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At the Frontiers of Scientific Advancement: The Factors that Influence Scientists to Become or Choose to Become Publicly Funded Principal Investigators

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ABSTRACT

This paper aims to unearth the factors that influence scientists in becoming and choosing to become publicly funded principal investigators (PIs). PIs are the linchpins of knowledge transformation and bridging triple helix actors, particularly academia-industry. At a micro level, PIs are at the nexus of engaging and interacting with other triple helix actors. No study to date has specifically focused on the factors that influence scientists to become or choose to become publicly funded PIs. For scientists taking on the role of a PI represents an important landmark in their research career. Set in an Irish research system we found two main categories of influencing factors - push and pull. Pull factors are where the PI has more choice in choosing to become a PI, where as push factors is where the PI has less choice in choosing to become a PI. Pull factors we identified were *control, career ambition and advancement, personal drive and ambition.* Pull factors we identified were *project dependencies and institutional pressures*.

Key Words: Scientists; Principal investigators; Careers; Push Factors; Pull Factors; Motivations; Triple Helix;

Classification Codes

INTRODUCTION

The triple helix has been developed as an analysis of university-industry-government relationships at the meso level. Different industries have followed different patterns, from close relationship in engineering to the ideation of start-ups in biotechnologies during the 90's. Triple Helix covers a wide range of university-industry relationship media, from license selling to joint research projects (Mangematin and Nesta, 1999). This paper focuses on one of the media of these relationships i.e. publicly funded projects. It specifically focuses on principal investigators (PIs), the scientists who are designing projects and in which public funding agencies are investing to develop innovation and collaborative research. Publicly funded research allows for the increase in skills, tacit knowledge and the development and expansion of networks of actors including PIs within a national innovation system (Rosenburg, 1990 and Patel and Pavitt, 1994). 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). Consequently this builds capabilities within national innovation systems and among the scientific community. Publicly funded research can 'have an impact on increasing work with industry'(Bozeman and Gaughan, 2007) less so than private industry funding and encourage private R&D investments particularly in higher technology industries (Bonte, 2004) and on academic research (Joly and Mangematin 1996)

Scientists that take on the role of publicly funded principal investigators are the linchpin of knowledge transformation through articulation of research programmes, the shaping of research avenues and the bridging of academia and industry (Mangematin *et al*, 2014). PIs are key actors to better articulate industry-university relationship. The limited studies on PIs to date have focused on institutional choice (Kidwell, 2014), strategic behaviours (O'Kane *et al*, 2013), PI practices (Casati and Genet, 2014), knowledge brokerage (Kidwell, 2013), managerial challenges (Cunningham, et *al*, 2014) and inhibiting factors (Cuningham *et al*, 2014). More general studies of the motivations of scientists have been concerned with such issues as financial motives (see Argyres and Liebeskind, 1998) contribution to society (Sauermann *et al*, 2010) and peer recognition (Mansfield, 1995).

PIs at the microfoundation level are at the nexus of interactions between triple helix actors. PIs influence and drive prioritised public research programmes through the development and implementation of their research programmes. In doing this PIs at a micro level are engaging with multiple triple helix actors and are realising top down triple helix policy objectives and ambitions for different industry and research domains that have economic and societial impacts.

To better manage the industry-university interaction, it is necessary to better understand the factors that influence scientists in becoming or choosing to become a

PI. Most of studies of the triple helix have been focused at the organisational or industry or institutional levels. There is a need to study the micro levels of the triple helix. Our study addresses this need by studying the influencing factors for scientists to become PIs at mirco and individual levels as well as advancing our understanding of the formation of the triple helix interactions.

Set in the Irish research system we found two main categories of influencing factors push and pull among PIs in science, engineering and technology. Our paper contributes to the limited but growing literature on PIs in several ways. At a micro level we identify two categories of factors that influence scientists in becoming or choosing to become a PI. This is of fundamental importance in advancing our understanding of triple helix actor engagements and activities at a micro level as the predominate focus to date has been at macro or meso levels. We advance the microfoundation perspective of the triple helix (see Barney and Felin, 2013) by identifying the influencing factors that underpin illumination capability development at the individual level – that of the PI. Moreover, our findings show that pull factors are more evident among PIs with higher career status in choosing to become a principal investigator, while push factors are more prevalent among PIs that low to mid-career status.

The paper is structured as follows. Section 2 discusses the conceptual background and our main research question. Section 3 provides a description of our study design, data collection and analysis. Section 4 present results and Section 5 concludes.

2. Background literature

2.1 Microfoundations and the Triple Helix

The triple helix approach attempts to understand the relationship and interaction between universities/public research organisations (PROs), industry and government (Godin, 2006; Leydesdorff, 2000). The dynamic interactions between these actors represent the true nature of innovation systems (Piekarski and Torkomian, 2005). Previous research on the triple helix has taken macro level perspectives, however little research has been undertaken taking a micro level perspective. Within the strategic management and organization theory a new debate and strand of research is emerging that is focusing on microfoundations. Drawing on these emerging debates, microfoundations research is concerned with such issues as the additive aggregation and independence of individuals, capability development, joint production motivation and value creation (Barney and Felin 2013; Foss and Lindenderg, 2013; Winters, 2013). In particular Foss and Lindenerg (2013) using goal theory argue that in joint production motivation each individual has different roles to play in achieving objectives through sharing of activities and cognition which 'leads them to exert intelligent and adaptive efforts that result in productivity gains and innovativeness.' and 'the heart of value creation in firms lies in the motivation for joint production for all involved.' In the triple helix context different actors such as PIs, universities industry and governments actors play a differ role in joint production motivations. The PI is a heart of value creation through development of knowledge that can be appropriated and utilized by other triple helix actors. This PI driven value creation can result in a number of scientific, economic and societal impacts and gains that contribute to a joint production motivation of the triple helix.

The development of capabilities has been another focus of microfoundations debate. In discussing what are microfoundations Barney and Felin (2013) address some half truths about microfoundations and suggest that future research directions school address capability development specifically ‘how capabilities are built, how the matching of individuals with organisations occurs, the role of specific actors in building capabilities.’ Moreover, Winters (2013) argues ‘that the microfoundation aspect has to do with the treatment of individual actors in the context of organizational routines and capabilities, especially issues of motivation and legacy.’ From a triple helix microfoundation perspective understanding the factors that influence why scientists choose to become PIs can better help us understand the basis of capability and capacity develop at the micro level.

2.2 Publicly Funded Research Characteristics and Benefits

The role of government in the triple helix of setting policy and providing public funding contributes to shaping the macro environment but also the micro environment that PI experience in third level and public research environments. Consequently publicly funded research characteristics and resultant benefits also influences and shapes macro and mirco levels. It influences the decision scientists make in relation to scientific advancement. The characteristics of publicly funded research is that it is owned and financed by governments (Perry and Rainey, 1988), responsive to interest groups (Quinn, 1980), transparency of objectives and content (Rainey *et al.*, 1976; Ring and Perry, 1985), resource utilisation efficiency (Whorton and Worthley, 1981) and there are differing pricing methods and performance evaluation (Banfield, 1975), as well as having positive impacts on the culture of organisations (Whorton and Worthley, 1981). Characteristics of publicly funded research varies across nations and stakeholders within national innovation systems (Malo, 2009) as publicly funded research schemes have different national priorities designed to support national scientific, economic and social priorities. 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 it allows for the increase in skills, tacit knowledge and the development and expansion of networks of actors within a national innovation system (Rosenburg, 1990). For publicly funded PIs this means they can grow and develop their research teams, skills and networks as well as advancing scientific knowledge.

Much empirical work has focused on the broad benefits of publicly funded research. 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 instruments 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). Public funded research can ‘have an impact on increasing work with industry.’(Bozeman and Gaughan, 2007) less so than private industry funding and encourage private R&D investments particularly in higher technology industries (Bonte, 2004). Moreover it 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.' Public funding also reinforces academic publications and networks, funds relevant topics and provides opportunities to learn new capabilities for PhDs (Mangematin, 2000). These benefits have a direct and indirect impact on publicly funded PIs.

Higher education institutions (HEI) are central organisations in supporting publicly funded research (Harman, 2010) and accrure organisational benefits from participation. Such funding benefits the HEI through research infrastructure, human capital (researchers, post doctoral and doctoral students) (Gibbons and Johnson, 1974) and interactions with industry and other societal stakeholders. Public funding supports individual HEIs in realising their research ambitions and outputs and in achieving their third mission activities particularly use of patents, licensing revenue and spin-offs (see for e.g. Feller, 1997; Pries and Guild, 2007). This enable HEIs as actors in in building capabilities at a microfoundation level to support their scientific community.

Individual academics, departments and research institutes also benefit from publicly funded research. One of the core benefits for academics is the development of new knowledge, methodologies and scientific instruments (Malo, 2009). This can support individual PI capabilities development. Publicly funded research contributes to research productivity by way of peer reviewed publications and this seen as one of the ways industry learns about public research (Arundel et al, 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 expand their networks necessary for knowledge production (Callon, 1994). Research funding including public sources increases the interaction between academic and industry, however depending on the career stage this maybe limited (Bozeman and Gaughan, 2007). Public funding enhances their recognition among peers and increases their personal income through royalty payments from patents or spin outs (Göktepe-Hulten and Mahagaonkar (2010). Fundamentally public funding supports research and the work of professors/chairs to advance new knowledge but also contribute to regional economic growth (see Antonelli et al, 2013).

2.3 Principal Investigator Roles and Definitions

From reviewing definitions of PIs in variety of organizational settings it is evident that the role is a leadership one centred on science and project delivery (see Table 1). One of the dominant selection criteria in becoming a PI is based on scientific excellence. The PI is responsible for delivering the project according to the project plan and adhering to the policies of their institution as well as the terms and conditions of the publicly funded research agencies. Funding agencies such as the National Science Foundation in the United States of American define: 'The Principal Investigator is the individual designated by the grantee, and approved by NSF, who will be responsible for the scientific or technical direction of the project. The term "Principal Investigator" generally is used in research projects, while the term "Project Director" generally is used in science and engineering education and other projects.' The role the PI has a significant administrative responsibility including day to day management, supervise and sometimes mentor research staff conduct, sign off on the project's budgets and financial management, ensure all deliverable and deadlines are met, and submit technical documentation and progress reports. PIs also take on a more general management role whereby they 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.

Table 1: Sample Funding Agencies Descriptions[2]

Funding agency	Key elements of PI description	Description emphasis
National Science Foundation (NSF)[1] - USA	• 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)[2] -USA	• 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)[3] -USA	• 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)[4] – European	• 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
Economic and Social Research Council (ESRC)[6] **European -UK**	• 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 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.	Focus on intellectual leadership, key contact point and all aspects of research project management
Science Foundation Ireland (SFI)[7]	• The lead applicant responsible for the scientific and technical direction of the research programme and the submission of reports to SFI.	Focus on scientific leadership and all aspects of research project management.

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[2] Original Table published in Cunningham, J. O'Kane, C., Mangematin, V. and O'Reilly, P. Managerial Challenges of Principal Investigators forthcoming International Journal of Technology Management

[1]. http://www.nsf.gov/pubs/2002/nsf02151/gpm2.jsp#210

[2]. *enhancing-peer-review.nih.gov/.../Tab_6b-Applicant_Survey_Version_B.pdf*

[3]. *www.hq.nasa.gov/office/procurement/nraguidebook/proposer2010.doc*

[4]. Provided by EUROPE DIRECT Contact Centre/ Research Enquiry Service

[5]. *www.ema.europa.eu/docs/en_GB/document.../10/WC500097905.pdf*

[6]. Provided by ESRC RTD Enquiries Service

[7]. http://www.sfi.ie/funding/grant-policies/sfi-investigator-titles/

[8]. *www.epa.ie/.../research/researchtcandguides/cgpp4%20guide%20for%20grantees.pdf*

European- Ireland	- 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).

For most scientists taking on the role of PI represents an important landmark in their research career, and the roles comes with significant managerial challenge (Cunningham *et al*, 2014). PIs have become central actors in the delivery of basic and applied publicly funded research in HEIs and public research organizations (PROs). When the scientist takes on the PI to role they moderate their role identity from that of scientific researcher to incorporate the other duties involved in being PI (Jain *et al* 2009). PIs are learning by doing, meeting industry needs, providing mentoring and support for their research team and coupling research and industry innovation. 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 and a key agent of economic development and policy as they preside over the investment of significant public monies in prioritized research domains. PIs are now core and critical to the knowledge transformation within the triple helix and have become 'linchpins' as Mangematin *et al,* (2014) argue in shaping of research avenues and the bridging of academia and industry.

Most of studies to date on the triple helix are at the organization, industry or institutional levels. There is a need to investigate micro level to better manage the interaction between triple helix actors. The limited number of empirical studies on PIs to date have in the main taken a micro perspective and found that they are involved in a wide range of practices and activities. Being a PI, Casati and Genet (2014) found they engage in a variety of practices when undertaking their duties. These duties focus on on scientific discipline, innovating and problem solving, sharing new paradigms and brokering science. For PIs being an effective broker between academia and industry supports the realization of their scientific and commercialisation objectives and these brokerage roles involve extrapolating, seeking, aligning and anticipating (Kidwell, 2014).

Studies have shown that scientists have taken on the role PIs for large scale, multi-partner projects experience a range of managerial challenges and inhibiting factors. Cunningham *et al*, (2014) found PIs managerial challenges focus on project management, project adaptability and project network management While the inhibiting factors that PIs experience include political and environmental, institutional and project based (Cunningham *et al*, 2014). Furthermore PIs learn the skills for the PI role primarily on the job (Cunningham *et al*, 2014; Kidwell, 2013).

Effective PIs use different strategic approaches to further their research agenda, exploit market opportunities and extend their influence. Some PIs are highly strategic in selecting an institution to conduct their research activities (Kidwell, 2014). Other PIs leave their institution to set up a new venture to enhance their influence (Baglieri and Lorenzoni, 2014). The strategic behaviours of PIs have been categorized by O'Kane *et al*, (2013) according to strategic posture (proactive or reactive) and levels of funding conformance. O'Kane *et al*, (2013) identified four categories of PIs research designer, research adapter, research supporter, and research pursuer. Research designer are highly purposeful in their research activities and have a clearly focused research trajectory and proactively pursue. Research adaptor PI are reactive and do not over commit to a focused long-term research agenda. Research pursuers are opportunists, very reactive and don't have a broad based research focus. Against this background we now turn our attention on the motivations of scientists.

2.4 Motivations of Scientists and other Considerations

In order to better understand why scientists become, or choose to become a PI for publicly funded research projects we draw on the literature that has focused on motivations of scientists. 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 prioritize discoveries in their work and are immersed in a normative system called the 'ethos of science', 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).

In contrast to this view, it is suggested that motives are being compromised as research scientist's increasingly pursue and become active in publicly funded research collaborations with industry agents in research projects that are more applied and commercial in their nature (Owen-Smith, 2005). With applied research becoming more imperative and scientists' attitude towards commercial involvement evolving from opposition to acquiescence to acceptance (Etzkowitz, 2002), there is a concern that research and science agendas are being influenced by motives of profit and technology development as opposed to solely the advancement of knowledge. The distinction between science and technology is important in this respect. 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). While scientists' motives and their relationships to collaborative, innovative and commercialisation activity may differ across broadly defined fields of life sciences, engineering and physical sciences (Melin, 2000; Sauermann *et al*, 2010), there is a broad view that the key payoff from applied research is the financial income associated with the commercialisation and technology transfer agenda (e.g. Jensen and Thursby, 2001; Thursby, and Thursby, 2007). The 'distraction' by money it is feared could jeopardize the amount of publicly available knowledge emerging from research activities and obscure the boundaries between universities and private firms (Argyres and Liebeskind, 1998; Louis *et al*, 2001).

Despite such views, motives other than those financial continue to be acknowledged as important factors for scientists (Haeussler and Colyvas, 2009; Murray, 2006).

Sauermann *et al*, (2010), for example, argue that financial motives and incentives have no association with the choice between basic and applied research, and have not shifted academics' attention towards applied work and commercialization activities. Previous studies support this that did not find negative relationships between patents and publications (Fabrizio and Minin, 2008; Mowery et al., 2001). The same authors support the view that motives can vary across different fields with, for example, a desire to contribute to society being a key motive predicting patenting in the life sciences; pecuniary motives being a strong predictor of patenting in the physical sciences; and patenting being strongly related to the motives of challenge and advancement in the field of engineering (Sauermann *et al*, 2010). Jain *et al*, (2009) also allude to the fact that a scientist's decision to pursue applied research, technology transfer or entrepreneurial activities can be divided into two perspectives: supply-side and demand-side (Thornton, 1999). The authors point out that the former is exemplified by the manner in which some academics are attitudinally more predisposed to commercialize their findings, or possess prior knowledge that makes them more capable of recognizing entrepreneurial opportunity (Etzkowitz, 1983; 2007; Shane, 2000). The latter can be characterized by changes in academic's institutional framework, research funding pressures, or the influence of their peers and or university/department (Pelz and Andrews, 1976; Etzkowitz, 2002; Kenney and Goe, 2004).

2.4.1 Other Factors

Other factors influencing scientists decisions can include the potential for publications, identification of new ideas and problems, increase in scientific and technological human capital, and a desire for recognition among peers (Mansfield, 1995; Agrawal and Henderson, 2002; Bozeman and Mangematin, 2004; Owen-Smith, 2003; Thursby et al., 2007). The potential for reward under political impact criterion can be a driver for scientists to deliver on technology transfer targets (Bozeman, 2000). For example, the role of the scientist is recognised by policy makers if the research project has a major impact on national or regional socio-economic priority areas. Secondly, appraisals of the research initiative by industry partners, often the technology recipients in a technology transfer process can see the industrial partner pursuing the policy maker, often a key funder of public research, to commend the academic partner for their work and commitment to technology transfer. Thirdly, as is evident by the aggressive pursuit of publicising research projects, partnerships, breakthroughs and technology transfer achievements by research institutions; research projects can be rewarded for the appearance of active and aggressive research and technology transfer success.

Finally it is our contention that there are significant discrepancies between the heightened expectations now associated with the PI role, and the assumed capabilities and formal preparation of scientists for the PI to deliver on publicly funded projects based on the limited research specifically conducted. The microfoundations perspective provides a backdrop to consider more broadly from a micro perspective the factors that influence scientists to become or choose to become a PI. For the triple helix to work effectively it requires effective joint production motivation and at a micro level the PI is at the nexus in being adaptive and innovate in developing and delivering research programme to meet the needs of triple helix actors. Moreover, we further argue by further understanding these factors they will provide us with a better understanding of the antecedent factors that ultimately influence the building of PI capabilities at the micro level.

3 Methodology

3.1 Data collection

To examine our primary research question of what are the factors that influence scientists to become or choose to become publicly funded principal investigators, we focus on the Republic of Ireland's publicly funded science, engineering and technology research environment. Since the 1990 the Irish national and research system has grown and developed significantly (see Cunningham and Golden, 2010) There were two key phases in our data collection. Our first phase involved compiling a dataset of publicly funded research projects and PIs in Ireland's science, engineering and technology sector between 2006 and 2011. We identified a total of 1,096 individual PIs selected publicly funded national and EU research funding programmes. During this phase we identified thirty PIs within this sample for closer examination. We selected these PIs to participate in phase two of our study with a primary selection criteria of that they only multi-annual and collaborative research projects with a funding value over €250,000. To gather a sufficiently holistic view of factors that influence scientists our final sample of thirty PIs were purposefully cross-disciplined, -gendered, -aged, and at different levels in their career. Our final sample included a range of scientific roles and institutional settings. 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; seventeen were completed and thirteen were on-going at the time of our data collection; and, the exact subject areas varied within the broader areas of natural and agricultural sciences, and engineering and technology. Table 2 categorises the PIs included in the sample.

Our second phase of data collection involved face-to-face semi-structured interviews with each PI. Semi-structured interviews were an appropriate instrument due to the depth of inquiry they can generate (Bell, 1987 Yin, 2004). Part of the interview discussions focused on the factors that influenced scientists in our sample to become a PI. The interviews conducted averaged 90 minutes in duration. We also examined documentation relevant to both the CV of the PI and the project in question (e.g., press releases, interim reports, final reports and workshop brochures, publication listings, patent listings, etc.) and this secondary data complemented our data analysis. Thirty interviews, amounting to just over 400 pages in transcripts was deemed an appropriate method, and indeed repetition in the final few interviews suggested a saturation point had been reached. To safeguard confidentiality, all respondents were allocated a unique identifier based on their position/status and the nature of the research they were involved in. For example "P1.T" referred to professor one who was involved in research exploitation (P2.E referred to professor two who was involved in explorative research).