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Glorified Administrators or Eminent Research Leaders: The Inhibiting Factors that Publicly Funded Principal Investigators Experience in Leading Collaborative Research Projects

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ABSTRACT

Publicly funded research continues to be an important and critical source of research funding for Higher Education Institutions, public research organisations and industry with many benefits accruing to the various stakeholders. Key actors in delivering publicly funded research projects are Principal Investigators (PIs). PIs are responsible for all aspects of publicly funded research projects and are awarded grants based on their scientific eminence, past achievements, the quality of the proposal and articulated outcomes relating to the public funding calls. Becoming a publicly funded PI is seen as significant developing in a scientists career.

Despite their importance, PIs have not been the focus of empirical investigation and the research eminence play is a significant consideration in awarding grants by funding agencies. The combination of increased level of competition for publicly funded research and a more managerialist approach being adopted by Higher Education Institutions, coupled with industry influences has heightened the expectations associated with the role of PI. This paper provides evidence of the inhibiting factors that Principal Investigators experience in leading collaborative publicly funded national and international research projects as well as the tensions it creates for them. The inhibiting factors that we have unearthed are *political and environmental, institutional and project based*. We have found the optimal balance for publicly funded PIs of conducting, leading and administrating research is significantly skewed towards administrative and managerial issues. The inhibiting factors that publicly funded PIs experience has the potential to undermine the 'ethos of science' (Merton, 1968), research autonomy and the prioritization of discovery by scientists.

Key Words: Publicly Funded Research; Principal Investigators; Inhibiting Factors;
Research Leadership; Research Management; Ethos of Science, Tensions

1 Introduction

Public investment in research has directed attention at the potential scientific, economic and social benefits that may be gained from public research within Higher Education Institutions and public research laboratories. The Triple Helix model is based on the assumption that industry, university and government are increasingly interdependent. The rise of this configuration is mainly due to the enhanced role of knowledge in our economy and society, while the role of universities in this configuration is often referred to as its 'third mission' (Hessels and Van Lente, 2008). There is now an expectation attached to most publicly funded research that the PI's efforts would make an economic and social contribution. This is normally realised through the technology transfer of the research outputs, with many arguing that the support and involvement of the inventor or research leader in the process is a critical determinant of success (Siegel, Waldman and Link 2003; Thursby and Thursby 2004).

Understanding the inhibiting factors in that PI experience in delivering publicly funded research requires the best scientists and research teams working on frontier research of national and international importance to optimise the scientific, economic and social benefits. Publicly funded research supports the development of scientific careers, the development of critical mass research activity in national research systems and maintaining the capacity necessary to continue to push knowledge frontiers. This requires a clear understanding of the inhibiting factors faced by publicly funded Principal Investigators who lead collaborative research projects.

Over the last two decades the amount of public investment in science through HEIs and public research organizations is significant. In tandem with this investment, HEIs have begun to embrace third mission and entrepreneurial activities which has without doubt begun to shape academic life and scientific careers. Many HEIs have become more managerialist in their approach, ethos and culture. A key actor in this knowledge system are publicly funded PIs who have the responsibility to deliver on publicly funded research and balancing this with other institutional expectations. Public funded principal roles have grown significantly in the last decade and are seen as prestigious by the academic community. Yet little is known about the experiences of PIs given their importance to university-industry-government relationships and in doing frontier research that will have spillover benefits for economies and societies.

In this paper, we investigate the inhibiting factors experienced by publicly funded Principal Investigators in leading collaborative research projects. Our analysis contributes to the debate on science careers, the ‘ethos of science’, the shifting mission focus of HEIs and the rise of managerialism and on research management and leadership.

The paper is structured as follows. We the paper by outlining the characteristics and benefits of publicly funded research and we focus our attention on the shift in HEI mission via third mission and entrepreneurialism. Drawing on existing work, we outline the debates on the reinterpretation of the traditional academic model and of science careers. We then focus our attention on the role descriptions and expectations of publicly funded PIs which has not been the focus of any empirical investigation. From this we outline our methodological approach, data collection and analysis for

our study and in the final section we present and discuss our results on the inhibiting factors that publicly funded PIs experience.

2. Conceptual considerations

2.1 Characteristics and Benefits of Publicly Funded Research

Publicly funded research characteristics distinguish it from other types of research funding as it is owned and financed by governments (Perry and Rainey, 1988), and responsive to interest groups (Quinn, 1980). Public funded research also yields resource utilisation efficiency (Whorton and Worthley, 1981) in addition, to differing pricing methods and performance evaluation (Banfield, 1975). Transparency of objectives and content are available to all stakeholders (Rainey *et al.*, 1976; Ring and Perry, 1985) and publicly funded research can also have positive impacts on the culture of organisations (Whorton and Worthley, 1981). In particular, public investment in research has the potential to change or alter the organisational culture of public research organisations and Higher Education Institutions.

Characteristics of publicly funding research varies across nations and stakeholders within national innovation systems as publicly funded research schemes have different national priorities designed to support national scientific, economic and social priorities (Malo, 2009). The main product of publicly funded research as Slater and Martin (2001) note is: ‘... is thus seen as economically useful information, freely available to all firms. In this context, scientific knowledge is seen as a public good. By increasing the funds for basic research, government can expand the pool of economically useful information.’ Another characteristic of publicly funded research

is allows for the increase in skills, tacit knowledge and the development and expansion of networks of actors within a national innovation system. (Rosenburg, 1990 and Pavitt, 1991).

Much empirical work has focused on the benefits of publicly funded research. The potential benefits can be spread among key actors, institutions, networks and the research itself. Society and the economy can benefit from publicly funded research. For example, in a study of combinatorial chemistry Malo (2009) found that publicly funded research lead the advancement of scientific knowledge, the provision of vocational skills, stimulation of networks, the development of new methodologies and scientific instruments. Other benefits of publicly funded research include increasing the stock of useful knowledge, training skilled graduates, creation of new scientific instrument and methodologies, forming networks and stimulating social interaction, increasing the capacity for scientific and technological problem-solving and creating new firms (Slater and Martin 2001). Publicly funded research can ‘have an impact on increasing work with industry.’(Bozeman and Gaughan, 2007) less so than private industry funding and can encourage private R&D investments, particularly in higher technology industries (Bonte, 2004). More importantly, publicly funded research can impact on economic growth through spin-off companies, as Vincett (2010) suggests: ‘that spin-off impacts represent incremental contributions to GDP, much larger than the government funding and directly attributable to it; government will also receive more in additional tax than they spent.’

Higher Education Institutions (HEIs) are central organisations in supporting publicly funded research (Harman, 2010) and have seen the benefits of publicly funded

research. Public funding benefits for HEIs include research infrastructure, human capital (researchers, post doctoral and doctoral students) (Gibbons and Johnson, 1974) and strengthens interactions with industry and other societal stakeholders. Such public funding supports individual HEIs in realising their research ambitions and outputs and in achieving their third mission objectives particularly the use of patents, licensing revenue and number of spin-offs (see for e.g. Feller, 1997; Pries and Guild, 2007). Governments, through publicly funded research are playing more of a direct and strategic role in funding research to Higher Education Institutions.

Benefits of publicly funded research also accrue to individual academics, departments and research institutes. One of the core benefits for academics is the development of new knowledge, methodologies and scientific instruments (Malo, 2009). Publicly funded research can contribute to research productivity by way of peer reviewed publications and this is seen as one of the ways industry learns about public research (Arundel, 1995). It provides graduate students with opportunities to progress with original research and engage with industry that enhances their understanding of industrial activities and processes that endure during their professional career (Gibbons et al 1994). Publicly funded research also benefits academics to expand their networks necessary for knowledge production (Callon, 1994). Such developments are necessary as research is becoming interdisciplinary and trans-disciplinary and requires academics to be able to access a variety of networks – industry and academic - to share and exploit ideas and developments. Research funding, including public sources, increases the interaction between academic and industry, however, depending on the career stage this maybe limited (Boozeman and Gaughan, 2007). The final benefit of publicly funded research for an academic is that the funding enhances their recognition among peers and increases personal income

through royalty payments from patents or spin outs (Hulten and Mahagaonkar (2010)). Such funding also supports their career advancement.

2.2 University Third Mission and Entrepreneurialism

The funding which HEIs receive by way of state block grants and the competitively secured publicly funded research are vital to sustaining core activities of teaching and research. This means governments play a significant role and exert influence over the direction and focus of HEIs as Harmen (2010) notes: 'In most industrialised countries, there is increased emphasis on establishing national and institutional research priorities, encouraging university research links with industrial partners, and efforts to commercialize university research inventions and discoveries, mainly through licensing of university patents or creation of start-up companies.' Universities are a significant source of knowledge and capabilities (Molas-Gallart et al., 2002). The establishment of linkages between industry and science are considered paramount to the realisation of an economy that emphasises the role of knowledge and technology in driving productivity and economic growth (Beesley, 2003:1522). The triple helix system recognises that the future location of research and technology transfer resides in a triple helix of university-industry-government relations (Etzkowitz and Leydesdorff 1999; Ledesdorff and Etzkowitz, 1996).

In responding to these external changes HEIs have adopted third mission or 'entrepreneurial' activities as part of their core activities which falls outside the traditionally accepted duties of academics. This includes large scale science projects (obtaining large externally funded research projects); contracted research (specific research projects within the university system for external organisations); consulting

(the sale of personal scientific or technological expertise to solve a specific problem); patenting/licensing (exploitation of patents of licences arising from research by industry); spin off firms (creation of a new firm or organisation to exploit the results of university research); external teaching (providing courses for non-university personnel and external organisations); sales (selling of products developed within the university) and; testing (providing of testing and calibration facilities to non-university individuals and external organisations) (Klofsten and Jones-Evans, 2000)

This significant shift in HEI mission has seen an increase in the private companies establishing or enhancing relationship with HEIs (Powell et al, 1996) and the manner in which HEIs have maintained a central position at the centre of the knowledge production system through exploiting collaborative mechanisms (Godin and Gingras, 2000). The re-conceptualisation of the role of academic institutions has seen them characterised as not only highly important for national economies but as integral elements of such economies (Brennan et al. 2007). ‘Universities play important roles in ‘the knowledge-based’ economies of modern industrializing states as sources of trained ‘knowledge workers’ and ideas flowing from both basic and applied research activities.’(Mowery and Smapat 2001). This expansion of focus from the traditional focus of research and teaching has far reaching consequences in changing the relationship between science, industry and society (Garrett-Jones et al, 2005). Such a significant shift in focus raises new tensions and conflicts particularly with respect to motivations of the university scientist on the one hand, and the firm or entrepreneur on the other (Siegel et al., 2003). For the publicly funded Principal Investigator the institutional shift in focus to embracing ‘entrepreneurial’ activities raises significant

issues in relation to how they can be effective in this new context of heightened expectations as well as dealing with competing institutional demands.

In responding to growing pressure being exerted by governments as major funders of universities, higher education administrators have adopted a managerial approach to managing core missions. This has resulted in changes to the academic work environment in universities in the USA, Europe and Austral Asia (Altbach, 1999; Churchman 2002; Huber 2003; Preston, 2002; 2002). Consequently, university administrators have become focused on putting in place managerial structures, systems and approaches that enable institutions to monitor and assess performance (Boyle, 1999). This has also led to increasing the visibility and importance of research, research management and administration (Shelly, 2010). Yet a key question remains as Shelly (2010) puts it: ‘The question of whether research managers manage academic research or simply administer the research process and manage the mechanism of research (for example, check budgets, audit research application success rates, sort out IRP issues) is complex.’ Such changes and the addition of new organisational roles such as research managers has implications for publicly funded Principal Investigators and as such potentially creates inhibitors for them in delivering publicly funded research projects in what Duberley (et al, 2006) describes as more ‘commercial and managerial environments’. The challenge for university leaders and administrators as Glassman et al, (2003) states is: ‘to create a cultural environment that promotes risk taking, self-confidence, optimism, and ambition.’

2.3 Reinterpretation the Traditional Academic Model

The expansion of university missions combined with more commercial and managerial environments has changed the academic profession. This has meant that academics have to become a member of an even greater array of groups while also belonging to a profession, institution and a national system of innovation and education as Clarke (1984, p.112) notes: ‘Academics are caught up in various matrices, with multiple memberships that shape their work, call upon their loyalties and apportion their authority.’ This can also have implications for their career development and the nature of their work.

Science work has long been advocated as one of the most self-dedicating forms of work, a vocation with personal rewards emanating from the autonomy, personal development and challenges it presents, as well as the intrinsic value of producing and expanding knowledge frontiers (Weber 1918). Similarly, Merton (1968) suggests that traditional academic scientists prioritise discoveries in their work and are immersed in a normative system called the ‘ethos of science’, one aspect of which is ‘disinterestedness’ (the others being ‘universalism’, ‘communism’ and ‘skepticism’) which posits that scientists have no emotional or financial attachments to their work. The primary attractions to work as a traditional scientist have been suggested to be the very meaningful nature of the work itself together with its ‘quality of professional life’ and the diverse and intrinsic characteristics of work that can improve job satisfaction and job performance (Miller, 1986; Jones, 1996; Keller, 1997).

2.4 Scientific Careers and Becoming a Principal Investigator

Academics constantly face tensions on how best to allocate time between teaching, research and service activities and can receive mixed messages from their own institution about what activities to prioritise (Clarke, 1986). Nevertheless, pressures within and outside their institutions, scale and type of available funding, third mission activities have influenced academic careers and work practices and have created 'new fault' lines (Smith and Powell, 2001). Rewarding individual researcher performance has become the norm in many institutions and in national research systems (Duberley et al, 2006). Entrepreneurship among science based academics is accepted and the norm or is what Colyvas and Powell (2007) described as a 'venerated practice'. Gulbrandsen and Smeby (2005) in their empirical study of Norwegian tenured professors have shown that those professors with industry funding have higher levels of collaborations with other researchers in academia and industry, publish more scientific articles and have 'more frequent entrepreneurial results.' However, Clark (2010) found that scientists that only work with industry partners had less academic to academic collaborations.

Against the background of these external environmental changes Snape and Snape (2006) found in their study that scientists are motivated 'by the ability to do high quality research and de-motivated by lack of feedback from management, difficulty in collaborating with colleagues and constant review and change.' Whereas D'Este and Perkmann (2011) suggest that scientists primary motivation to engage with industry is driven by research rather than commercialisation. Engaging with industry has challenged the identity and values of scientists but as Goktepe-Hulten and

Mahagaonkar (2010) argue, they should not give up their traditional values and identity. Being an academic scientist is more respected by peers and society.

For science academics, taking on the role of lead researcher or principal represents an important landmark in their career. Being a publicly funded PI is seen as prestigious by peers, the funding agency, their institution and external stakeholders. To become a publicly funded PI is highly competitive requiring a competitive proposal that is aligned to the objectives of the funding agency research call and threshold levels of professional attainment, particularly in relation to research, eminence are normally required. For example, an academic that is a recipient of a National Science Foundation grant carries what Rosser and Chameau (2006) describe as ‘considerable prestige’. It also places additional demands on the PIs institution.

With the rise in publicly funded research PIs have become central actors in the delivery of basic, applied and experimental research in HEIs and public research organisations. As PI, the lead researcher will be expected to moderate their role identity from that of scientific researcher to incorporate other duties involved in being PI (Jain, George, Maltarich, 2009). Traditionally an agent of research management and science policy, the duties of the PI have typically been broadly confined to forging goals, defining research programs and planning and implementing the research strategy. More recently, however, in line with the changing research environment and need to coordinate with multiple organizations, including industry, the PI has become increasingly important as key agent of economic development and policy. PI responsibilities now include, but are not restricted to: project manager; stakeholder relationship manager; research strategist; technology transfer agent (see

for example Thursby and Thursby 2004 for the importance of the scientist or inventor to technology transfer success); resource manager; people manager; trainer; and potentially entrepreneur. What is implicitly understood, but has been given low status among scientists and Principal Investigators is their management capabilities. Of the few studies that do exist, some point to the fact that management and leadership issues are not significant considerations for those scientists working as Principal Investigators. Indeed, some studies note that in many research environments, research management is allocated a lower status than the scientific work, discouraging Principal Investigators from addressing leadership and management issues (Mulec, 2006; Fredberg et al., 2007) and increasing the challenge of achieving legitimacy for the research managers. It is noteworthy also that funding agencies do not appear to prioritise managerial capabilities. An audit of research proposal evaluation criteria by the authors identified a clear emphasis on the scientific performance of the lead scientist or Principal Investigator, with little reference to their experience or qualifications to manage and lead what sometimes amount to very complex research projects. Coupled to these evaluation criteria, proposal evaluation is dominated by independent academic evaluators who may be inclined to reinforce the dominant academic tradition of evaluating on the basis of track record measured by academic achievement.

Aligned with the low status of management among scientists also is the lack of management development opportunities. While technical accomplishment has been identified as a key attribute of the effective leader in several studies (Sapienza, 2005), a longstanding and mostly unaddressed issue is that public scientists are, in effect, narrowly trained professionals. Most of their training consists of a specialist,

discipline-based education programme where rewards are based largely on individual accomplishment, normally the production of new knowledge that can be codified in the format of a doctoral thesis document (Sapienza, 2005). Following on from this training, the researcher normally undergoes a lengthy socialisation process in the form of postdoctoral training that reinforces autonomy and solo effort (Turner, 1987). Eventually researchers become more interdependent on others, often in a publicly funded project and as documented in some of the scientific press, ‘management skills (are learned) on the fly’ (Kreeger, 1997).

2.5 Role Descriptions and Expectations of Publicly Funded Principal Investigators

There is no universal description or definition of publicly funded researchers from funding agencies or higher educational institutions. Role descriptions from funding agencies in US tend to focus on the organisational institutional supports necessary for the role, scientific research management and leadership, where the European definitions are looser in description with some emphasizing the research management and reporting aspects of the role (see Table 1).

- Insert Table 1 about here -

Role descriptions of Principal Investigators from Ivey League universities in the US place the total of responsibility at an individual level for all aspects of the publicly funded project and provide degrees of freedom to allow other co-PIs, as in Princeton University, or individuals from the university community to become PIs, such as Brown University (see Table 2). What is also striking about the role descriptions is

the emphasis on internal management with only one explicitly outlining an external engagement focus. Moreover, in the cases of Yale and Princeton PIs, they are selected by the institution rather than self selected by applying for public funding.

-Insert Table 2 about here-

In reviewing the variety of PIs role descriptions, what becomes apparent is that PIs are at a minimum, expected to complete the research project within the funding limits awarded and, in accordance with the policies, terms and conditions of the funding agency and their institutions. To become a Principal Investigator the minimum core expectation is that they have demonstrated scientific leadership and outlined an achievable research project plan over a defined period of time. In doing so, PIs have outlined the necessary resources, human, infrastructural and capital resources as well as key milestone deliverables, in addition to defined outcomes. PIs have also sought and described the institutional support that they have in order to deliver on the project. This could require a signature from a research institute director, Vice President for Research and a review of project budget costs by research accounts. Despite the importance and formal status of the role, from the role descriptions there is a strong managerial focus expectation stated by universities where, as funding agencies stated, predominate expectation focus is on scientific leadership.

PIs are expected to oversee the day to day management of the project, supervise and sometimes mentor staff conduct, sign off on the project's budgets and financial management, ensure all deliverables and deadlines are met, and submit technical documentation and progress reports. PIs are also expected to take on more significant

managerial roles, whereby they are expected to design and schedule the research project, coordinate and direct a research team, liaise with stakeholders and act as a primary contact point with the funding agency, and flag and respond to institutional or project issues (see Table 2 for examples). Significantly, however, the responsibilities associated with the position of PI are somewhat heightened with the added expectations that they will develop and maintain their own status and expertise in the field, demonstrate intellectual leadership, set the scientific direction, deliver technical success, and oversee the project's impact activities following the projects' completion. In addition, PIs have to deal with two layers of control mechanisms from their own institutional and the public funding agency as well as expectations of industry parties. In summary, responsibilities enshrined in the Principal Investigator role by the funders include:

- (i) acting as primary conduit between the project organisation or team and the funder;
- (ii) leading project scientific and technical direction;
- (iii) ensuring compliance with intellectual property requirements of the award;
- (iv) maintaining proper conduct on the project and appropriate use of funds;
- (v) assembling and coordinating the project team; and
- (vi) designing project management structures.

National policy direction relating to public research has also imposed new demands on PIs. The transfer of scientific and technological know-how into valuable economic activity has become an important priority on many policy agendas, with links between industry and science being a crucial element of this policy direction (Debackere and Veugelers, 2005). PIs also often have to play a type of market shaping role, as they must form expectations about future markets at the outset of their project. Moreover, as argued by Jain et al. (2009), it can require the PI to take on the complex challenge

of 'delegating' and 'buffering' where they modify their identity and adopt a hybrid role, in which they simultaneously employ a scientific and entrepreneurial persona. This role can also bring with it difficulties in terms of dealing with the contrasting expectations of scientific and industry partners. More specifically, science is expensive and seldom contributes to near-term profitability in a direct sense.

More generally, research on successful research environments has pointed to the importance of management and leadership for good research output (Peltz and Andrews, 1976). In a study of NASA scientists, Day (2002) cited in Sapeinza (2005) concluded that '[It] is no longer enough to be excellent in [one's] scientific discipline. . . . A research leader needs to get work done with and through other . . . Time, money, morale and quality of product are only a few of the elements that are at risk when ineffective leaders are at the helm' (p. 3). Such observations contribute to an increasingly managerial and administration focused role descriptor aligned to both management and scientific role challenges.

Given the role descriptions and expectations of Principal Investigators against a background of significant external environmental changes our primary research focus is to establish what are the inhibitors factors that publicly funded Principal Investigators experience in leading collaborative research projects.

3 Methodology

Our core research focus for this study is to examine the inhibiting factors that publicly funded Principal Investigators experience. The exploratory nature of this research was particularly suited to an interpretative case study research design (Burrell and

Morgan, 1979). Using such a qualitative approach is consistent with previous research studies that have examined challenges associated with boundary spanning activities (Adler et al, 2009; Druskat and Wheeler, 2003; Lehtonen and Martinsuo, 2008; Ashill et al, 2001; Suchitra and Sankaran, 2007). The case study method is an appropriate selection when the context, or ‘natural setting’, of study is important and when an understanding, or the ‘how’ ‘what’ and the ‘why’, of a complex phenomenon/process needs attending to (Yin, 1984). Indeed, according to Strauss and Corbin (1990) ‘[s]ome areas of study naturally lend themselves to more qualitative types of research, for instance, research that attempts to uncover the nature of persons’ experiences with a phenomenon’. Multiple-case studies were used to obtain more robust findings, because, compared to a single case study research design, the emerging theory is better grounded, more accurate and theoretically transferable (Eisenhardt, 1989, 1991, Yin, 2003). The subjects of analysis are the Principal Investigators who conceived of and/or coordinated their respective projects. These projects are classified as individual case studies and in all there are thirty.

3.1 Data collection and analysis

There were two key phases to the data collection process. The first phase involved compiling a dataset of publicly funded research projects in Ireland’s science, engineering and technology sector over the last five years. This phase also involved identifying appropriate projects or cases of study within this sample for closer examination. Consistent with the concept of theoretical sampling, we looked for projects in which the challenges of mode 2 knowledge production would be most clearly manifested. Our primary selection criteria ensured that only multi-annual and collaborative (preferably with industry) research projects with a funding value over €250,000 were considered. After narrowing the sample somewhat, we then worked

towards developing a final sample of thirty projects with Principal Investigators who were cross -disciplined, -gendered, -aged, and at different levels in their career. In terms of 'title', our final sample of Principal Investigators included eleven professors, four research directors, four senior researchers, nine research leaders, one lecturer and one research officer. There were twenty-five males and five females; twenty were based in universities, five in institutes of technologies and five in state research centres. In terms of the projects, sixteen were national and fourteen international; sixteen were applied in nature and fourteen were basic; and the exact subject areas varied within the broader areas of natural and agricultural sciences, and engineering and technology. Compiling such a diverse sample would ensure that we could gather as a complete view as possible of the strategic behaviour of the Principal Investigator, and improve the validity of the findings with respect to the broader public research environment. More detailed analysis by gender, type of institution, specific subject area, partners, and national or international collaboration were beyond the scope of this research. Table 3 presents an overview of the Principal Investigators and respective projects that were researched.

The second phase of data collection included an analysis of documentation collected before, during and after the interview relevant to both the project and the CV of the Principal Investigator. The primary research instrument involved semi-structured interviews with each Principal Investigator (approximately 90 minutes each). Semi-structured interviews are particularly suited to exploratory case-based research due to the depth of inquiry they can generate (Yin, 1984). Thirty interviews, amounting to just over 400 pages in transcripts, were deemed an appropriate amount and indeed

repetition in the final few Principal Investigator interviews suggested a saturation point had been reached.

The interview guide explored the Principal Investigators' observations and behaviour with regard to their respective projects in a processual structure, from project initiation to post-project review. Key areas of the interviews included – 1) the Principal Investigator's rationale for, and role in, conceiving of the project idea and project organisation; 2) the Principal Investigator's perceived challenges from initiation to completion of the project; and 3) their subsequent role and performance in leading the project's implementation. All interviews were transcribed and sent back to interviewees for clarification and confirmation. These were then combined with the relevant Principal Investigator and project documentation in separate project case studies.

The analysis followed the process described in Miles and Huberman (1994) where analysis consists of three concurrent flows of activity: data reduction, data display, and conclusion drawing/verification. Data reduction was undertaken for each of the 30 interviews using a list of predefined codes. Sub-codes were then added within each of the codes in order to categorise the data further. As additional insights and observations emerged, additional codes were applied. The analysis was centred on the Principal Investigator's challenges, their intents, and project, institution and environment characteristics that were seen as constraints or enablers during the project delivery. It involved evidence (key words and phrases) of Principal Investigator perceived challenges and responses. This process had the effect of organising the data into institutional, environment and project organisation categories.

More in-depth analysis and the chronological ordering of the Principal Investigator challenges in the course of project delivery provided a fuller understanding and categorisation of challenges perceived. The analysis resulted as a categorization of the domain of management activities and a listing of the project, organisation and environment characteristics that served as enablers or challenges during project delivery. Direct quotes from the data and comparison to earlier literature were used to interpret and highlight the main findings.

- Insert Table 3 about here –

This research is not without its limitations. The data collection was in Ireland and it would be beneficial to extend the study internationally and across other disciplines to examine whether these inhibiting factors and tensions exist to the same extent, particularly in stated funded HEIs.

4. Results

From our data analysis, Table 4 outlines the three categories of inhibitors that publicly funded PIs experience - political and environmental, institutional and project based.

- Insert Table 4 about here –

4.1 Political and Environmental Factors

One of the most significant inhibitors factors that all public funded Principal Investigators experienced in our studied related to *technology transfer policy*, particularly in relation to project direction and focus, stakeholder demands and IP

valuation. Technology transfer was an aspect for all of the publicly funded projects in our study. Publicly funded Principal Investigators were expected to demonstrate some technology transfer activities and outcomes in their reporting to their funding agency. This became an inhibiting factor for PIs in achieving the appropriate balance between academic publication and an IP focused approach. This inhibitor is best articulated by (WH) who stated: ‘there is competition between getting international recognition and getting IP because once you publish something you are limited. Knowing how to divide that and to sustain both is crucial and can be challenging. If you go too far down the IP route you don’t get the acknowledgement and it doesn’t feed through to grants and things like that. And vice versa, if you go too far into publishing etc. you can lose IP, so that is a big challenge.’ The tension is exacerbated among the PIs in our study by the institutional and academics expectations of attaining quality scholarship outputs and funding agencies desire to see technology protected and utilized by external stakeholders. This was reaffirmed by another AS who noted: ‘stakeholders were always putting us under the grill asking ‘what did we produce?’, ‘how did you do it’, ‘how relevant was it?’

Dealing with *competing stakeholder interests*, particularly industry was an inhibiting factor for all the publicly funded PIs in our study. This meant that PIs found themselves balancing the competing demands from industry partners, funding agencies as well as carrying out the research. PIs also had to deal with demands of internal stakeholders, particularly if they had other duties such as teaching. As SH put it: “There is an argument that EU projects should all be more applied and there is also an expectation that because you have companies in there, of course they will be applied but quite often what happens with these companies is that they get involved in

EU projects, do academic research, and produce prototypes that they can sell to a business. But it is only if they can actually sell a business case around one of those prototypes that they will build any real technology. I think the companies and guys that participate in these projects are part of a research arm of the company and are as disconnected from the core business of the company as we would be. I think that is one of the challenges for EU projects, how do they become more aligned to what is going on in the market environment, and what is going on in the business?' Similar to SH other publicly funded PIs expressed their frustration about companies ability to understand the potential of the technology, competitors and under estimated the time that it would take to develop it to a near market stage. As BH commented 'there are competitors working away and of course that worries me because I am funded by EI (Enterprise Ireland) to the tune of a few hundred thousand euro, not millions like these other players.' For the PI a key tension arises in how to prioritise these competing demands during the course of research project.

Another notable technology transfer inhibiting factor that publicly funded PIs experience is *IP valuation* by Technology Transfer Offices. The value of IP does impede technology transfer opportunities as affirmed by WS : 'If you try to say it is really really valuable then they might not want to sell it. I always think of the universities as wanting to be the gatekeeper, they are almost afraid of letting anything out no matter how good the deal is because maybe it will be even better in the future. In some ways I can understand that position but it can be somewhat infuriating.' Over valuation of IP and a conservative managerial approach by the TTO can inhibit the exploitation of technology transfer opportunities that potentially have public, economic or social outcomes. This creates a tension around the independence of IP

valuation for public research and whether the TTOs are best placed to carry this out given their primary responsibility of IP protections.

Based on our analysis, *poor support reliability of publicly funded* by various national and international funding agencies was another significant external initiating factor for publicly funded Principal Investigators. The poor support reliability of funding agencies related to core issues of short notices given for funding calls which can fall at busy academic periods and near end of year for funding agencies annual accounts, adhering to deadlines and slowness in releasing payments for the project. For one Principal Investigator an extreme case of poor reliability by a publicly funded agency meant no funding despite being 'successful' as TE described: 'as early as they know that they are going to have a call in a certain area they should let us know so that we can do some degree of planning. When they say there will be a call in a certain area they should always follow through on it. I spent most of last year working with *** and found after submitting and being successful that they had no money. The call is still actually on their website, they insist the call is still open.' This creates a tension for the publicly funded PI about balancing workload and exploiting new funding opportunities.

We found that *strategy and the transparency of public fund agency* is an inhibiting factor for publicly funded Principal Investigators. The issues of the strategic focus, remit and purpose of publicly funded agencies was noted by a majority of PIs in our study and how the different public funding agencies aligned with national strategies for education, industry and research. All publicly funded PIs in our study viewed publicly funded agencies as vital to funding basic and applied research. However, PIs

reported that there was a clear need for funding agencies to communicate directly with PIs and associated academic communities their long term research vision in developing activities under their remit.

In relation to transparency some PIs felt that funding agencies may have shifted their balance of funding support from basic to more applied without any broad consultation creating a 'mission drift'. Other PIs were more concerned as to the spread and scale of research funding between emerging and established research activities as an inhibiting factor for them in pursuing their research ambitions. This was succinctly described by MD as; 'I would have wrote probably six or seven project proposals to try and get money in which were unsuccessful. That can be demoralising when you see projects in other areas which you would feel are already adequately funded getting more money when you are there trying to write the most financially competitive proposal you can.' Such uncertainties have implications for the research productivity, direction and focus of publicly funded PIs and the insitutions they are employed in.

The final *political and environmental* inhibiting factor that the we found in our study was the variation of engagement and interest by funding agencies with the Principal Investigators that they fund. PIs in our study experienced a variation of formal engagements with funding agencies which ranged from regular submission of six monthly progress reports through to site visits. However, the majority of PIs in our study expressed frustation at the level of engagement and interest that funding agencies had with them as PIs and in their funded project. A majority of PIs where disappointed with funding agencies and their project officers, particularly in respect to their familiarity with the project, the lack of interest and knowledge. In some cases

PIs had invited project or scientific officers to project meetings for the benefit of the project but often they did not come to meetings as they ‘had so many projects going and was busy with these.’as JP described. KU further reinforced this lack of engagement as ‘many of the people who administer these projects have never done research, certainly not research at the PI level. They are administrating something about which they don’t know a lot about. Many of them in my view are not research literate.’ This can put a significant strain on the relationship between the PI, their institution, the funding agency and industry partners. Some PIs in our study suggested that a ‘more hands on involvement and more meangiful site visits’ would be beneficial to the project particularly with respect to the scientific elements.

4.2 *Institutional Inhibitors*

We found three significant institutional inhibitors factor that PIs experienced – technology transfer support, tailored support for the role of PI and human capital support. It should be noted that all the organizations of the PIs in our study had centralized administration services such as finance, human resources and technology transfer.

With increasing emphasis by national governments and associated public funding agencies on technology transfer, it is not surprising that PIs experienced limitations to the level of dedicated *technology transfer support* available to them. One explanation is in part due to the increase in research funding in Ireland between 1999 and 2009 and the embryonic nature of some TTOs. While all PIs recognized the ‘professionalism’ and ‘dedication’ of TTO personnel, some inhibiting factor arise given the lack of expertise in TTOs. The technology transfer inhibiting factors are most acute for publicly funded PIs who wish to go beyond just protecting the IP and

commercialize their research through a technology transfer mechanism. TTOs seems to be ‘strong at legals’ as in IP protection ‘not so much [strong] on pushing patents out.’ – socializing with potential buyers of technology. Not all PIs in our study were in agreement that TTOs were ‘strong at legals’ particularly in the context of large scale legal agreement running to over 100 pages involving multiple academic and industry partners. The expectation among PIs is that TTOs would have the experience and expertise to push technology towards the market once it has been protected. The majority of PIs in our study found that the market orientation of TTOs, expertise and experience when it comes to fully exploiting publicly funded IP, is lacking. The TTO orientation from our research would appear to be more balanced toward IP protection rather than active market exploitation, while PI orientation would appear to be going beyond IP protection to exploitation causing tensions for PIs, particularly with funding agencies.

This is a significant inhibiting factor for publicly funded PIs as SF noted: ‘the element that I always felt was missing in relation to tech transfer was the kind of savvy agent who comes from a technical background, who understands research and research labs, and has a very broad knowledge right across the bio sciences, the health sciences, the physical sciences etc. So they are able to sit down and connect with you as the PI. They are out there looking, that bit is missing, the actual scanning of the market. The venture capitalists are there and they are not interested in existing companies as most of them are burdened with debt so they are keen on new ideas and new start ups. You have tech transfer offices which are very good in terms of the administration, legal work and paper work, and in the middle you have the guy who really could have the killer process for a very large company and he does not know it. What I think you

need is proactivity between the tech transfer office and the venture capitalists so that the ideas are not lost, and I think they are being lost at present.’ In essence, ‘there is a lot of IP on their books and there is no sales man’ as JR explained.

Several PIs recognized that TTOs are ‘stretched’, and in an impossible position. Some even questioned whether the whole university structure is ‘best’ placed for IP commercialisation. This meant that the technology transfer support on offer was not ‘meaningful’ for individual publicly funded projects. Some PIs experienced mismatch in expectations between what they wish to do and what the TTOs wanted them to protect IP. TTOs expected that PIs would always want to patent their IP, but sometimes, when they do not want to do it, then this causes added tensions between PIs and the TTOs.

Another source of tension that has become an inhibiting factor for publicly funded PIs is when IP protection and subsequent exploitation involves external parties be it other universities or private companies. As MW stated : ‘My closest involvement with them [TTO] was a multi-discipline partner program and they along with the tech transfer offices of the four other universities involved were disastrous. They were all fighting for their own corner and creating difficulty in getting agreement.’ Another PI observed that for complex multi party public projects that involve companies that TTOs are ‘detached in their thinking from where companies are’ (FH).

Another significant institutional inhibiting factor reflected by the majority of PIs in our study was the lack or *inadequate support for the Principal Investigator role*. We found that PIs were frustrated by the organisational constraints of their institutions

and the experience of the support they received was not 'helpful' and was 'compliance' based. Publicly funded PIs need some 'flexibility' and 'proactive' support in delivering on their research objectives. One PI (HI) described it as "There is a problem with institutional support in general, they seem to tell you what is possible and what you can or cannot do but that is not very helpful." Another PI (HQ) reaffirmed this 'you are part of the university and you are not the opposition yet you nearly have to remind the people in research accounts that we are all the one team.' Some PIs even went so far as to question whether the university wants them to succeed or not. This is a source of tension for publicly funded PIs as they are encouraged by their institution to seeking research funding but when they secure public grants that there is inadequate institutional support available as LH stated: 'It seems like you are encouraged to get in funding and then they do everything to stop you progressing with it. If you are talking to someone down in headquarters they will often have no concept of what you are doing or why you are doing it, you are just another number.'

This raises the issue of how institutions really support rather than inhibit individual projects and publicly funded PIs. We found that some PIs viewed inadequate PI support as more of a systemic issue to do with the culture of 'mentoring', 'nurturing' and 'tormenting' of the institution. In essence, it is about how does an institution support and provide professional development opportunities for its staff to enable them to cope with the pressure, tensions and challenges experienced as a publicly funded PI. For some PIs the need to create a 'nurturing' institutional environment is critical as VS put it 'One thing that support structures miss is personalisation, someone sitting on your shoulder giving you advice and guiding you and actually

tormenting you as well as mentoring because you sometimes need that sort of engagement to do it properly.’ The combination of creating appropriate supports for publicly funded PI role combined with a performance culture with mentoring supports provides publicly funded PIs with the capability to deal with the institutional level inhibitors that they experienced. One could argue that the support that PIs experience are adequate and should be standardised at institutional level to achieve economies of scale and if institutions focus on developing a ‘one team’ approach in all aspects, then publicly funded PIs would feel better supported and valued.

The final institutional inhibiting factor that we found of significance in our study were to do with *human capital factors* – recruitment of research officers and career paths for researchers. The recruitment of research officers was seen as a ‘crucial task for the PI’ but one that required significant attention and management. We found that some PIs found this process ‘cumbersome’ and the time between advertising and filling the post is too long in some instances up to 18 months.

Not having a defined career paths for researchers was seen as a human capital inhibiting factor for PIs as many experienced high turnover of researchers, the loss of talent and experiences and potentially undermining the sustainability of the research effort. A fundamental inhibitor that exists for the PIs is how best to retain talented researchers. For many in our study this means seeking further public funding for researchers in their teams to lessen the uncertainty about their future career perspectives. As one PI commented: ‘I struggle with how I can create employments for my team for a number of years, and not have them constantly looking over their shoulder. The thinking on this needs to move on significantly.’(SO). The other tension

revolves around professional and scientific development. The lack of a career path means higher levels of mobility, a loss of talent and ‘continuity’ for the project. It also means that PIs can see their role as ‘more like a trainer than a scientist.’ (TP). This has implications for career management and professional development for publicly funded PIs that have to manage mobile and short term researchers, while ensuring project continuity associated with the publicly funded project objectives.

4.3 Project Inhibitors

We found several project level inhibitors that impact on publicly funded PIs and their projects, the most significant among all PIs in our study being administration, the lack of dedicated support for the role and the power of industry partners.

The most significant project level inhibitor that we found among all the PIs in our study was *administration*. The totality of the administration that is required in being a publicly funded PI is best summed up by DF as ‘all of the responsibility from the initiating the idea right through to winning the funding, putting the infrastructure in place, writing all the reports, managing the budgets and everything that happens in between – it is all down to the PI.’ Similarly another PI reflected that “I probably spend most of my time fixing problems as they arise, so this can be down to personnel issues or issues in relation to the technical research, the project’s direction, or even the expectations of the different partners, or hiring people. So to be honest I don’t be writing any code or research papers or anything like that, it will be more of a management role” (JM). Other PIs noted that they spend their time ‘fixing problems’, ‘writing reports’, ‘collating information’ or what one PI described it as being a ‘glorified secretary.’ From this we see evidence that PIs role is greatly consumed in the

administration rather than the research. One PI quantified this as 'I would say 40 per cent of my role is about administration.'(HR) while another commented 'It is 99% management 1 % technical to be honest.'(TA).

The emphasis on the managerial aspects of the PI role was reiterated by all of the PIs in our study and as one PI stated: 'It is a research organisation, we are the scientists who are supposed to be driving the organisation, we are not supposed to be driven by the admin.' This creates tension between managing the project from a research leadership perspective – the basis of the award – and research management – project administration. The reason for this rise in administration and management is best captured by HA who stated: 'While the funding agencies still want to give out money to have a record of achievement and the universities want you to bring in money, the dynamic has shifted for PIs with both sides now increasingly pushing in on the PI at the same time to manage the project properly. What I find is that more and more is being pushed back to the PI in terms of management.' This push towards increased levels of administration and management has led to PIs having to manage their academic credentials as well as ensuring that they manage and lead publicly funded projects. As one PI described it as: 'So I need to maintain the academic persona in parallel with the coordination role.'

The second most significant inhibiting factor we found was the lack *dedicated training for publicly funded Principal Investigators*. PIs in our study participated in training and professional development activities focused on writing competitive proposal bids, project management, management courses and 'generic' courses. For the majority of PIs in our study 'self learning' and learning on the job, rather than

any tailored and formalised training support that they received from their institution or funding agency. As one GP stated: 'Most of it is self learning as far I am concerned. I fumbled through and found my own way, it is down to being sociable and confident.' or as another TZ commented 'it really is 'in at the deep end' stuff'. Another agreed with the self learning aspects of being a publicly funded PI: 'if you compare what I know now to what I knew in 2002 it is primarily down to self-learning.'(BH). Other PIs described the self learning as 'most effective' and learning 'the hard way' as the most common experiences but recognized that 'snappy training courses, experience and self learning are the most important mechanisms' (GO). However some PIs were skeptical about the value of the training they received particularly with respect to managerial training as OB reflected: 'I have gone on a few management courses that were not very good or applicable.' Overall, the PIs in our study felt that the formal support and training they received was not tailored specifically to the role of PI as such an inhibitor. Generic training, while helpful to the PI role, did not address key managerial issues. Self learning was the predominant approach among PIs in our study, hence the inadequate training

The third significant inhibitor that publicly funded PIs experienced was the *power of industry partners*. The power that industry partner over publicly funded project and PIs is not in doubt as LM stated. 'The reality is that industrial partner dictates a lot when they are getting involved.' The influence that industry has extends from the project conception right through to the project itself, which can be difficult for PIs to deal with. As one PI stated: 'if you have an industrial partner that is involved in the direction of the project the research goals can change easily. Six months in they might say that they want something else and they might want you to change. You have to be pragmatic and see how that can be done whilst reminding them of the constraints of

students if they are on it.’ (LM). Securing industry partners can be difficult but maintaining their interest over the duration of the project can be ‘tricky’. To overcome this one PIs noted from his own experience that ‘Motivated efficient company contacts with managerial support is critical.’(DC).

The mismatch between industry and project timeline can be an inhibiting factor for some PIs, where companies need more immediate outcomes such as an ‘immediate product coming off the line in the next six months.’ As one PIs stated: ‘industrial partners don’t understand the dynamics like ‘can’t hire’ or ‘students are not delivering’ or whatever it might be.’(HA). Moreover, we found that industries real interest in publicly funded projects can change dramatically. OP reflected this trend by noting: ‘My experience with industry partners would suggest that they don’t tell you too much about what they are doing and how close you are to solving the problem. On one project I was working on the industry partner all of a sudden stopped their funding. There are two likely reasons for this, either they have given up on it or else they have solved it and they won’t tell you as they will then bring it in-house. This puts huge pressure on you as a PI and it makes for a very volatile situation” (PR). This creates additional pressures on PIs and KDW re-affirms this as ‘industry partners often take a lot of the results and do their own thing with it as they have a lot of similar things going on in parallel.’

5 Discussion

In this paper, we investigate the inhibiting factors that publicly funded Principal Investigators experience in leading collaborative publicly funded national and international research projects. We identified three main categories of inhibiting

factors: (1) Political and Environmental; (2) Institutional; (3) Project Level as well as identifying the associated tensions it created for publicly funded PIs.

Our study and the findings raise some fundamental questions for the organisation of publicly funded science and the role of the Principal Investigator. Our research reaffirms many of the positive benefits of public research that have been identified in the literature. In general terms these benefits include enhancing of skills, expansion of networks, engagements with industry, social interaction and ‘entrepreneurial’ activities. For the HEIs the benefits include research infrastructures, human capital as well as IP protection. However, the benefit accruing to publicly funded PIs are less clear cut. PIs in our study have expanded their networks, as Bozeman and Gaughan (2007) and Callon (1994) suggested, but this expansion seems to be more orientated towards industry rather than academic to academic networks. Our study would suggest that publicly funded PIs are inhibited to a significant extent in relation to the development of new knowledge, methodologies and scientific instruments, as Malo (2009) suggests, as project level administrative and managerial activities are significant and seem to over shadow their scientific activities.

The expansion of HEIs towards third mission and ‘entrepreneurial’ activities is more of a dominant pre-occupation of publicly funded PIs as they deal with political and environmental inhibiting factors. Given their boundary spanning roles, publicly funded PIs bear over exaggerated expectations by their own institutions, funding agencies and industry partners. A study of boundary spanning activities in change programme projects by Lehtonen and Martinsuo (2008) identified a framework of five types of intents driving boundary spanning activities during program initiation: (1)

defining and shaping the boundary, (2) representing the program and creating legitimacy, (3) information scouting and negotiating, (4) ensuring continuity, and (5) guarding and isolating. Many of the PIs in our study have demonstrated these types of intent. The study also highlights the role ambiguity which places increased stress on the decision maker in our study the PI (Jemison, 1984).

This shift in the HEI environment combined with role ambiguity has raised some significant new tensions and conflicts for publicly funded PIs beyond what Siegal et al, (2003) described for academics and has resulted in some unintended consequences (see Clark, 1986). We have found the optimal balance for publicly funded PIs between conducting research and administration is not optimal and significantly skewed towards dealing with administrative and managerial issues rather than providing the research leadership. The extent of this is worrying when some publicly funded PIs in our study question the value of the funding and the role.

Our study unearthed tensions around the inhibiting factors we identified. Key tensions are focused on the desired 'entrepreneurial' outcomes versus academic, generic versus dedicated supports for the PI role, IP protection versus IP exploitation, formal learning versus self learning and research management and research leadership. These micro level tensions generated by inhibiting factors reflects clearly the changes that have occurred in academic life and the influence of 'commercial and managerial environments' (see Boyle, 1999 and Duberley et al, 2006). In responding and dealing with these tensions, PIs have a high level of interest in all of these that directly impact on their role but have low levels of control over many of the inhibiting factors, despite the fact they are eminent researchers who are key core actors in delivering public

research. As a key stakeholder their power to influence and control is low. Moreover, the tensions that we have unearthed and the inhibiting factors are contrary to the cultural environment of a HEI that Glassman et al, (2003) suggests that ‘promotes risk taking, self confidence, optimism and ambition.’

The managerial approach that has been adopted by many universities which has resulted in changes to academic work environments has led to publicly funded PIs adopting a managerialist approach rather than that of research leader, the basis on which publicly funded research was competitively secured. It has also forced PIs to enhance their networks and has without doubt ‘shaped their work’ as Clark (1984) noted. More significantly, the inhibiting factors potentially undermined PI loyalty to their institutions given the lack of tailored dedicated supports they received being a publicly funded Principal Investigator. This is in contrast to the prestige that they bring to the institution in securing public funding. Consequently, we argue that this potentially undermines the ‘quality of professional life’ that publicly funded PI experience and can potentially decrease job satisfaction and performance contrary to what is argued in the literature (Miller, 1986; Jones 1996; Keller, 1997). The inhibitors that we have identified potentially could exacerbate this for individual publicly funded PIs, which could ultimately lead to more scientists leaving public publicly funded organizations or even not competing for public funding.

The inhibitors that publicly funded PIs experience, that we identified, have created ‘new fault’ lines (Smith and Powell, 2001) which encompass a wider set of stakeholders inside and outside HEIs. Our study found support for D’Ester and Perkmann’s (2011) study that publicly funded PIs primary motivation is research

enhancement, but we argue that the inhibitors have the potential to undermine the traditional values and identity of scientists (Goketepe-Hulten and Mahagaonkar, 2010) and even de-motivate academics to become a publicly funded PI. The experienced realities of public funding and the inhibiting factors and the associated tensions have the potential to undermine what Merton (1968) termed the 'ethos of science'. Public funding in some respects provides scientists with the enabling capacity to prioritize discovery and provide research autonomy. Based on the evidence from our study it can undermine scientist's prioritization of discovery and places even greater managerial and administrative constraints on PIs. More fundamentally, we argue that the inhibiting factors and managerial focus of PIs is a function of the mixed messages that their own institutions, funding agencies and national governments attach to the key activities of academics and publicly funded PIs.

Our study is the first to really understand how macro changes in research environments and institutions impact on an empirically neglected core actor group that drive public research. At an institution level our study highlights the inadequate nature of the research supports available in large publicly funded organizations that are dependent on state to fund core activities and whose research funding income is balanced towards public funding. It also highlights the influence of industry partners in publicly funded projects. Our findings in relation to inadequate research supports concurs with some of the findings of Alder et al (2009) on the managerial challenges encountered when managing research activities. 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 PIs for what are normally large scale collaborative projects in context where the existing support structures are ‘stretched’ with limited human capital support, means that PIs become research managers rather than research leaders. In addressing the question posed by Shelly (2010) the evidence from our study would suggest that the balance for publicly funded PIs is that they spend a significant proportion of their time on administrating the research process and less on research leadership. The danger is that publicly funded PIs in the absence of dedicated support have embraced research management more than research leadership. In essence, predominately through self learning they have learned ‘management skills on the fly’ as Kreeger (1997) described it. It would appear that PIs have adopted a hybrid role employs a scientific and managerial persona rather than a scientific and entrepreneurial persona as Jain et al (2009) argues. This creates significant tensions for the PIs who have a significant interest in public research but little or no control over any of the inhibiting factors that we identified in our study.

6 Conclusion

Our results have captured the significant inhibiting factors and the associated tensions for publicly funded Principal Investigators, but have implications for public funding of science, formation and professional development of PIs, universities and public funding agencies. There is no doubt that there is demand and a need to continue public funding of science, particularly when large investments have been made in building infrastructure, human capital and where there is sustainable industry involvement. However, the ‘ethos of science’ and the prioritisation of discovery has to be protected and nurtured. An erosion of this core principal has the potential to

undermine science as a profession and the reputation aspects of being a scientist that competes for securing public funding.

Our study also brings into focus how PIs are prepared for the role. Publicly funded PIs have experienced institutional support in pre funding application phases, but don't receive dedicated or tailored support for the actual project. While PIs have experienced support from their institutional central services they are not sufficiently focused on their specific needs. They are not 'meaningful' as one PI put it. However, is a 'self learning' approach sufficient to becoming a PI, particularly when balance seems to be orientating toward research management rather than research leadership. We would argue there is a need to readdress the research management and research leadership balance that PIs experience and, via institutions and disciplines, better prepare academics for the PI role, which continues to be seen as prestigious.

For state funded universities, the study raises the issues in relation to appropriate institutional support for publicly funded PIs post funding. So, how can universities support PIs on the one hand to carry out the necessary administrative duties that do not over shadow their research leadership duties, the basis on which they secured public funding in the first instance. The more concerning issue for universities is if publicly funded PIs are taking on more managerial and administrative activities and not devoting sufficient time to research leadership, then over time their competitiveness in securing research grants lessens. This means less, probably large scale, research income from public sources for state funded universities.

For funding agencies, there appears to be a need to engagement with publicly funded PIs that is challenging and supporting. More consideration in funding calls should be given to the leadership and managerial capabilities of applicants but also the types of dedicated PI supports institutions actually provide. In addition, there is a need for funding agencies to articulate consistently to their stakeholders clear and consistent statements as to their core activities and future intentions and well as ensuring operational efficiency in terms of the research programmes that they manage.

Finally our results suggest that the role of publicly funded Principal Investigators extends beyond scientific leadership to the managerial leadership. Also, given the results of our study it is understandable to comprehend the extent to which there is scepticism with respect to the scope for science faculty to engage in commercial activity while simultaneously retaining a due regard for traditional scientific values (Callinicos 2006), and these concerns account for significant variance in the perception of research commercialisation within academia itself. Additionally, the question of public good dominates the rationale for the re-positioning of the role of academic organisations in society, as the emergence of the third mission changes on a fundamental level the manner in which university research is expected to contribute to society (Glenna et al. 2007). The evidence from our study would suggest that publicly funded PIs are the core of the fundamental shift with HEIs which has the potential to undermine the role of academia in science and society.

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Table 1: Sample Funding Agencies Descriptions

Funding Agency	Key elements of PI description	Description Emphasis
National Science Foundation (NSF) ⁱ - USA	<ul style="list-style-type: none"> the individual designated by the grantee, and approved by NSF, responsible for the scientific or technical direction of the project. 	Organisational support with the necessary scientific, research management and leadership
National Institute of Health (NIH) ⁱⁱ -USA	<ul style="list-style-type: none"> judged by the applicant organisation to have the appropriate level of authority and responsibility to direct the project or program supported by the grant 	Organisational support and the necessary scientific, research management and leadership
National Aeronautics & Space Administration (NASA) ⁱⁱⁱ -USA	<ul style="list-style-type: none"> a research organization designates as having an appropriate level of authority and responsibility for the proper conduct of the research, appropriate use of funds and administrative requirements such as the submission of scientific progress reports to the agency 	Organisational support and the necessary scientific, research management and leadership. Particular emphasis on the research management and reporting
European Research Council (ERC) ^{iv} – European	<ul style="list-style-type: none"> The Principal Investigator is the individual that may assemble a team to carry out the project under his/her scientific guidance 	Loose definition lead by an individual that can lead a team with scientific credentials
European Medicines Agency (EMA) ^v European	<ul style="list-style-type: none"> the responsibility for the coordination of investigators at different centres participating in a multicentre trial, or the leading investigator of a monocentre trial, or the coordinating (principal) investigator signing the clinical study report 	Loose definition focusing on the co-ordination across different organizations. No explicit focus on scientific or managerial leadership.
Economic and Social Research Council (ESRC) ^{vi} European -UK	<ul style="list-style-type: none"> is the individual who takes responsibility for the intellectual leadership of the research project and for the overall 	Focus on intellectual leadership, key contact point and all aspects of research project management

	<p>management of the research.</p> <ul style="list-style-type: none"> • He/She will be the Council's main contact for the proposal. • The nature of the role includes making a significant contribution to the design, project management, scientific leadership, impact activities, and overall supervision of staff conduct/responsibilities 	
<p>Science Foundation Ireland (SFI)^{vii} European- Ireland</p>	<ul style="list-style-type: none"> • The lead applicant responsible for the scientific and technical direction of the research programme and the submission of reports to SFI. • primary contact point and have primary fiduciary responsibility and accountability for carrying out the research within the funding limits awarded and in accordance with the terms and conditions Science Foundation Ireland (SFI) 	<p>Focus on scientific leadership and all aspects of research project management.</p>
<p>National Development Plan (NDP)^{viii} European- Ireland</p>	<ul style="list-style-type: none"> • will co-ordinate the research and drive the overall objectives. • They must ensure that all reports are submitted on time and that they are of a satisfactory standard that clearly details progress on the project. 	<p>Focus on research leadership, project delivery and research management</p>

Table 2: Ivy League Descriptions of Principal Investigators

Funding Agency	Key elements of PI description	Description Emphasis
<p>University of Pennsylvania^x</p>	<ul style="list-style-type: none"> • is an individual designated by the University and approved by the sponsor to direct a project funded by an external sponsor. • S/he is responsible and accountable to the University and sponsor for the proper programmatic, scientific, or technical conduct of the project and its financial management 	<p>An individual with total responsibility for all aspects of project delivery.</p> <p>Internal Management Focus</p>
<p>Dartmouth University^x</p>	<ul style="list-style-type: none"> • has primary responsibility for achieving the technical success of the project, while also complying with the financial and administrative policies and regulations associated with the award. • Although Principal Investigator's may have administrative staff to assist them with the management of project funds, the ultimate responsibility for the management of the sponsored research award rests with the Principal Investigator 	<p>An individual with total responsibility for all aspects of project delivery irrespective of the administrative support</p> <p>Internal management focus</p>
<p>Columbia University^{xi}</p>	<ul style="list-style-type: none"> • The full administrative, fiscal and scientific responsibility for the management of a sponsored project resides with the Principal Investigator named in the award 	<p>An individual with total responsibility for all aspects of project delivery.</p> <p>Internal management focus</p>
<p>Brown University^{xii}</p>	<ul style="list-style-type: none"> • the individual responsible for all scientific or technical aspects of the project and for the overall day-to-day management of the project or program. • This person may be 	<p>An individual member of the institutional community with total responsibility for all aspects of project delivery.</p> <p>Internal management focus</p>

	any member of the Brown faculty, or, with special permission and the signature of the senior officer for their division, a graduate student, medical student, or an exempt staff member	
Cornell University ^{xiii}	<ul style="list-style-type: none"> • is the individual responsible for the conduct of the project. • This responsibility includes the intellectual conduct of the project, fiscal accountability, administrative aspects, and the project's adherence to relevant policies and regulations. • A project may have multiple individuals as PIs who share the authority and responsibility for leading and directing the project, intellectually and logistically 	<p>An individual or number of individuals with total responsibility for all aspects of project delivery. .</p> <p>Internal management focus</p>
Princeton University ^{xiv}	<ul style="list-style-type: none"> • is an individual judged by the University to have the appropriate level of authority, expertise, and responsibility to direct a research project or program supported by a grant. • There also may be multiple individuals serving as co-PIs who share the authority and responsibility for leading and directing the project, intellectually and logistically. • Each PI/co-PI is responsible and accountable to the University for the proper conduct of the project or program. PIs 	<p>An individual or a number of individuals <u>all</u> with total responsibility for all aspects of project delivery.</p> <p>Internal management focus</p>

	<p>are responsible for mentoring students involved in the project. They are also responsible for fulfilling the programmatic, management, and other requirements of the sponsoring organization</p>	
<p>Harvard University^{xv}</p>	<ul style="list-style-type: none"> • is the project director of a research grant or contract responsible for seeing that the work is carried out according to the terms, conditions, and policies of both the sponsor and the university. • The Principal Investigator is solely responsible for the intellectual integrity of the work. Normally, a Principal Investigator must hold a full-time academic ladder appointment 	<p>An individual with total responsibility for all aspects of project delivery. Normally full time academic</p> <p>Internal management focus</p>
<p>Yale University^{xvi}</p>	<ul style="list-style-type: none"> • is designated by the University and approved by the sponsor to direct a project funded by an external sponsor. • S/he is directly responsible and accountable to the University and sponsor for the proper programmatic, scientific or technical conduct of the project, and its financial and day-to-day management. • The Principal Investigator is a critical member of the sponsored project team responsible for ensuring compliance with the financial and administrative aspects of the award. • The Principal 	<p>An individual <u>approved by the university</u> with total responsibility for all aspects of project delivery. Clear expectations set in terms of accountability, co-ordination and accountability.</p> <p>Internal management focus</p> <p>External engagement focus</p>

	<p>Investigator works closely with appropriate administrators within the University to create and maintain necessary documentation, including both technical and administrative reports; prepare budget justifications; appropriately acknowledge external support of research findings in publications, announcements, news programs, and other media; and ensure compliance with other Federal and organizational requirements.</p> <ul style="list-style-type: none">• It is expected that the Principal Investigator will maintain contact with the appropriate sponsor representative with respect to the scientific aspects of the project and the business and administrative aspects of the award	
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Table 3 PI Interviews Overviews

Principal Investigator Details				Project Details		
Gender	Title	Institution	Area of Research	Focus	Partners	Nature
Male	Research and Training Coordinator, Dr.	University	Marine Science	National	6	Applied
Female	Research Development Officer, MBA	State Research Body	Marine Science	National	9	Applied
Male	Research Leaders, Dr.	Research Centre	Food Science	National	2	Basic
Male	Research Leader, Dr.	Research Centre	Food Science	National	3	Basic
Female	Head of Food Safety Research, Dr	Research Centre	Food Science	National	6	Basic
Female	Research Leader, Dr.	Research Centre	Food Science	International	9	Basic
Male	Professor	University	Food Science	International	12	Basic
Male	Research Unit Leader, Dr.	University	Web Science and Technology	National	2	Applied
Male	Professor	University	Computer Science	International	2	Applied
Male	Research leader, Dr.	University	ICT	International	10	Applied
Male	Research Unit Leader, Dr.	Institute of Technology	ICT	International	10	Applied
Male	Executive Director	Institute of Technology	ICT	National	2	Applied
Male	Executive Research Director, Dr.	Institute of Technology	ICT	International	5	Applied
Male	Professor	Institute of Technology	ICT	National	2	Applied
Male	Deputy Research Director, Prof.	University	Physics	International	3	Applied
Female	Senior Researcher, Dr	University	Physics	National	3	Applied
Male	Senior Researcher, Dr.	University	Physics	National	2	Basic
Male	Professor	University	Physics	National	2	Basic
Male	Professor	University	Physics	National	2	Basic
Male	Research Centre Director, Prof	University	Chemistry	International	11	Basic
Male	Research Leader, Dr.	University	Chemistry	International	7	Applied
Male	Lecturer, Dr.	University	Chemistry	National	2	Applied
Male	Professor	University	Geological Sciences	International	9	Basic
Male	Professor	University	Biotechnology	International	3	Basic
Female	Professor	University	Biotechnology	International	4	Applied
Male	Lecturer, Executive Research Director, Dr.	University	Engineering	National	2	Applied
Male	Professor	Institute of Technology	Engineering	National	3	Applied
Female	Senior Researcher, Dr.	University	Engineering	International	5	Applied
Male	Executive Research Director, Dr.	University	Engineering	International	2	Basic
Male	Research Unit Leader, Dr.	Institute of Technology	Engineering	National	2	Applied

Table 4: Significant Inhibiting Factors and Tensions Experienced by Publicly Funded Principal Investigators

Inhibiting Factor	Tension	Level of PI Interest	Level of PI Control
Political and Environmental			
Technology Transfer (1) Direction and focus (2) Competing Stakeholder Interests (3) IP Valuation	'Entrepreneurial' activities versus academic outputs.	High	Low
Poor Support Reliability of Public Funding Agencies	Balancing existing workloads versus apply for new funding opportunities	High	Medium
Engagement Variation and Interest Publicly Funded Research Agencies	Formal paper based contact versus active support and scientific interrogation and analysis	High	Low
Institutional Inhibitors			
Technology Transfer Support	IP protection versus IP Exploitation	High	Low
Dedicated Support for the PI	Generic skills versus tailored leadership support	High	Low
Human Capital Support	Project sustainability versus continual loss of talents and experiences	High	Low
Project Level Inhibitors			
Administration	Research Management versus Research Leadership (Driven versus Driving)	High	Low to Medium
Training and Support	Formal Learning versus Self Learning	High	Low
Power of Industry Partners	Timeline and Project Objectives Mismatch	High	Low

ⁱ <http://www.nsf.gov/pubs/2002/nsf02151/gpm2.jsp#210>

ⁱⁱ enhancing-peer-review.nih.gov/.../Tab_6b-Applicant_Survey_Version_B.pdf

ⁱⁱⁱ www.hq.nasa.gov/office/procurement/nraguidebook/proposer2010.doc

^{iv} Provided by EUROPE DIRECT Contact Centre/ Research Enquiry Service

^v www.ema.europa.eu/docs/en_GB/document.../10/WC500097905.pdf

^{vi} Provided by ESRC RTD Enquiries Service

^{vii} <http://www.sfi.ie/funding/grant-policies/sfi-investigator-titles/>

^{viii} www.epa.ie/.../research/researchtcandguides/cgpp4%20guide%20for%20grantees.pdf

^{ix} www.upenn.edu/researchservices/faq.html

^x <http://www.dartmouth.edu/~osp/resources/manual/post-award/pirole.html>

^{xi} www.columbia.edu/cu/compliance/pdfs/PI_Quick_Guide.pdf

^{xii} research.brown.edu/pdf/PSAF_Guide.pdf

^{xiii} www.research.cornell.edu/VPR/Policies/PI-policy.html

^{xiv} www.princeton.edu/.../PI%20Request%20for%20Website%20-%20Final.pdf

^{xv} http://www.gsd.harvard.edu/academic/faculty_resources/faculty_handbook/chapter_three.htm

^{xvi} www.yale.edu/ppdev/policy/1310/1310.pdf