric conceptual model of entrepreneurial ecosystems at the micro level that details PC capabilities, costs and benefits, and governance solving mechanisms for partner organisations (see Figure 3).

The PC has to balance project leadership and management responsibilities with other demands with respect to teaching and service, and they need to manage their time effectively (Link et al, 2008).

Figure 2: P1-Centred Entrepreneurial Ecosystem Governance Framework



(Cunningham et al, 2018)

3.2.6 Preparation for Role of PC

In summary, the main key responsibilities of PCs can be aggregated into three main domains that broadly correlate to the criteria used to assess applications for collaborative research in Horizon 2020:

- Scientific leadership
- Managing the resources and relationships (budgets, people, project, etc)
- Research dissemination and impact (technology transfer, etc)

This diverse range of responsibilities highlights the pivotal role of the PC in successfully delivering research and innovation outcomes from collaborative and publicly funded research. The complexity of the PC role and the different skills and competencies that are required also highlights the importance of preparation for this role. However, despite the range and complexities of these responsibilities, based on an Irish PC study by Cunningham et al (2014), PC preparation for the role is based on accumulation of knowledge and experience through on-the-job learning. Scientists in the various studies of PCs acknowledge that there is a deficit of dedicated career support to take on this role (Cunningham, 2015).

4 Antecedent Individual Factors

4.1 Motivation and Faculty Interest

There has been a growing body of literature examining what motivates scientists. Studies have used Merton's (1973) seminal work as the basis for research; in brief, these conclude that scientists' primary motivation is focused on prioritising new knowledge. Scientists are not motivated by financial rewards. Peer recognition, such as awards, grants, publications, etc, are rewards that contribute to the motivation of scientists. In her study of UK scientists, Lam (2011:1365) concludes that 'a fuller explanation of scientists' commercial behaviour will need to consider a broader mix of motives beyond the narrow confines of extrinsic rewards to include the social and affective aspects related to the intrinsic motivation'. Experience and networks (academic, industry, scientific) are factors that influence scientists to start their own company (Krabel and Mueller, 2009). Having the scientists involved in the technology transfer process through social networks of the triple helix is essential to greater involvement (Padilla-Meléndez and Garrido-Moreno, 2012). Cunningham et al (2016) in their empirical study of the motivations of PCs found push and pull factors; key pull factors included control, career ambition and advancement, personal drive and ambition, and push factors identified were project dependencies and institutional pressures.

Becoming a PC gives a scientist control over their scientific direction and also adds to career prestige (Romano et al, 2017). A key fear for scientists is that, by not choosing to become a PC, they would lose 'scientific direction, influence and resources' (Cunningham et al, 2016). Early career researchers may have no choice but to become a PC so that they maintain their position in an academic institution. If they are not successful in securing funding, they are forced to search for alternative employment, probably outside academia (see Cunningham et al, 2016). Evidence of this more forced motivation is further highlighted by Rizzo (2015), who found in an Italian study that early career researchers set up academic spin-outs 'in order to find a job position related to their background field of expertise'. Linked to this, an interesting subtheme emerges with respect to motivation – research autonomy. Cubin and Hackett (1990) considered publicly funded research as the 'freest form of support' for publicly PCs; it provides them with the organisational space to pursue the scientific mission. This autonomy is an attractive element of motivation and is necessary to engage in effective technology transfer (see Zalweska-Kurek et al, 2018).

4.2 Networks

The nature of scientific work means that scientists have the opportunity to participate in academic, industry and societal networks to advance their research agenda. These networks are influential in building and sustaining their scientific networks to maintain scientific excellence and in particular to support the creation of new scientific trajectories (O'Kane et al, 2015). Networks outside of academic ones, particularly with industry, provide a platform that scientists can use and leverage to support the commercialisation of scientific discovery. These networks evolve over time and are structured both informally and more formally through, for example, collaborative research agreements, contract and sponsored research, etc. Moreover, these networks and relationships are essential to driving commercialisation and, as Breschi and Catalini (2010:24) highlight in their study, 'certain individuals, i.e. author-inventors, play a key role in connecting the scientific and technological research communities, by acting as gatekeepers that bridge the boundaries between the two domains.' Furthermore, the peer networks influence how scientists engage with industry and are particularly influential for early-career scientists and less so for star scientists (Tartari et al, 2014). International mobility of scientists also shapes their scientific and industry collaboration at home and in other countries as well as further enhancing their scientific productivity (see Edler et al, 2011). The emerging literature on PCs finds that to be effective they need to boundary-span between different stakeholders in the entrepreneurial ecosystem to create value that addresses the different value motives (see Cunningham et al, 2018; Cunningham, 2018; Mangematin et al, 2014). The boundary-spanning activities that PCs undertake in the role support the bridging activities between academia and industry. As Bohem and Hogan (2014) suggest: 'PIs are better placed than Technology Transfer Office managers to act as boundary spanners in bridging the gap between science and industry'.

4.3 Individual Knowledge and Knowhow

Information, skills, judgment and wisdom form a taxonomy of knowledge with respect to technology transfer (Gorman, 2002). The scientist inventor knowledge contributes to the technology transfer and they should be involved to some degree in the process. In particular, Lowe (2006) argues that 'when the knowledge related to the invention is largely tacit, an inventor can extract full monopoly profits related to an invention'. Moreover, Lerner (2006) notes that it is 'hard' setting up a university-based technology venture and that 'universities can add considerable value to young firms that faculty begin'. Given their knowledge intensity and types of networks, universities can provide a good environment for a scientist to access the knowledge and knowhow required to successfully commercialise their scientific discovery.

For grant applications and managing successful grants, universities provide different forms of organisational support such as research offices and technology transfer offices that, in theory, are designed to support the PC and to complement any knowledge deficits or gaps they may have with respect to commercialisation and the research management of the project. For scientists, the core individual knowledge that pertains to their scientific domain provides the basis for original knowledge creation and competitive research funding applications. This knowledge is codified in relevant peer-reviewed journals, books, book chapters, etc., which forms part of the basis for peer assessment for competitive funding applications. Knowledge and knowhow is also accumulated outside an academic environment, through industry. Such knowhow and knowledge gained in an industrial setting can support the exploitation of scientific discovery and complement scientific-domain expertise. Using data in an Irish context studying gender differences between male and female PCs, Cunningham et al (2017:245) found 'some evidence that male PIs have more commercial experience, are more externally orientated and are involved in more academic entrepreneurship activities than female PIs'. This would suggest that industrial experience brings some knowledge advantages to PCs, and thus increases the probability of commercialisation. Combining such knowledge, knowhow and commercialisation interest can provide the PC with a better understanding of the industry problem their scientific research is orientated towards. Choi and Lee (2000) state that 'labs researchers' commitment to commercial success, their understanding about user firms, and education or non-periodical consulting are critical to the success of technology transfer'.

4.4 Incentives

Incentives play a role in effective technology transfer (see van de Burgwal et al, 2017). In the academic literature, there is some debate on how incentives influence technology transfer, and there is some agreement that having faculty more involved in technology transfer does matter. Friedman and Silberman (2003) succinctly state that 'universities that provide greater rewards for faculty involvement in technology transfer will generate more licenses and royalty income'. Universities' policies with respect to incentives associated with commercialisation can shape individual scientists' behaviour. However, as Renault (2006) found, personal beliefs about universities' role in commercialisation really matter in how individual scientists respond to technology transfer incentives. Other incentives focus on the enhanced academic status and prestige that new venture creation can bring to the individual academic (Fini et al, 2009).

4.5 Policy Environment

Research on the policy environment focused on such issues as academic spinoff (Degroof and Roberts, 2004), academic patenting (Mowery and Ziedonis, 2002) and research centres (Feller et al, 2002). Funding structures are essentially part of the framework for the innovation system. They have a major influence on how public research is managed, particularly as they often directs how projects should be managed. Mode 2 models of research management are largely endorsed by funding agencies, but funding agency expectations vary across a number of areas, including expectations relating to technology transfer, industry involvement in public research, technical project management requirements, and nature of research (basic, applied, etc.). The funding structure within which the PC is operating has direct implications for the management approach taken. In the emerging empirical studies of PCs, the policy and funding environment they inhabit influences behaviour with respect to interest in funded projects and the support for technology transfer and commercialisation activities. The changing policy environment, as reflected by the evolving funding agencies' remit and priorities, creates more long-term uncertainty for PCs in terms of realising their long-term research ambitions. Transparency from funding agencies in their dealings and intentions with scientists is critical (see Cunningham et al, 2014). Furthermore, the lack of knowledge among funding agencies and their project officers has been a source of frustration for PCs. Cunningham et al (2014:101) state: 'This can put a significant strain on the relationship between the PI, their institution, and the funding agency and industry partners in a collaborative project'. In addition, from the policy operational perspective, PCs have highlighted challenges with respect to timing of funding calls, contracts and payments, which they view as inhibiting factors for the PC role. More broadly, national policy on technology transfer and commercialisation set the behaviour intent for stakeholders. For example, the Bayh-Dole Act, along with other legislative initiatives in the US, has influenced how scientific knowledge from universities and public research laboratories is exploited (Grimaldi et al, 2011; Link et al, 2011; Stevens, 2004).

4.6 Career Trajectory, Experience and Professional Development

When a scientist decides to become a PC, one influence is the stage of career. While there is a growing array of publicly funding schemes to support early career researchers to become independent researchers, they are very competitive and highly sought after in practice. Such publicly funded programmes within the EU, such as the European Research Council schemes, target researchers at different stages of their career to pursue blue-skies research. To support scientists' research trajectory and to facilitate them in becoming a PC, institutional and faculty support and investment are also required (Rosser and Chameau, 2006). To provide such support and to encourage scientists to pursue commercialisation, universities have put in place specific programmes that sometimes are supported by public funding, such as the i-Corps programme funded by the National Science Foundation in the US (Huang-Saad et al, 2017). Other public policy and funded initiatives are used to support career trajectories at different stages, such as the START programme in Austria aimed at post-doctoral fellows (see Seus and Bührer, 2017), the Swedish INGVAR programme, and the EU Marie Curie Programmes (European Union, 2004). A study of researchers funded by the Dutch Research Council Innovation Research Incentive (IRI) Programme by Gerritsen et al (2013) found evidence that IRI awardees were more likely to stay in academia, more likely to become a full professor and more likely to receive future grants. In essence, such programmes strengthen the research capacity of an individual researcher with respect to original research, which is critical threshold factor in becoming a PC. Also, such programmes offer opportunities for scientists to enhance this knowledge and skills base. The stage of career does matter as to whether a scientist can become a PC.

Previous commercial experience influences PCs in their propensity to commercialise their scientific discoveries in publicly funded research. This experience gives them additional knowledge over and above their scientific domain knowledge, which they can use in building up industry networks, to create credible business cases and commercialisation strategies to support the exploitation of their scientific discoveries. However, while their career stage and previous experiences influence PCs with respect to technology transfer, they also need dedicated professional support to prepare them for the role and while they are in the role (Cunningham et al, 2014). PCs are professionally trained to be excellent researchers. During this period they receive little or no professional support that prepares them for the expanded roles and responsibilities of becoming a PC, which requires leadership and managerial skills coupled with being an effective boundary-spanner bridging difference ecosystem actors. Increasingly the role demands commercial and business acumen and knowledge to effectively create and implement credible commercialisation strategies. Cunningham et al (2014:105) sum this up as, 'in particular, the lack of leadership development opportunities for researchers and multiple (and sometimes contradictory) expectations and logics from different stakeholders. The lack of formal structured preparation to becoming a PI in what are normally large-scale collaborative projects in a context where the existing support structures are 'stretched' with limited human capital support, means that PIs tend towards research management rather than research leadership'. There is a formal professional development need for researchers to be better prepared for the PCs that is not currently being fulfilled by current professional development training that they receive as part of their career and formation process. PCs learning on the fly (Kreeger, 1997) and on the job (Cunningham, 2014).

4.7 Other Relevant and Discrete Factors

Scientific Domain: There are obvious differences between different disciplines when it comes to eagerness and need to collaborate, and hence the forms in which it is done. In the medical sciences, there are almost always teams working together, from time to time collaborating with other teams. In the humanities, on the other hand, there are basically no teams and collaborations are not common (Melin, 2000). Moreover, consultancy and contract research are more of the norm with respect to commercialisation (see Olmos-Peñuela et al, 2014). The scientific discipline norms that PCs experience influences their involvement in commercialisation and how they seek to ensure societal impact for their publicly funded research projects.

Time Allocation: PCs in leading and managing large-scale funded projects have to allocate their time to different key tasks associated with project delivery. Some of these key tasks include leading and conducting the research, project administration, technology and market-shaping activities, which are combined in a project to create value and impact that can be measured in a variety of ways. A study that specifically examined the time allocation of PCs found that 'PIs who spend more time on general research related activities allocated a higher proportion of time to technology transfer activities and that PIs who spend more time on technology activities engaged more in end of project reports and collaborative research with industry. Furthermore, PIs who spend more time on technology transfer placed greater value on technology transfer, market and economic impact' (Cunningham et al, 2016). For PCs, having sufficient research administrative support helps them to concentrate on tasks and activities that create value for the overall project and its partners. The danger is that PCs will misallocate their time on activities for which they lack the expertise and skills, and thereby take time away from conducting the core research that they were funded to undertake.

Gender: Several themes such as scientific productivity, careers stage and patenting have been explored with respect to gender differences among scientists (see Borrego et al, 2010; Ding et al, 2006). The only gender study to date of PCs (see Cunningham et al, 2017) found that male PCs that have more commercial experience are externally focused and more involved in academic entrepreneurship, while female PCs are more focused on internal project dynamics and concentrate on scientific capital impacts. Commercial experience, project organisational experience and international projects are leveraged by male PCs, and they place greater importance on activities that suggest they have a stronger academic entrepreneurship focus than female PCs. Moreover, an overriding issue is that there may under-representation of females among the population of PCs

5 Project Organisation Factors

5.1 Challenges and Benefits of Collaborative Research

A key instrument to support knowledge transfer between research institutions and industry has been the promotion of collaborative research delivered through research consortia. Collaboration is seen as important for scientific research (Jones et al, 2008) and innovation (Hoekman et al, 2013). Research funding programmes such as Horizon 2020 underline the idea of diverse international consortia assembled to deliver research and innovation objectives (European Commission, 2011). However, knowledge transfer within groups for the purpose of delivering combined innovation outcomes is not without challenge from an organisational perspective, and particularly from the perspective of the PC. In particular, it requires establishment and maintenance of strong social relations between consortia members (Alexopoulus and Buckley, 2013). The PC is required to bring together different actors, often from different institutional, disciplinary and cultural contexts, in an effective and arguably quasi-firm arrangement. The diversity of research consortia offers specific benefits and challenges.

5.2 Diversity of Discipline

Multidisciplinarity is defined as the spanning of a diversity of knowledge areas, which could be disciplines, technological fields or industrial sectors (Rafols and Meyer 2010). In terms of research funding systems promoting multidisciplinarity, the thinking is that such research favours a greater diversity of idea generation and creativity (Alves et al, 2007). Bringing together ideas and actors from different domains increases the chances of innovation (Cummings, 2005), particularly recombinant innovation (Fernandez-Ribas and Shapiro, 2009). However, multidisciplinary research is not without challenges. Too much distance between disciplines can lead to communication problems (Jeong and Lee, 2015). However, it is to be expected that these potential difficulties are mitigated in the formation process of the consortium, and that partners have sufficient proximity to collaborate successfully (Boschma, 2005). The expectation from this is that we expect that the degree of multidisciplinarity of a project has a positive effect on innovation outcomes.

5.3 Size of Consortia

Van Rijnsoever et al (2015) state that the number of actors refers to 'the size of the project consortium in terms of distinct actors'. The benefits from research collaborations involving larger numbers of actors are that they can support more dynamic collaboration that achieves faster outcomes, shorter product lifecycles and competitive advantages (Edmondson and Nembhard, 2009). Larger project teams also provide a greater chance of recombining different types of knowledge, expertise and ideas, and thus innovation (Powell et al, 1996; Ruef, 2002). However, it is also argued that, when a large number of parties is involved, the process of communication, agreement, problem-solving and project coordination requires a complex process of integration and coordination of knowledge (Jeong and Lee, 2015).

5.4 Diversity of Institutional Context

An additional feature of research collaborations is the types of actors that can be involved. These can be from different institutional contexts – for example, universities, public research centres, public bodies, SME enterprises, large enterprises, multinational enterprises, etc. Each actor type brings to the project unique knowledge and skills that can be recombined to form novel concepts and designs (Mo, 2016), creating more technological diversity (Van Rijnsoever et al, 2015). However, having too much diversity among actor types requires the capacity to manage collaborative research and to take advantage of the knowledge from the network to achieve the goals of the project. Not all the actor types have these managerial capabilities (Pandza et al, 2011). Additionally, researchers from diverse types of organisations need to understand different points of view, people from different institutional backgrounds and cultures, or even diverse technical language (Paez-Aviles et al, 2015).

Diversity in terms of the nationalities of the members exposes the research team to different norms and beliefs, possible difficulties in communicating across cultural categories (Dahlin et al, 2005), and higher costs of coordination and management.

Having international teams can also hamper diversity creation. Cultural differences lead to difficulty in transference or decoding of certain types of messages (Lundvall, 1992). Hence, the costs of international teams can exceed the gains of diversity (Faber et al, 2016; Sirmon and Lane, 2004; Williams and O'Reilly, 1998), since resources can be diverted into smoothing cultural differences in the team, which comes at the expense of innovation and diversity creation (see Nepelski et al, 2019).

From a project coordination perspective, key questions for PCs are: what is the appropriate level of diversity in a project, and how should diversity be managed to successfully deliver research and innovation outcomes. Limited research has been done on this in a European context. Coad et al (2017) examined the diversity of research collaborations that received FP7 funding. They found that indicators of diversity in organisational form, nationality and inequality in research funding are negatively correlated with each other. This research is limited in that it refers to projects that were funded, for which there are a multitude of factors, and successful funding achievement does not imply automatic achievement of innovation outcomes. A key question not addressed is whether diversity in collaborative research teams in EU-funded research is a factor in successful technology transfer of innovation outcomes. A further question is how influential is the capacity of the PC to effectively manage this diversity in order to achieve successful technology transfer of innovation outcomes.

5.4 PC as Boundary-Spanner

The role of PCs as boundary-spanners to articulate different disciplines, different points of view and logics to solve problems has been approached in several studies (Adler et al, 2009; Bozeman and Corley, 2004; Comacchio et al, 2011; Jain et al, 2009). The boundary-spanning perspective is set out across three dimensions. First all, as boundary-spanners PCs are bridging different areas, academia, higher education, policymakers and firms. They have a role to articulate different objectives, timeframes, logics and cultures. They also have a role within academia to create a dialogue between disciplines, shape research avenues and combine different approaches and instruments to propose solutions. Finally, emphasising the boundary-spanner roles obliges scholars to reconsider the definition of PCs and their characteristics, and to question their role in academic science, not only in the light of their productivity but also their ability to implement visions and to share expectations.

5.5 Research Collaboration Management Capabilities

As outlined in the previous section, the coordination of collaborative research is both challenging and complex. The level of complexity is reinforced by diversity in a range of project-level characteristics. While it is suggested that research collaboration is quasi-firm in nature, in practice it is unlikely that many firms would be as diverse in nature as a typical EU-funded collaborative research project. This raises the question of how important collaboration management is in the context of delivering successful innovation outcomes. Leischnig and Geigenmuller (2018) observe that technology transfer requires universities to maintain and strengthen research capabilities, but also to strengthen management capabilities to build and manage relationships with external partners. Their study of academic units in German universities found that the academic unit's alliance management capability has a significant positive effect on technology transfer success. Academic unit and institutional influences on technology transfer effectiveness have been addressed in other studies also, with organizational capacity to manage alliances shown to contribute to more structured interactions between alliance partners and more effective technology transfer (Leischnig et al, 2014). However, the focus of their research was on the academic unit – typically the research group or centre, and not the PC.

Leischnig and Geigenmuller (2018) conceptualise alliance management capability as supporting technology transfer as a multi-faceted construct that consists of four components that commence prior to the research collaboration:

- Alliance Proactiveness – this refers to efforts to identify potentially valuable partnering opportunities.
- Alliance Transformation – this refers to the flexibility of a transfer agent or recipient to adapt the transfer process with regard to changing conditions.
- Interorganisational Coordination – this pertains to the governance of individual relationships within the research collaboration. It involves identifying and building consensus about task requirements, ensuring efficient governance of processes.
- Interorganisational Learning – this refers to the ability to acquire and use knowledge throughout the collaboration, allowing for improvements in knowledge bases and also for research collaboration interactions.

A useful feature of their concept is that it integrates institutional and individual actor requirements in alliance management. In addressing the deficit of empirical studies on managerial challenges at the level of the PC, Cunningham et al (2015) found three main categories of managerial challenges: *project management, project adaptability* and *project network management* (see Cunningham et al, 2015). These challenges are summarised:

Project management: The main managerial challenges that PCs face are organising and controlling. The research found that most PCs experienced the managerial challenges of assembling and managing the research team and consortia, project supervision and project alignment. PCs have to ensure that they have the best research team fulfilling the publicly funded project objectives.

Project adaptability: As well as dealing with the project management-orientated challenges, PCs are focused on challenges related to maintaining project relevance. Specifically, project adaptability consists of two PC tasks: environment scanning and maintaining project agility. In dealing with this management challenge, the research found that PCs adopted different approaches. Experienced PCs were more likely to engage in environmental scanning and to purposefully develop flexibility within projects, while less experienced PCs tended to be more concerned with completing the project as per the specified details of their research proposals.

Project network management: This relates to challenges PCs have to deal with when working in their own institutions. It also highlights the range of external stakeholders that PCs engage with for publicly funded projects. To negotiate their way through bureaucracy, PCs had to build up institutional social capital. In dealing with external networks, the overall preference of PCs is to have a range of external stakeholders to assemble project teams and for project execution. However, PCs are cautious about the type of commitments they seek from these external stakeholders. In the context of managing external consortia partners, PCs find that they can exert influence rather than control. The managerial function of organising and influencing is critical for PCs in dealing effectively with external network management.

6. Effectiveness and Impact

The final element of our review of PCs is focused on effectiveness and impact. Much of the literature on effectiveness and impact that we have reviewed as part our systematic literature review takes a macro or meso-level perspective. Measurement of PC effectiveness is intrinsically tied to the success or otherwise of the overall research project or research programme. The project management literature identifies a range of potential effectiveness criteria. The starting point for considering these criteria is to determine the unit of analysis – in this case, what exactly constitutes a project? A widely quoted definition of a project is 'a set of activities with a defined start point and a defined end state, which pursues a defined goal and uses a defined set of resources', and which has cost, quality, and time objectives and a project lifecycle (Slack et al, 2004). In a traditional project context, project success dimensions typically include: (i) meeting time and budget requirements, (ii) impact on the customer and (iii) benefit to the performing organisation (Shenhar et al, 2001). However, for the purposes of publicly funded academic research, project success is a multidimensional strategic concept that extends beyond quantitative and economic measures.

6.1 Scientific Impact

An important primary benefit of publicly funded research is the creation of platforms for research collaboration and the teamwork advantages that this offers. The perspective of knowledge recombination predicts that knowledge creation is often enhanced by combining different expertise and knowhow from a wide variety of sources (He et al, 2009). According to this perspective, when partnering scientists bring together complementary knowledge and skills in a research project, the resulting research output should be of higher quality than it would be otherwise. Moreover, by working together, research collaborators form an internal quality control process to improve research quality by rigorously selecting out unpromising combinations. The teamwork advantage should also realise additional scientific outputs in the form of publications. Various studies demonstrate a positive correlation between co-authorship, especially international co-authorship, and an article's quality as measured by the number of citations it receives from other articles. However, there are also warnings that publications should only be used as a partial measure (He et al, 2009). First, research collaboration does not always lead to co-authored articles. For example, a researcher may provide a key idea for an article but, for some reason, does not appear as a co-author. Secondly, co-authorship can arise without research collaboration. A researcher may be listed as a co-author simply by providing experiment materials or performing a routine test. Moreover, the scholarly outputs from publicly funded research projects contributes to the body of knowledge in a particular domain. The measurement of such scientific outputs can be measured in a variety of standard ways. Such measurements are used to understand and evaluate the quality of research excellence. Previous scientific quality and excellence is also used as part of the evaluation process for PCs.

6.2 Technology Transfer Impact and Project Innovations

Technology transfer has been defined in many ways across various dimensions, but it can be simply defined as the movement of knowhow, technical knowledge or technology from one organisation to another. The transfer of scientific and technological knowhow into valuable economic activity has become an important priority in many policy agendas, with links between industry and science being a crucial element of this policy direction (Debackere and Veugelers, 2005). Indeed, in many countries, an optimisation of the interface between science and economy has become one of the most important guidelines of technology policy (Balthasar et al, 2000). Measures of technology transfer can be derived from the take-up of the science through IPR licenses, spin-outs and technology-related consultancy. Furthermore, this literature examines different technology transfer mechanisms such as spin-off firms (see Druilhe and Garnsey, 2004; Wright et al, 2004; Lockett et al, 2005) and patents (Hall, 2004; Jaffe, 2002; Cohen et al, 2002; Balconi et al, 2004). Many of the studies of technology transfer and university-based R&D have found that they can have beneficial impacts on firms as well as universities (see Thursby and Kemp, 2002). For example, Coupe (2003), using US data, found that 'more money spent on academic research leads to more university patents'. In their study of the European Space Programme, Bach et al (2002) found three factors that have a major impact on the technology transfer process: first, the nature of the technology, the network of participants in the funded project, second, their ability to collectively engage and their absorptive capacity; and, third, the organisational structure of the firms and organisation participating in the consortium Wu et al (2015) found that university inventions are more likely to be commercialised when academic investors are working with industry partners and if they are positively disposed to technology transfer. When it comes to technology-orientated disciplines, Perkmann et al (2011) found that faculty quality is positively related to industry involvement. Moreover, there is a growing body of evidence indicating that private-sector R&D is dependent on public-sector research (see Tijseen, 2002).

Innovation outcomes available for technology transfer can be classified by the type, the degree of novelty and the nature (Terziovski, 2007; Tidd et al, 2005). The Oslo Manual (OECD, 2005) distinguishes four types of innovation: product or service innovations, process innovations, marketing innovations and organisational innovations together with three degrees of novelty: new to the firm, new to the market and new to the world. There are also three types of innovation nature defined: incremental, radical, disruptive (Terziovski, 2007). Types of innovation, degree of novelty and innovation nature define the dimensions of technology transfer impact, and are reflected in the Joint Research Centre Innovation Radar's innovation potential assessment (de Prato et al, 2015). Types of innovation included in the Innovation Radar potential assessment framework include product innovation, service innovation, process innovation, marketing method innovation, and organisational innovation. In a review of 279 projects, the Joint Research Centre identified 517 innovations of which 55% were product innovations and 23% were service innovations (de Prato et al, 2015).

6.3 Scientific and Technical Human Capital Impact

Scientific and technical human capital (S&T human capital) is the sum of scientific, technical and social knowledge, skills and resources embodied in a particular individual (Bozeman and Corley, 2004). It includes both human capital endowments, such as formal education and training, and social relations and network ties that bind scientists and the users of science together in a value-creating collective. S&T human capital is the unique set of resources the individual brings to his or her own work and to collaborative efforts. Research collaboration offered through publicly funded research projects provides a learning experience for a scientist to acquire skills and techniques from partners for their future research activities (He et al, 2009). The acquisition of tacit knowledge between scientists is best achieved when they jointly experience problem-solving and spend time together discussing and reflecting.

6.4 Economic Impact

The cost of public research and particularly research collaboration is rarely examined in the literature. One notable exception applied the concept of transaction costs to investigate why a certain governance structure is adopted in organising collaborative research (Landry and Amara, 1998). Publicly funded research projects can be envisioned as mini joint ventures where collaborating scientists exchange resources and skills to generate and share expected research output (Landry and Amara, 1998). Research management, including research collaboration, entails various costs, including the costs of finding and assessing research partners, of establishing an agreement to organise collaboration and allocate the credit of expected research output, and of coordinating the collaborating scientists, among others. International collaboration incurs additional costs relative to local collaboration. Because of bounded rationality, no-one could exhaust all the contingencies of a public research project, no-one is absolutely sure what research findings will be produced in the future, and no-one is fully aware of the costs of implementing a specific part of the project. This impossibility of designing complete project plans creates room for opportunistic behaviours such that a scientist may strategically misrepresent information to secure more resources or credit for their contribution to the final research output. Some attempts have been made to assess how to measure economic impacts (see Table 2). Martin et al (1996) argue that publicly funded research contributes to economic growth through useful knowledge, skilled graduates, new scientific instruments and methodologies, new social networks, new ventures and enhanced problem-solving. Measuring the economic impact of public funding is difficult and challenging; economic analysis is the most widely used methodology. In summarising their review of economic evaluation models of basic research, Salter and Martin conclude (2001:527) that there is 'no simple model of the nature of economic benefits from basic research is possible'.

Table 2: Economic Impact Measures of University-Based Research

Outputs Benefiting Private Sector	**Outputs Benefiting Public Investors**
New products sold (revenues per year). License agreements (revenues per year). Manufacturing improvements (cost savings per year).	New jobs created (average annual salary per job). Retained jobs (average annual salary per job). Tax revenues.
Trained graduates hired by a company (work force cost savings).	Secondary impact of worker's spending on local economy.
Start-up company (projected annual revenues).	Indirect effect on secondary subcontractors.
Knowledge spillover (revenues in creating another product).	Acquisition of federal funds.

Source: Bessette, R. W. (2003). Measuring the economic impact of university-based research. *Journal of Technology Transfer*, *28*(3-4), 355-361.

At a macro level, several studies have examined the economic impact of publicly funded research programmes. In the main, these studies have found positive economic impacts of publicly funded research. For example, a study by Amesse et al (2002) cited some of the overall economic affects, both direct and indirect, of the Canadian space programme as private firm sales, new technology and knowledge, new research consortia, industry standards and use of physical infrastructure. In studying the returns of NASA's life-science technology transfer, Hertzfeld (2002) found economic returns that centred on commercial applications, as well as extending the product lines Mueller (2006), based on her study of West German regions, found that 'the proposed knowledge transmission channels – entrepreneurship and university-industry relations – increase the permeability of the knowledge filter, thus improving regional economic performance'. For R&D projects with universities, geographical proximity matters when the lead time to market is short, but does not when the R&D projects are long-term (Broström, 2010).

Studies at the micro level are challenging from a methodological and data perspective and thus the literature includes few empirical studies. However, the Zellner (2003) study of those formerly employed at the Max Planck Society (MPS) 'supports the claim that important socio-economic benefits of basic research accrue through the embodied knowledge transfers associated with scientists' migration into the commercial sector'. Hoye and Pries (2009) identified a group of researchers that they termed repeat commercialisers who are different from other academics, and can account for a significant percentage of a university's commercialisation activities (up to 80% in the institutions studied). They suggest that these repeat commercialisers are very productive researchers, have extensive linkages with industry and should be supported and incentivised differently from other academics. Such studies highlight the important and understated role that individual scientists play in supporting commercialisation.

6.5 Societal and Social Welfare Impacts

Evaluating the impact of the societal and social welfare impacts of publicly funded research and researchers can be problematic given the lack of universally accepted measures and indicators. Many publicly funded programmes are now being increasingly orientated toward society issues that affect society in both beneficial and negative ways. Moreover, there is increasing expectation among funders that publicly funded science will have spillover societal and social welfare impacts. As a consequence, there is a growing literature that attempts to address these impacts by using the notion of the end user. For example, Link and Scott (2004) combine private and social to assess the social impacts of public-sector R&D using the Advanced Technology Programme in the US. In this study, they looked at pull costs to society, and defined society to include consumers and private-sector firms. Mazzoleni (2006) argues that: 'the social welfare impact of university patenting depends largely on whether or not the disclosure and patenting of a particular university invention allows firms engaged in downstream R&D to obtain patents on their innovative achievements.' However, Langford et al (2006:1595) raise an important concern about the use of indicators and associated proxies in measuring socio-economic impacts of universities and suggest that they 'do not measure several important paths of knowledge flow'.

6.6 Collaboration and Political Impact

As noted above, public research typically involves collaborations between public and private partners, with varying numbers of partners depending on the scale and complexity of the project. Collaboration provides scientists with social networks where they can capture valuable information on research opportunities and expose themselves to future research collaboration, which leads to future research output (He et al, 2009). The ability of a scientist to develop and maintain network contacts is thought to vary with distance, but there is also evidence that the success of the individual researcher in a collaboration is due to success as a social individual and as a scientist at the same time (Melin, 2000).

In terms of political impact, there are three possible avenues for political reward for scientists delivering on technology transfer targets, which are also applicable in the overall project management context (Slack et al, 2004). Where research projects or programmes have the potential to have a major impact on national or regional socio-economic priority areas, the PC role in developing and transferring the technology is recognised by policymakers. Another avenue for political reward to be achieved is via appraisals of the research initiative provided by industry partners, often the technology recipients in a technology transfer process. In this scenario, the industrial partner actively pursues the policymaker, often a key funder of public research, to commend the academic partner for their work on the project and their commitment to technology transfer. The policymaker, in turn, 'rewards the lab for being a good industrial partner'. The third and most common rationale under the political impact criteria is for the research project or initiative to be rewarded for the appearance of active and aggressive research and technology transfer success. This part explains the aggressive pursuit of publicising research projects, partnerships, breakthroughs and technology transfer achievements by research institutions.

7 Discussion

7.1 PC Role Tensions

This review affirms the invisible and central role that PCs play in creating original knowledge, by assembling the mix of relevant stakeholders that support their scientific and commercialisation efforts and ambitions. The scope of our literature review also highlights the invisibility of the PC's role in shaping and influencing the impacts of publicly funded science. Our review highlights that, while there is common understanding in practice of the PC role, there is no consensus as to a universally acceptable definition of the PC role. The role also brings with it some tensions that individual PCs can find challenging to reconcile in practice when leading a large-scale publicly funded research project.

The first of these tensions is *scientific versus economic activities*. In the main, publicly funded research is now designed to leverage economic impacts such as the creation of new ventures, enhancing the innovation capacity of industry partners, new patents, etc. Scientists have been formally and professionally trained to be excellent researchers. They have not been professionally trained to be knowledge brokers and technology transfer agents. The tension arises when they have to balance the scientific and economic/commercialisation impacts in a manner that delivers for both agendas.

The second source of tension centres on *balancing governance and fiduciary responsibilities*. It is clear from the definitions of PCs and the empirical evidence to date that they have a responsibility to govern and manage funding in an effective manner. This requires careful project management so as to ensure that the funded project complies with financial requirements, good scientific governance, etc. For the PCs, the core tension arises on how to balance this research management associated with leading a funded project against scientific research leadership. This, in essence, means that PCs spend more of their time focused on the research management of a funded project and less time on scientific leadership.

The third tension arises around managing market-shaping expectations. At the time of the funding application, PCs outline a commercialisation strategy for their proposed scientific discovery that is supported with relevant market data and analysis. In some cases, given the consortia design, an industry partner can further enhance this commercialisation strategy and its execution. The tension for the PC is proposing a validated market-shaping/commercialisation strategy that is credible but also is adaptive to respond to external environmental changes or related scenarios, such as an industrial partner no longer having an interest in the scientific discovery because their business needs have changed over the duration of the funded project.

Based on the literature review, we conclude that, when a scientist takes on the PC role, they take on threshold roles and responsibilities that are necessary to fulfil the role. However, we posit that, for PCs to fulfil the basic role requirements and responsibilities, they require further role enhancements that are essential in shaping multiple impacts.

7.2 Threshold Roles and Responsibilities

PCs need to fulfil three main threshold roles and responsibilities in leading publicly funded research projects. They are research leader, resource allocator and controller, and project coordinator and manager (see Table 3). Each of these roles has a core focus.

Research Leader: The PC designation signifies that the PC is the research leader for the duration of the publicly funded project. The PC thus needs to be a competent and excellent researcher and have the ability to coordinate different academic, industry and societal actors to support their research leadership of a publicly funded project. The role responsibility means that they have to ensure that the project delivers on the research objectives set out in the project proposal. Where there are setbacks or unexpected challenges or failures, the PC must provide the research leadership that enables delivery according to the stated research objectives.

Resource Allocator and Controller: The aspect of the role means that the PC has acquired the necessary resources (financial, knowledge, expertise, infrastructure, etc.) to support scientific discovery and a broad range of impacts. This is initially scoped out during the project initiation stage and is finalised when a project proposal is approved for support by a publicly funded research agency. The responsibility of the PC changes once the funding is allocated by the agency to ensuring that the financial and other resources are deployed appropriately. The PC also has to put in place necessary control measures to ensure that the project meets the financial and other conditions set by the funding agency. This requires the PC to also adhere to the control systems that are in place in the institution that the PC is based in. This fiduciary responsibility is central, and a critical factor in determining the success of the funded project.

Innovation Enabler: In a project context, the role of the PC as an innovation enabler commences in the project formation phase where the PC as the project designer is required to be aware of market requirements and new opportunities, to enable them to detect project partners that will facilitate technology transfer – either as agent or recipient. The innovation role then extends throughout the project, with the PC having a lead role in aligning delivery of research and innovation outcomes. A key aspect of this is optimal inter-organisational co-ordination.

Project Co-ordinator and Manager: A publicly funded project typically involves a range of academic and industry partners across different geographical regions and countries. At the project development phase, the role of the PC is to assemble the best research team involving such partners in order to maximise the probability of securing the grant. This requires selecting partners that have specific expertise, through the project plan is that they complement each other and are aligned with the project objectives. The responsibility of PC post-funding is focused on ensuring that all project activities are undertaken according to the project plan, as well as ensuring through their co-ordination that project deliverables are met on schedule and within the allocated budget. This may require day-to-day operational management as well as putting in place the project governance structure needed to support effective project co-ordination and management.

Boundary-Spanner: As boundary-spanners, PCs bridge different areas, academia, higher education, policymakers and industry. They have a role to articulate different objectives, time-frames, logics and cultures. They also have a role within academia to create a dialogue between disciplines, shape research avenues and combine different approaches and instruments to propose solutions. This emphasis on the boundary-spanner role initiates a reconsideration of the definition of PCs and their characteristics, and raises the question of their role in science, not only in the light of their productivity but also of their ability to implement visions and to share expectations.

Table 3: PC Threshold Roles and Responsibilities

	Role	Core Responsibility
Research Leader	Research excellence	Deliver stated scientific research objectives
Resource Allocator and Controller	Determine resource requirement	Acquire and deploy resources
Innovation Enabler	Innovation excellence	Envision and maintain scientific and innovation alignment
Project Co-ordinator and Manager	Proactively manage all facets of the project	Deliver delivery of project objectives on time
Boundary Spanner	Bridge gap between science and industry	Manage and coordinate internal and external boundaries (discipline, international, intersectoral, institutional)

Source: Authors

7.3 Expanded PC Role Competency Framework

To go beyond fulfilling the basic PC role, scientists in this role need to have an enhanced role capacity that enables them to achieve the multiple impacts that are now required from large-scale publicly funded research programmes. Fulfilling the threshold role requirement demonstrates to a funding agency an ability to manage and lead. Being able to go beyond the threshold role requirement provides the basis to build and demonstrate a track record of research excellence and multiple impacts. Such enhanced roles that we have identified are as follows:

Research Strategists: PCs need to be always scanning research and industry horizons for novelty, the basis for new knowledge and scientific discovery. This requires them to constantly strategise about new developments within their discipline as well as monitor relevant industry environments so that they can respond in a proactive manner to realising their scientific mission and to create the necessary value for relevant stakeholders.

Economic Agent: The novelty and new knowledge that PCs create as part of scientific discovery can be translated for economic means. PCs thus become economic agents and their research can support the evolution of industries or the creation of disruptive technologies that can form the basis for new industries. To be an effective economic agent, the PC needs to have a clear understanding of how their research enhances value creation for industry, where their novelty is positioned (demand or supply), and how it can be exploited collectively or individually within an industry context.

Technology & Knowledge Transfer Enabler: An increasing number of research funding bodies expect that the projects they support through peer review processes will have technology and knowledge transfer. An enabling role capability for PCs is that they have a knowledge of the different mechanisms of technology and knowledge transfer, and have some expertise in this domain. This means that PCs can determine and operationalise the optimal approach to exploit the new knowledge that they create. This capacity enables the PC to bridge the academic-industry gap and in doing so optimise individual value-creation for stakeholders in each of these settings.

Collaboration and Value Creation Leader: To be an effective PC it is essential to collaborate with partners irrespective of discipline and with any size of industry, policy and societal stakeholders. They need the individual openness to consider all forms of collaboration with any configuration of partners that enables the realisation of multiple impacts. Coupled with collaboration is the ability of the PC to identity relevant value drivers for collaborators and to align these with the overall project objectives so as to create and deliver value for individual partners as well as for the overall project.

Manager and Governor: Becoming a PC is career-enhancing. It also means taking on additional responsibilities. This requires PCs to be very effective managers of people, resources, and relationships within and outside the institution in which they are based. PCs have to be able to navigate effectively among different institutional governance systems and that of the funder.

7.4 Antecedent Individual Factors

From our literature review, it is evident that individual factors underpin and influence the PC. The *personal motivation* of the individual scientists is a key driving factor, along with how they view their role in science. Are they focused purely on scientific discovery or do they want to realise scientific discovery through technology and knowledge transfer to the marketplace or society?

It is essential for a PC to have extensive *networks* within and outside academia in order to build consortia that increase the probability of success both in securing competitive funding and in realising the multiple-impact objectives that are now becoming a prerequisite for such large-scale projects. Building such networks takes time and also requires trust between the PC and relevant stakeholders. It is about building long-term collaborative arrangements that are a mix of formal and informal, and over time are mutually beneficial.

Knowledge and knowhow support the sustainability of scientists in the PC role. A unique advantage that PCs possess is their domain/discipline knowledge. Knowhow centres on the practices and activities of being a PC. It can, for example, involve knowhow on developing and ultimately implementing a technology and knowledge transfer strategy for the project that fulfils the value-creation needs of all stakeholders; knowhow with respect to the legal and value-creation implications associated with different technology transfer mechanisms, and knowhow about resourcing and managing large-scale project budgets across different academic and industry partners.

The final antecedent individual factor centres on *career trajectory and experience*. The literature and emerging empirical evidence suggests that PCs with prior industry experience are able to bridge the gap between academia and industry and tend to be more effective with respect to technology and knowledge transfer. The stage of career influences whether a scientist becomes a PC. Scientists gain knowledge and experience of the PC role by being a co-PC and through experiences of being part of a funded research team led by a PC.

Context also influences antecedent individual factors, in particular *incentives and the policy environment*. Incentives can influence whether a scientist takes on the role of PC. Such incentives can include career progression, retention of a proportion of project overheads, institutional recognition, leave, etc. Such incentives create the conditions to support the PC to undertake the role and/or when they are in the role. The broader policy environment also can influence the scientist in terms of pursuing commercialisation and collaborating with relevant stakeholders in realising such opportunities. The policy environment scope includes the broad environmental conditions that affect any business but also encompasses specific supports that encourage scientists in the PC role to pursue technology transfer opportunities from publicly funded research programmes. These supports can range from hard supports such as grants to softer supports such as industry mentorship.

7.5 Project Factors

Much of the literature on research consortia relates to complexity driven by different types of diversity. As stated above, assumptions have been made by funding agencies, including the European Commission, that diversity in discipline, institution and nationality will support the delivery of innovation outcomes, and there is evidence to support this rationale. From a PC perspective, translating this infrastructural preference into research funding instruments puts an onus on PC competencies relating to boundary-spanning, alliance planning, alliance formation, and alliance management. While the project can be envisaged as a quasi-firm, the PC does not have the same controls as a CEO in an actual firm. The public-private nature means that firing and replacing project partners is usually not an option. The PC is required to manage project commitment and the limited range of project management controls available to them. This requires leadership and technical competencies. The context of the project, including its diversity and commitment of actors, further influences the project operating environment. The overall range of competencies is quite invisible and their development is influenced by a myriad of factors, including the PC’s prior experience and the operating practices and culture of the PC unit (e.g. research centre).

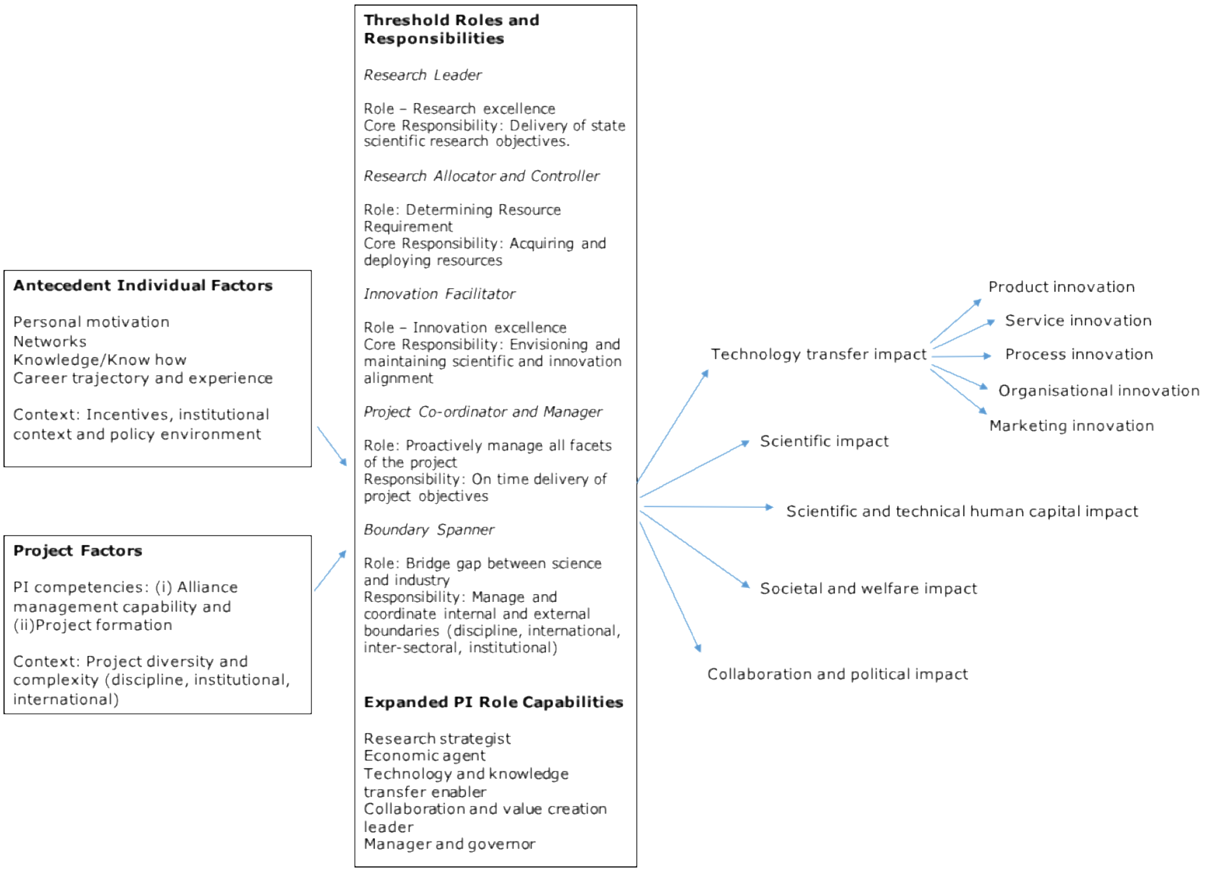
8 Contingent Model of Project Coordinator Effectiveness and Conclusions

8.1 Contingent Model of Project Coordinator Effectiveness

This paper proposes a model for studying the effectiveness of PCs (see Figure 4). The model suggests that a number of factors affect the approach of the PC. These include imposed conditions but, perhaps more importantly, are contingent on the PC's interpretation of their role and the impact of the PC's previous experiences, including training.

The invisible centrality of the contribution of the PC in the delivery of innovation from publicly funded science is largely unexplored. Much of the literature relating to technology transfer addresses the impact of the institution or the research unit. At an individual scientist level, the focus of research undertaken tends towards examining the impact of different antecedent individual factors. Few studies have sought to interpret the lynchpin role of the PC.

Figure 4: Contingent Model of Project Coordinator Effectiveness



The model addresses the individual and project factors that influence the PC in their choices and practices. PCs are engaged in the different practices at different levels, and their engagement shapes their roles, from that of project manager (mostly focusing and innovating) to that of scientific entrepreneur (shaping new models and paradigms and brokering science). The scientific entrepreneur links different worlds and different activities to cross the borders of knowledge, and enacts their environments by changing the boundaries of their organisation and setting up new ones.

In the proposed model, the practices of PCs are translated into five roles, each with specific responsibilities for which additional learning is required in order to assess and measure the necessary thresholds for PC effectiveness. Typically, it is the scientific achievement of the prospective PC that carries most weight at the research application phase in terms of evaluating their competence to successfully lead a project. However, this review demonstrates that the PC qualities are of an ambidextrous nature. This observation also suggests that it is necessary to examine how PCs are prepared for their responsibilities from a professional development perspective.

8.2 Conclusions

This paper supports a micro-level investigation of the challenges involved in the leadership of publicly funded research projects. The role of a PC is in some ways akin to that of the CEO of a temporary organisation, but the measurements required to evaluate PCs are under-developed and require further study. Similarly, our understanding of the human resource development of PCs needs to be enhanced. The managerial challenges are both complex and extensive, yet there are few formal mechanisms for training and developing PCs outside traditional business-school MBA-type programmes. At this point, we caution against an easy assumption that the PC requires to undertake management or leadership training. It is arguable that many of their roles and responsibilities are more akin to that of an entrepreneur, where prior to the project and during the proposal development phases they envision the scientific and commercial trajectory of the research. Through public research funding applications, they acquire the resources to deliver on this vision through assembling the optimally diverse research consortia. Finally, during the project, they prepare and manage the environment and project resources to deliver their scientific and innovation outcomes. Further study is also required on how PCs interpret their role and responsibilities: what attributes do PCs perceive as most significant in delivering both scientific and innovation project outcomes? Given the movement of the PC towards centre stage of science and innovation policy and the expenditure of vast amounts of public monies, it is essential to enhance understanding of the exact role and responsibilities of the PC in delivering innovation outcomes and impact.

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List of Abbreviations and Definitions

EC	European Commission
EU	European Union
FP7	Framework Programme 7
JRC	Joint Research Centre
PC	Project Coordinator
PI	Principal Investigator

List of Figures

List of Tables

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