Northumbria Research Link

Pre Print Version

Publicly Funded Principal Investigators Allocation of Time for Public Sector Entrepreneurship Activities

Professor James A. Cunningham, Newcastle Business School, Northumbria University, United Kingdom

Paul O'Reilly, College of Business, Dublin Institute of Technology, Dublin, Ireland

Brendan Dolan, Centre for Research Medical Devices, National University of Ireland Galway, Ireland

Dr. Conor O'Kane, Department of Management, University of Otago, New Zealand

and

Professor Vincent Mangematin, Grenoble Ecole De Management, Grenoble, France

Final version of the paper is available at
http://link.springer.com/article/10.1007/s40812-016-0054-5

Please cite as James A Cunningham, Paul, O'Reilly, Brendan Dolan, Conor O'Kane and Vincent Mangematin (2016) Publicly Funded Principal Investigators Allocation of Time for Public Sector Activities, *Economia e Politica Industriale*, 46(4): 383-408.

DOI: 10.1007/s40812-016-0054-5

Abstract

In this paper we explore the allocation of time of publicly funded principal investigators (PIs) for public sector entrepreneurship activities. We examine their allocation of time in general to research activities and specifically at a project level in relation to the type of research, knowledge transfer activity, project impact, deliberate technology transfer strategy and boundary spanning activities using data from a full population survey of publicly funded PIs in Ireland in science, engineering and technology across national and European research programmes. We find that PIs who spend more time on general research related activities allocated a higher proportion of time to technology transfer activities and that PIs who spend more time on technology activities engaged more in end of project reports and collaborative research with industry. In relation to the importance placed on impact criteria, PIs who spend more time on research placed more importance on technology and market impacts than those spending less time on research related activities. Furthermore, PIs who spend more time on technology transfer placed greater value on technology transfer, market and economic impact. We find projects of PIs spending more time on research related activities had a greater impact on technology transfer and a greater market impact, according to the assessment of respondents, than the projects of PIs spending less time on research activities. Finally, with respect to boundary spanning activities we find PIs spending more time on research engaged more in direct consultation with industry end-users and direct consultation with their technology transfer office at the pre-proposal stage of their selected project and they had significantly larger than average amount of industry partners. We conclude our analysis by considering the implications for public sector entrepreneurship.

Keywords: Public Sector Entrepreneurship; Principal Investigators; Time; Technology Transfer; Impact; Ireland; Economic Impact; Societal Impact; Boundary Spanning

Acknowledgements: The authors wish to thanks all who participated in this study, the reviewers and acknowledge the funding support of the Irish Research Council. James A Cunningham wishes to acknowledge the funding support from the Irish Social Science Platform administered by the Higher Education Authority (HEA), Programme for Research in Third Level Institutions Cycle 4 and co-funded by the European Regional Development Fund (ERDF). James A Cunningham and Brendan Dolan acknowledge the funding support of Science Foundation Ireland (SFI) and co-funded under the European Regional Development Fund under Grant Number 13/RC/2073.

1. Introduction

Public sector entrepreneurship through the implementation of specific programs can support the generation of economic growth and can be transformational in nature (Leyden, 2016). Leyden and Link (2015:14) define public sector entrepreneurship as: 'Innovative public policy initiatives that generate greater economic prosperity by transforming a status-quo economic environment into one that is more conducive to economic units in creative activities in the face of uncertainty.' The affect of public sector entrepreneurship is the creation new knowledge networks, advancement science and knowledge as well as mobilizing different actors that will result more innovation (Audretsch and Link, 2016:1). Taking a lead from Klein et al (2010), this paper considers that the research project and programme leaders in publicly funded research systems, from here on referred to as principal investigators (PIs), are in effect public agents and nominal stewards of resources owned by the public. Entrepreneurship in this public context is enacted principally through envisioning future scientific trajectories and research commercialization. Publicly funded PIs are key transformative actors in the shaping and implementing of public sector entrepreneurship, through their scientific endeavors and the exploitation of these through technology transfer mechanisms (Cunningham et al. 2016). Such activities have an array of impacts such as market, economic and societal impacts. PIs are boundary spanners and engage with a wide variety of actors such industry, policy makers, technology transfer specialists, technology transfer offices etc. PIs are beneficiaries of public sector entrepreneurship programmes through the allocation of public resources on a competitive basis to purse research activities that will advance knowledge and now increasing that will have an impact beyond academia. Traditionally, public research provides some autonomy for PIs as is it seen as the 'freest form of support' (Chubin and Hackett, 1990). However, being a publicly funded PI places additional responsibilities on scientists and they have to deal with additional managerial challenges and complexities (Cunningham et al. 2015). The university environment that enables PIs to deliver on publicly funded research programme also matters. Previous studies highlight the importance of high quality research and its benefits to entrepreneurship and start-ups (see Colombo et al. 2010; Di Gregorio and Shane, 2003). The changing university environment in which PIs work is typified now as increasingly dynamic, managerialist and commercialized (Deem and Brehony, 2005; Fitzgerald and Cunningham, 2015; Kok et al. 2010; Kolsaker, 2008). For universities there is a brain drain concern that academic effort and time is being utilized for activities such as entrepreneurship that diverts them away from knowledge development (see Toole and Czarnitzki 2010). The allocation of time of PIs matters to universities, the implementation of public entrepreneurship programmes and on knowledge production.

Set against this context our paper focuses on how publicly funded PIs allocate their time when they are beneficiaries of public sector entrepreneurship through public funded programs nationally and internationally. We examine their allocation of time in general to research activities and specifically at a project level in relation to the type of research, knowledge transfer activity, project impact, deliberate technology transfer strategy and boundary spanning activities. Our project level focus on the allocation of time is unique and this has not been done before in other studies of time within the academy. Our paper is structured as follows. We begin by focusing on the multiple roles of PIs, PI responsibility and the allocation of time. In Section 3 we outline our research methodology and then present our key findings in Section 4. We conclude our paper with some concluding remarks.

2. Background Literature

2.1 PIs Multiple Roles and Boundary Spanning

Contributing to scientific advancement, autonomy, prioritisation of new knowledge as well as status are key motivating factors for scientists (Cunningham et al. 2016b; Erez and Shenerson 1980; Merton, 1968). For a scientist to be a publicly funded PI is a significant career move and this adds prestige and status. Where they exist, definitions of PIs tend to be set by funding agencies and universities, and as a consequence such definitions typically emphasise project management, project technical direction, administration, and fiduciary responsibilities. Cunningham et al. (2014) define publicly funded PIs as: 'scientists who orchestrate new research projects, combine resources and competencies, deepen existing scientific trajectories or shape new areas.' As research systems have evolved, PI roles and responsibilities have expanded beyond traditional scientific and project administration avenues. Boehm and Hogan (2014) describe the PI as 'a jack of all trades' who must take on a multitude of roles: 'project manager, negotiator, resource acquirer, as well as the traditional academic roles of Ph.D.

supervision and mentoring.' Similarly, based on a study thirty PIs Cunningham et al. (2014) identified a range of roles including: scientist, research strategist, project manager, team leader, knowledge broker, administrator, stakeholder manager, project promoter, resource manager, supervisor and mentor. Publicly funded PIs are now the linchpin for scientific transformation, shaping new research avenues, and bridging academia and industry (Mangematin et al. 2014) and are 'transformative agents of public sector entrepreneurship programmes' (Cunningham et al, 2016). To varying degrees PIs seek to deepen scientific trajectories and shape new areas (Casati and Genet, 2014).

Large-scale funding programmes now require publicly funded PIs to provide the bridge and become a broker between scientific research and industry. They act as boundary spanners across and amongst academic disciplines, industry and policy makers (Mangematin et al. 2014). Undertaking boundary spanning activities positions PIs at the nucleus of public sector entrepreneurship and provides them with insights into various stakeholders needs as well as having a clearer understanding of market needs. PIs also act as knowledge brokers, creating value by bridging structural holes and building trust between the lab and industry through four distinct PI roles – extrapolation, seeking, aligning and anticipating (see Kidwell, 2013). PIs mobilize resources to enact their research agendas and make critical strategic choices to effectively facilitate achievement of their scientific vision. (Kidwell 2014). In making these strategic choices PI adopt strategic behaviours that adopt a strategic posture that is proactive or reactive (O'Kane et al. 2015).

2.3 PI Responsibilities

The growing studies of PIs have identified that the responsibilities of PIs have expanded beyond undertaking pure scientific activities (see Cunningham et al. 2016b; Menter, 2016). PIs are responsible for all aspects of publicly funded projects that they lead. They manage the research programme, budgets, people, liaise with internal university functions such as finance, human resources and technology transfer as well collaborating with other academic, industry and policy partners in delivery of these projects. Periodically, they are required to formally report to their funding agency with updates in relation to project progress against project objectives. Cunningham et al. (2016: 71) outline these responsibilities in the context of public sector entrepreneurship as: 'The reality for publicly funded PI is they are expected to be the implementation agents of public sector entrepreneurship policies, programs and initiatives. This involves overseeing the day-to-day management of a research project or research program, supervising and mentoring researchers, conducting and signing-off on the research project financial arrangements, ensuring all deliverables and deadlines are met, and submitting technical documentation and progress reports to both funding agency and their own institution.' This increases the time PIs can spend on research administration and has implications in relation how their existing workload is allocated post becoming a publicly funded PI. Managing these responsibilities effectively places increasing levels of research bureaucracy and research management on PIs and pushes them to be more operationally focused (Cunningham et al. 2014; Cunningham et al. 2016). Moreover, there is a growing expectation that scientists fulfill PI responsibilities and associated commercialization related to funded projects and to more broadly related to their discipline, department and faculty (Perkmann et al. 2013).

2.3 PIs, Entrepreneurs and the Allocation of Time

Numerous studies have been undertaken on the allocation of time in relation to organisational contexts (such as firms, homes etc), activities and individuals (see Ejrnaes and Pörtner 2004; Ghez and Becker, 1975; Juster and Stafford, 1991; Levison and Kumar 1995; Wolf and Soldo, 1994). Cooper et al (1998) identify time as a critical resource for entrepreneurs and as such should be related to organizational performance. In this context they note that if entrepreneurs devote insufficient time to critical decisions and activities, their ventures may suffer or fail. Bird (1988: 449) observed that entrepreneurs want to be "where the action is, in contrast to managers "with a bias for action, who encourage others to do it. A number of studies have looked at how entrepreneurs spend their time. McCarthy et al (1990) concluded that the time allocation behaviours of entrepreneurs changes as the enterprise moves through different stages of development, suggesting that time-allocation patterns vary with organisation settings. Stayton and Mangematin (2016) in a study of international technology start-ups highlighted how time was critical and that entrepreneurs need to compress product and organisation launch timelines. Van de Ven et al (1984) observed that less successful entrepreneurs tended to spend more time on external matters such as customers and networks in comparison to time allocated to internal activities.

Barham et al (2014) observe that time for research is a crucial determinant of academic productivity.

However, to date there has been relatively limited consideration with regards to how academic researchers, and more specifically research leaders or PIs, allocate their time, as Harman (2001) observes: 'Little is known how academics in different universities actually make decision about the allocation of time.' This is somewhat surprising given that researcher time, and in particular the time of PIs, is a critical innovation system resource. Faculty allocation of time and the associated work pressures has been the focus of some limited empirical research (see Fairweather, 1993; Finkelstein, 2014; Plonsky et al. 2003; Massy and Zemsky, 1994; Nieuwoudt et al. 2006). In terms of work pressures, Bozeman and Boardman (2013) describe the rapidly changing expectations of researchers and their increasingly complex roles as faculty, especially in their evolving relationship with business and industry. There are numerous studies that explore the faculty time allocation across research, teaching and service roles (Link et al, 2008; Link and Segal, 2005; Singell et al, 1996). For example, Milem et al (2000) in their study found that faculty spend an increasing amount of their time engaging with research relative to other activities such as teaching, while Link et al. (2008) found differences in the allocation of time based on tenure, as well as finding some gender differences. Houston et al (2006) noted the intensification of academic workload for faculty, the increasing expectations and accountability, as well academics working considerably in excess of full-time. Toutkoushian and Bellas (1999) in their faculty study found variations in time allocation with respect to gender, family and ethnicity. Competing demands places time pressures on individuals in relation to what activities to prioritize (Seshadri and Shapira (2001). Libaers (2012) analyzed how time allocation decisions of scientists in US universities and how this impacted on their likelihood to engage in technology commercialization, finding complementary and substituting effects between certain types of research and time spent on teaching and their impact on being involved in research commercialization.

Less attention has been paid to how researchers allocate their research time – pre-project, research and post project activities. Rockwell (2009) reports on the results of a survey of US scientists that identified the scientists spend 42% of their time pre-grant and post-grant activities. Other research measures research time allocation to administration activities by biotechnology scientists to be in the 30-40% range (Rabinow, 1997; Kenney, 1986). Longitudinal research by Barham et al (2014) analyses the evolution of the research-administration time balance in Tier 1 US universities from 1975 to 2005. This research shows a 20% decline in time spent on research and a doubling of time spent on administration. These findings point to the importance of greater scrutiny of how faculty distribute their research time rather than how faculty distribute their time across research, teaching and service responsibilities.

Porter and Umbach (2001) report that how faculty allocate their time is an issue of growing importance for university administrators, and that university administrators increasing seek to influence and impact on how faculty allocate their time. The complex challenges of university administrators to control allocation of time spent by university faculty members on their various work activities has been documented (Hull 2006; Paewai et al. 2007). Anderson and Slade (2016) found that pressure from university management increased the likelihood of faculty allocating more time to the pursuit of grants, including what they describe as uninteresting grants that contribute to decreases in work satisfaction.

Auranen and Nieminen (2010) suggest that the shift in research funding from institutional-based to competitive grant based system has impacted adversely on faculty research time. Coupled with reductions in administrative support (Brown et al, 2010) and increased coordination requirements stemming from multidisciplinary and multi-partner research collaborations, it is safe to conclude that research leaders have become more time poor. The additional roles, responsibilities and the managerial and leadership dimensions of the PI position and now increasingly the commercialization nature of the publicly funded PI role and associated responsibilities intensifies the prioritization of allocated time to critical in ensuring that public sector entrepreneurship program outcomes are attained or exceeded. These pressures run counter to the traditional understanding that public research in theory provides scientists with more autonomy and freedom. Trade-offs between different types of faculty work activities have received little attention (Link and Siegel 2005). To date no study has investigated how do funded PIs actually allocate their time for publicly funded projects as part of public sector entrepreneurship program activities. This is warrants investigation given the significant investments that governments are making in funding public sector entrepreneurship programs.

The literature is clear that time is an essential resources for universities and indeed public research systems. Within this our interests lie in how time impacts on decisions made by PIs. Time is considered in two ways. As considered in a range of studies as discussed, academic workload models distribute faculty time across the different activities of the university – teaching, research and service. Our study is interested in time allocated to publicly funded research and how this impacts on the public sector entrepreneurship engagement of PIs. We look at time in terms of both the amount of time a PI can allocate to research from their overall workload model as well as how the allocate this time to the different stages of research (pre-project, research, dissemination, and technology transfer). Our survey seeks to examine the impact of time allocation on a range of public sector entrepreneurship engagements. How does this PI time allocation impact on their propensity to engage in different knowledge transfer activities? How does it impact on where PIs position themselves on the research continuum – from basic to experiential? How does PI time allocation impact on how PIs evaluate the effectiveness of their research programs?

3 Methodology

The data analyzed in this study is taken from a survey of the full population of publicly funded PI in Ireland in science, engineering and technology. For the purposes of developing a survey database PIs were nominated as the individual lead researcher for projects funded by public national and European research programs in higher education institutional and public research organizations. Publicly funded research programs and schemes included in the survey were administered by public agencies in Ireland including Science Foundation Ireland, Enterprise Ireland, Health Research Board, Program for Research in Third-Level Institutions, Food Institution Research Measure, SafeFood, and the Environmental Protection Agency, as well as in European Framework Program 6 and 7. The survey had a project focus and addressed PI activities and practices as they designed, led and managed publicly funded research projects. Areas of activity surveyed included project design, project management, collaboration strategies, stakeholder management, and technology transfer activities.

While a significant number of researchers in the database were identified as a PI on more than one publicly funded research project, the database identified 1,391 individual PIs. Respondents were contacted by email and requested to fill out an online survey, using Survey Monkey. After three rounds of the survey distribution, a total of 441 valid responses were received, generating a response rate of 31.7%. The response group comprised 334 males (75.5%) and 107 females (24.3%), and the average age of respondents was 44 (SD = 8.5). The average period since the respondent first became a PI was 15 years. PIs were also asked whether and for how long they had been employed in a commercial orgnization at some point in their scientific career, with 32.2% (N=142) of respondents responding that they had previously worked in a commercial organization for an average length of time of 4.6 years.

4. Descriptive Statistics and Empirical Findings

Our analysis with respect to the allocation of time firstly focuses on the time attributed by PIs to research related activities in general before we then report project level time allocation with respect to type of research, knowledge transfer activity, project impact, deliberate technology transfer strategy and boundary spanning activities.

4.1 Time Spent by PIs on Research-Related Activities

PIs were asked to breakdown the percentage of time they spent engaged in research related activities.[1] Time allocated to administration specifically was not requested as we took the position that administration is a component of each of the research stages and it was these stages that were principally interested in. On average, of the time PIs engaged in research almost 50% of this time was on actual research, with 19% on pre-project activity, 22% on dissemination activities, and 8% on technology transfer.

PI respondents were also asked what percentage of their total work time they spent on research-related activities. PIs were divided into two groups based on whether they spent 50% or more of their time on research-related activities, or less. 39.7% (n=175) of PI respondents spent less than or equal to the average percentage of time (19%) on pre-project activities compared to 50.6% (n=175). 39.2% (n=173) of PI respondents spent less than the average percentage breakdown of time (48%) on research

[1] [1] Pre-project activity (e.g. proposal development, relationship organization); Research (e.g. project tasks, supervision of researchers); Dissemination (e.g. paper/report preparation, conferencing, seminars); and Technology transfer (e.g. patent preparation, spin-off activities, consulting & technical services).

compared to 50.8% (n=224). 52.4% (n=231) of PI respondents devoted less than the average percentage of time (22%) on dissemination activities compared to 37.4% (n=165) and 47.8% spent less than or equal to the average amount of time (8%) on technology transfer activities compared to 37.2% (n=164). These dependent variables based on time spent on research-related activities were analysed to examine the entrepreneurial actions of PIs in relation to time (see Table 1).

- Insert Table 1 about here -

We found that PI respondents who spent more than half their time on research related activities devoted a higher percentage of this time to technology transfer activities (9% compared to 6%). A key factor for this, and a concerning finding was that some 37.7% of PI respondents who devoted less than half their overall workload to research indicated that they spent none of their time on technology transfer. Interestingly the researchers with more than half their workload attributed to research spent more time on pre-project activities (21% compared to 18%. This may be attributed to these researchers spending more time on grant applications or attributing more of their research time outside of formal research projects. There was no significant difference between the two groups with regard to percentage of time spent on research and dissemination activities (see Table 2).

- Insert Table 2 about here -

4.2 Type of Research and Time

PIs were asked to indicate the primary type of research involved in their selected publicly funded project[2] (Basic, applied or experiential). The publicly funded projects of respondents spending less time on research activities were more likely to be engaged in basic research than projects of PIs spending more time on research, though not to a significant degree (p=0.411). In terms of availability of total research time impacting on type of research, 64.9% of responding PIs with less than half of their overall faculty workload indicated that their research projects were either applied or experiential compared to 70.3% of respondents from the PIs with more than half of their time allocated to research.

Not surprisingly, the only significant difference between PI respondents spending more or less time on specific activities was in technology transfer; 83% of projects of PIs who spent more than the average amount of time on technology transfer were applied or experiential in nature, compared to 56% for projects of PI spending less time on technology transfer (see Tables 3 and 4).

- Insert Tables 3 and 4 about here -

4.3 Type of Knowledge Transfer Activity and Time

PIs were asked to indicate the most common dissemination and knowledge transfer activity in relation to their selected publicly funded project. In relation to overall time available for research, PIs with more time allocated to research were more likely to engage in knowledge transfer to industry activities (collaborative research with industry, contractual research for industry, consulting services and licensing of intellectual property) than PIs with less time (21.8% compared to 16.2%). PIs with less research time were more likely to invest their knowledge transfer time in academic dissemination (80.7% compared to 75.5%). Overall these differences were not significant.

The only significant effect of time on the most common dissemination and technology transfer activities was in technology transfer. PIs who chose to allocate more time on technology transfer activities engaged more in end of project reports (12.9% compared to 9.9%) and collaborative research with industry (8.8% compared to 4.7%). These PI respondents that spent less time on technology transfer engaged more in peer publication (55.2% compared to 38.1%) and research symposiums and colloquiums (18.2% compared to 15.6%) (see Tables 5 and 6).

---

[2] Basic: Experimental or theoretical work undertaken primarily to acquire new knowledge, without any application or use
Applied: Original investigation undertaken in order to acquire new knowledge, primarily directed towards a specific aim or purpose Experiential: Systematic work, drawing on existing knowledge gained from research and practical experience that is directed to producing new materials, products and devices, to installing new processes, systems and services, or to improving substantially those already produced or installed

- Insert Table 5 and 6 about here -

4.4 Importance Placed on Impact Criteria

Asked to rate the importance of impact criteria for their selected publicly funded project on a 7-point Likert scale, projects of PIs who spent more time on research placed more importance on technology transfer and market impact than those spending less time on research-related activities. The most statistically significant difference was in the importance placed on the technology transfer impact of their project. PIs spending less time than average on dissemination activities placed more importance on technology transfer and market impact for their selected projects. Given a slightly higher propensity for this group of PIs and their projects in the basic research area, this is a little surprising. Less surprising is that those who allocated more time to technology transfer activities placed greater value on technology transfer, market impact and economic impact. Those who spent less than the average amount of time on technology transfer rated scientific publication significantly higher in terms of importance to their publicly funded project. Similarly projects of PIs engaging more in dissemination activities placed more importance on scientific publication (see Tables 7 and 8).

-Insert Tables 7 and 8 about here-

4.5 Impact of Projects in Relation to Impact Criteria

PIs were asked to assess, on a 7-point Likert scale, the amount of impact their project had on various impact criteria. The findings here were as expected and indicated expected returns for time allocations. Projects of PIs spending more time on research-related activities indicated that their projects achieved greater impact on technology transfer and a greater market impact, than the projects of those spending less time on research activities. Projects of PIs spending more time on pre-project activities or technology transfer had a greater market impact, while projects of respondents spending more time on dissemination had significantly less market impact. Projects of PI respondents that engaged more in dissemination activities also had a greater impact on scientific publications. Projects where PIs spent less time on dissemination or more time on technology transfer activities had greater technology transfer and market impacts. Interestingly, and reflecting government and public funding agency priorities, projects of PI respondents spending more time on technology transfer also had a greater political impact, but lower scientific capital and human capital impacts (see Table 9 and 10).

- Insert Tables 9 and 10s about here -

4.6 Deliberate Technology Transfer Strategy

To consider the relationship between PI deliberate technology transfer intentions and time allocated to research, the PIs were asked to rate the relevance of the statement 'the technology transfer strategy was deliberate and highly planned' in the context of their research project on a 7-point Likert scale. PIs spending more of their overall workload on research-related activities rated significantly higher the relevance of this statement to their project organization than those who spent less time on research. PIs that spent more than the average amount of time on dissemination activities rated the statement significantly lower than those spending less time on dissemination (2.77 compared to 3.51). As expected assuming rationale allocation of research time, PIs with a higher level of engagement in technology transfer than average rated this statement higher in describing their project's organization (4.14 compared to 2.54). It should be noted that respondents in general did not rate the relevance of this statement to their project very highly in general (3.22 on a 7-point Likert scale) (See Tables 11 and 12)

- Insert Tables 11 and 12 about here -

4.7 Boundary Spanning Activities

Exploring the boundary spanning activities of PIs in relation to time spent on research, there was a significantly larger number of industry partners, and partners in general, for projects of PIs that spend 50% or more of their total work time on research-related activities, than those who spent less than half their time on research. Those who spent more time on pre-project activity or technology transfer had a significantly larger average number of industry partners, whereas those spending a higher percentage of their time on dissemination activities had a lower average of industry partners (0.62 compared to 1.44). In general projects of PIs that spent less time on dissemination had a higher average number of partners for their publicly funded project (see Table 13 and 14).

- Insert Table 13 and 14 about here -

PIs spending more time on research engaged more in direct consultation with industry end-users and direct consultation with their technology transfer office (on a 7-point Likert scale) at the pre-proposal stage of their selected project. There was a more significant difference between the groups with regard to direct consultation with industry end-users than with the technology transfer office, with PIs spending more than half their time on research related activities engaging more with industry end-users. PIs spending more than the average percentage of time on pre-project activity engaged more their technology transfer office (2.83 compared to 2.40). PI respondents that spent more time on technology transfer activities also engaged more with their technology transfer office (3.52 compared to 2.05) as well as with industry end-users (3.85 compared to 2.42). PIs devoting a larger proportion of their time than average to research or dissemination activities were in engaged less in direct consultation with their technology transfer office (see Tables 15 and 16).

- Insert Tables 15 and 16 about here -

5. Discussion

Our study builds and extends previous empirical studies on allocation of time with the focus of our study on publicly funded PIs and uniquely at the project level. Some interesting issues emerge from our findings. Our study further confirms the increasing pressures and expectation academics face in engaging with business and industry through technology transfer (see Bozeman and Boardman, 2013) and this activity has filtered further into their workload at a project level when participating in publicly funded research programmes as part of public sector entrepreneurship initiatives.

Given the nature of the PI role and the accountability associated with publicly funded research programmes our study quantifies the allocation of time that Houston et al (2006) discuss in their paper. The PI allocation of time is significant in relative terms when you consider the other demands on their time. This then places even greater pressure on PIs on what activities do they actually prioritize for their publicly funding projects and also in relation to other responsibilities they have outside of their funded projects such as teaching and other service activities. Our findings show the additional complexities that university administrators have to deal with when scientists take on the PI over and above other duties and responsibilities (see Hull, 2007 and Paewai et al. 2007). Furthermore, PIs need to allocation sufficient time to publicly funded projects not alone to deliver them as planned but to ensure that their adhere to funding body, institutional and research governance arrangements. While some of this time allocation may be seen as redundant and not important, it is crucial that this activity is recognized by all stakeholders as important and necessary to maintain public trust and confidence in publicly funded science and in public sector entrepreneurship. Moreover, other studies of time allocation found differences in terms of gender, tenure, ethnicity (see Link et al, 2008; Toutkoushian and Bellas (1999) where as our study has found some differences among PIs at the project level in the allocation of time for technology transfer activities and their engagement with industry end users. Interestingly, PIs who spend more time on research engaged more in direct consultation with industry end-users and direct consultation with their technology transfer office at the pre-proposal stage of their selected project and they had significantly larger than average amount of industry partners.

The brain drain, the diversion of time and effort away from knowledge development that Toole and Czarnitzki (2010) highlighted is not as evident in our study. One explanation may be that experienced PIs operate efficiently in terms of effort and time as publicly funded research programme provides them with the resources to optimize both knowledge production and academic entrepreneurship simultaneously in supportive university and public research organizational environments. However, for early career PIs or less experienced PIs the diversion of time and effort away from knowledge production may be more pronounced. Future research should focus on this issue particularly for early career PIs, serial PIs and those scientists that are PIs for multiple grants simultaneously. Moreover, for scientists a key question when is it or is it optimal from a career perspective to divert time and effort away from knowledge development to purse technology transfer activities.

The commercial and societal impact of research is growing importance among policy makers and for realizing the desired outcomes posited in relation to public sector entrepreneurship programmes. How to shape research impact for scientists is challenging (see de Jong et al 2016). It is clear from our study is that scientists in the PI role at a project level do spend time on technology transfer and place a value on this activity and this further highlights the importance of public sector entrepreneurship programmes. PIs who spend more time on technology transfer placed greater value on technology transfer, market and economic impact. Even taking account of the limitations of the study PIs we found projects of PIs spending more time on research related activities had a greater impact on technology transfer and a greater market impact, than the projects of PIs spending less time on research activities. This provides some modest evidence that PIs in order to be effective need to understand, value and have a technology transfer strategy that is aligned to their own research strengths and excellence and of commercial interest to end users. Moreover, it highlights that for scientists to be successful in securing public funding and implementing public sector entrepreneurship programmes their research has to have greater impact beyond academia and in order to realize this they need to invest and allocate time to develop relationships with end users that will enhance their research and envisaged multiple impacts. Our findings suggest that when it comes to time allocation for PIs spending more time on research engaged more in boundary spanning activities such as direct consultation with industry end users and engaging directly with their TTOs at pre proposal stage. This would suggest that PIs at the particularly at the pre proposal stage are focused on enhancing multiple impacts beyond the academia arena. Overall, our findings reinforce the boundary spanning nature of being a PI at a general research level and a project level as posited by Mangematin et al. (2014)

6 Concluding Remarks

Our empirical findings in this paper have some limitations, the main one being the potential for respondents self-reporting bias. Also, while the survey was send to the full population of publicly funded PIs in science, technology and engineering receiving public funding from Irish and European funding agencies, there may have been some PIs that were not included in the survey given the range of public agencies and numbers involved. However, we mitigated against this limitation as best we could by doing further sample checks to see if we had included all those scientists that were in receipt of public research funding from other publicly available data. Lastly, the Irish research system and infrastructure was in a capacity building phase when conducting our survey in comparison to other more established systems, so our findings should be interpreted cautiously (Cunningham and Golden, 2015b). That said our findings support three important observations. The first observation is that publicly funded PIs are spending an increasing amount of their time on preparing and delivering public sector entrepreneurship programs and that the allocated time for PIs probably is in excess of full-time. Our second observation is the allocation of time to public sector entrepreneurship that was reported by publicly funded PIs reflects the increasing complexity and workload intensification across institution types – universities and public research organizations and also at the project level. Our third observation, while public research that is delivered through public sector entrepreneurship programmes is not the 'freest form of funding' as we find that PIs have to allocate time to a range of activities and attach different orders of importance to project impact depending on their own research intensity.

Our study has implications for how organizations support PIs in the design and delivery of public sector entrepreneurship programs. If the public funding system prioritizes increased technology transfer and industry collaboration, it is necessary to create PI workload models that allocate more time to research overall. The findings indicate that this increased research time will support PIs to increase their engagement with industry and technology transfer offices during the pre-project phase, and particularly during the concept development phase of potential research projects. More importantly PIs with more time to allocate to research are also more likely to place a greater importance on technology transfer and market impact in their project objectives and but more importantly their research motivations is critical to delivering the public sector entrepreneurship ambition.

Public funding should include sufficient dedicated research administrative support that accrue the benefits and transformational intentionality that is posited in public sector entrepreneurship is actually realized. The danger is that PIs may be misallocating their time on tasks that are not within the scope of their expertise and this deflects them from undertaking core activities that they were funded to undertake. The danger is that they may also be allocating time to tasks that are not perceived as adding value to publicly funded science such as adhering and completing project reporting requirements. For PIs who engage in public sector entrepreneurship programs they have to be realistic in relation to the additional responsibilities that becoming a publicly funded PI entails and the implications this has on project time allocation as well as to their own overall general research time. Inevitably time allocation required to delivery public sector entrepreneurship program may be underestimated by PIs, their own institutions as well as funding agencies. For policy makers the implications of our study is it highlights that PIs are allocating time for dissemination and technology transfer and some of this activity is undertaken as the latter end of a funded project. It takes time for PIs to fully realize the anticipated and envisaged outcomes of public sector entrepreneurship programs. This needs to be recognized by policy makers and university administrators and managers or else significant diversion of PIs from knowledge production can potentially diminish the impacts that they can have across different arenas.

Focusing on the time dimension for the delivery of public sector entrepreneurship programs warrants further empirical investigation. Given our acknowledged weakness of the potential of self-reporting bias of this study other data collection approaches could be used with PIs such as diary methods and ethnographic approaches to further explore the allocation of time. There is a need to move beyond the studies that explore the impact of time allocation across research, teaching and service activities, and develop a better understanding of how researchers allocate their actual research time. In particular, research is required to establish what criteria and approaches do PIs actually use to deal with time dilemmas associated with managing short term pressing operational project problems against their long term scientific vision and the medium term goals to realize project outcomes. Observations from studying these issues will offer important insights to the design of public research funding programs, design of PI workload models in universities and public research organizations, and the design of human resource development programs for PIs. In addition, examining the time dimension and dilemmas are worth exploring in other domains such as social sciences and humanities and also across the career lifecycle of scientists.

References

Anderson, D.M. and C.P. Slade, C.P. (2016). Managing institutional research advancement: implications from a university faculty time allocation study, *Research in Higher Education* (57): 99-121.

Audretsch, D. B., & Link, A. N. (2016). *Essays in Public Sector Entrepreneurship*. Springer

Auranen, O. and Nieminen, M. (2010). University research funding and publication performance: An international comparison. *Research Policy*, 39 (6) 822–834.

Barham, B.J., Foltz, J.D., and Prager, D.L. (2014). Making time for science. *Research Policy* (43)1, 21–31.

Bird. B. (1988). Implementing entrepreneurial ideas: The case for intention. *Academy of Management Review*. 13(3), 442-453.

Brown, J., Dimmock, S.G., Kang, J., and Weisbenner, S. (2010) Why I lost my secretary: The effect of endowment shocks on university operations. *NBER Working Paper* 15861.

Boehm, D., & Hogan, T. (2014). "A jack of all trades": the role of PIs in the establishment and management of collaborative networks in scientific knowledge commercialisation. *The Journal of Technology Transfer*, *39*(1), 134–149.

Bozeman, B. and Mangematin, V. (2004) Editor's introduction:scientific and technical human capital. *Research Policy*, 33(4), 565-568.

Bozeman, B., & Boardman, C. (2013). Academic faculty working in university research centers: Neither capitalism's slaves nor teaching fugitives. *Journal of Higher Education*, 84(1), 88–120.

Casati, A., & Genet, C. (2014). Principal investigators as scientific entrepreneurs. *The Journal of Technology Transfer*, *39*(1), 11–32.

Chublin, D.E. & Hackett, E.J. (1990) Peerless science; peer review and US Policy, SUNY Press: New York.

Colombo, M. G., D'Adda, D., & Piva, E. (2010). The contribution of university research to the growth of academic start-ups: an empirical analysis. *The Journal of Technology Transfer*, *35*(1), 113-140.

Cunningham, J and Harney, B. (2006) *Strategic Management of Technology Transfer: A New Challenge on Campus*, Oak Tree Press, Cork. Ireland.

Cunningham, J. A., O'Reilly, P., O'Kane, C., & Mangematin, V. (2016). Publicly Funded Principal Investigators as Transformative Agents of Public Sector Entrepreneurship eds Audretsch D.B & Link, A.N. *Essays in Public Sector Entrepreneurship*, 67-94: Springer.

Cunningham, J. A., Mangematin, V., O'Kane, C., & O'Reilly, P. (2016b). At the frontiers of scientific advancement: the factors that influence scientists to become or choose to become publicly funded principal investigators. *The Journal of Technology Transfer*, 41(4), 778-797.

Cunningham, J. O'Reilly, P., O' Kane, C., & Mangematin, V. (2015) Managerial Challenges of Publicly Funded Principal Investigators. *International Journal of Technology Management and Innovation*, 68(3/4):176-202.

Cunningham, J. A. & Golden, W. (2015b). National Innovation System of Ireland. *Wiley Encyclopedia of Management*. 13:1–14

Cunningham, J., O'Reilly, P., O'Kane, C., & Mangematin, V. (2014). The inhibiting factors that principal investigators experience in leading publicly funded research. *Journal of Technology Transfer*, *39*(1), 93–110.

Deem, R., & Brehony, K. J. (2005). Management as ideology: The case of 'new managerialism'in higher education. *Oxford review of education*, *31*(2), 217-235.

De Jong, S. P., Smit, J., & van Drooge, L. (2016). Scientists' response to societal impact policies: A policy paradox. *Science and Public Policy*, *43*(1), 102-114.

Di Gregorio, D., & Shane, S. (2003). Why do some universities generate more start-ups than others?. *Research Policy*, *32*(2), 209-227.

Ejrnæs, M., & Pörtner, C. C. (2004). Birth order and the intrahousehold allocation of time and education. *Review of Economics and Statistics*, *86*(4), 1008-1019.

Erez, M., & Shneorson, Z. (1980). Personality types and motivational characteristics of academics versus professionals in industry in the same occupational discipline. *Journal of Vocational Behavior*, *17*(1), 95-105.

Fairweather, J.S. (1993) Faculty reward stuctures; Toward institutional and professional homogenization. Research in Higher Education, 34(5), 603-623.

Finkelstein, M. (2014). The balance between teaching and research in the work life of American academics. In *Teaching and Research in Contemporary Higher Education* (pp. 299-318). Springer Netherlands.

Fitzgerald, C., & Cunningham, J. A. (2015). Inside the university technology transfer office: Mission statement analysis. *The Journal of Technology Transfer*, 1-12. doi:10.1007/s10961-015-9419-6.

Franzoni, C., (2009). Do scientists get fundamental research ideas by solving practical problems? *Industrial and Corporate Change* 18: 671–699.

Ghez, G.R. and Becker, G.S (1975) The Allocation of Time and Goods over the Life Cycle. Columbia University Press: New York.

Harman, G. (2001). Academics and institutional differentiation in Australian higher education. *Higher Education Policy*, 14, 325–342.

Hull, R. (2006). Workload allocation models and 'collegiality' in academic departments. *Journal of Organizational Change Management*, 19(1), 38–53.

Juster, F. T., & Stafford, F. P. (1991). The allocation of time: Empirical findings, behavioral models, and problems of measurement. *Journal of Economic literature*, *29*(2), 471-522.

Kidwell, D. (2014). Navigating the role of the principal investigator: a comparison of four cases. *The Journal of Technology Transfer*, *39*(1), 33–51.

Kidwell, D.K. (2013) 'Principal investigators as knowledge brokers: A multiple case study of the creative actions of PIs in entrepreneurial science', *Technological Forecasting and Social Change*, 80(2):212-220.

Klein, P.G., J.T. Mahoney, A.M. McGahan and C.N. Pitelis (2010) Towards a theory of public entrepreneurship. European Management Review, 7, 1-15.

Kok, S. K., Douglas, A., McClelland, B., & Bryde, D. (2010). The move towards managerialism: Perceptions of staff in "traditional" and "new" UK universities. *Tertiary Education and Management*, *16*(2), 99-113.

Kolsaker, A. (2008). Academic professionalism in the managerialist era: A study of English universities. *Studies in Higher Education*, *33*(5), 513-525.

Levinson, D., & Kumar, A. (1995). Activity, travel, and the allocation of time. *Journal of the American Planning Association*, *61*(4), 458-470.

Leyden, D. P. (2016). Public-sector entrepreneurship and the creation of a sustainable innovative economy. *Small Business Economics*, *46*(4), 553-564.

Leyden, D. P., and Link, A. N. (2015). *Public sector entrepreneurship: US technology and innovation policy*. New York: Oxford University Press.

Libaers, D.P. (2012) Time allocation decisions of academic scientists and their impact on technology commercialization. IEEE Transactions on Engineering Management. 59(4), 705-716.

Link, A. N., & Siegel, D. S. (2005). Generating science-based growth: An econometric analysis of the impact of organizational incentives on university-industry technology transfer. *European Journal of Finance*, 11(3), 169–181.

Link, A. N., and Link, J. (2009). *Government as entrepreneur*. Oxford: Oxford University Press.

Link, A. N., Swann, C. A., & Bozeman, B. (2008). A time allocation study of university faculty. *Economics of Education Review*, *27*(4), 363-374.

Link, A. N., Swann, C. A., & Bozeman, B. (2008). A time allocation study of university faculty. *Economics of Education Review*, 27(4), 363–374.

Link, A. Swann, C.A. and Bozeman, B. (2008) A time allocation study of university faculty, *Economics of Education Review*, 27:363-374.

M. Kenny, M. (1986). Biotechnology: The University-Industrial Complex. New Haven, Yale University Press.

Massy, W. F., & Zemsky, R. (1994). Faculty discretionary time: Departments and the academic ratchet. Journal of Higher Education 65, 1-22.

McCarthy, A. M., Krueger. D. A.. & Schoenecker, T. S. (1990). Changes in the time allocations patterns of entrepreneurs. *Entrepreneurship Theory & Practice*. 15(2), 7-18.

Menter, M. (2016). Principal Investigators and the Commercialization of Knowledge. In *University Evolution, Entrepreneurial Activity and Regional Competitiveness* (pp. 193-203). Springer International Publishing.

Milem, J. F., Berger, J. B., & Dey, E. L. (2000). Faculty time allocation: A study of change over twenty years. *Journal of Higher Education*, 454-475.

Nieuwoudt, M. J., Wilcocks, J. S., & Kilpert, O. V. (2006). Time perceptions of South African accounting academics. *Meditari Accountancy Research*, *14*(2), 17-32.

O'Kane, C., Cunningham, J., Mangematin, V., & O'Reilly, P. (2015). Underpinning strategic behaviours and posture of principal investigators in transition/uncertain environments. *Long Range Planning*, *48*(3), 200-214.

Paewai, S. R., Meyer, L. H., & Houston, D. J. (2007). Problem solving academic workloads management: A university response. *Higher Education Quarterly*, 61(3), 375–390.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., & Krabel, S. (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy*, *42*(2), 423-442.

Polonsky, M. J., Juric, B., & Mankelow, G. (2003). Attitudes about work practices, time allocation, and publication output: Profiles of US marketing academics. *Journal of Marketing Education*, *25*(3), 218-

230.

Porter, S. R., & Umbach, P. D. (2001). Analyzing faculty workload data using multilevel modeling. Research in Higher Education, 42(2), 171–196.

Rabinow, P. (1997). Making PCR: A story in biotechnology. Chicago, University of Chicago Press.

Rockwell, S. (2009). The FDP faculty burden survey. *Research Management Review*, 16 (2), 29–44.

Seshadri, S., & Shapira, Z. (2001). Managerial allocation of time and effort: The effects of interruptions. *Management Science*, *47*(5), 647-662.

Singell, L., Lillydahl, J. H., & Singell, L. D. (1996). Will changing time change the allocation of faculty time? *Journal of Human Resources*, 31, 429–449.

Stayton, J. & Mangematin, V (2016). Startup time, innovation and organizational emergence: A study of USA-based international technology ventures. *Journal of International Entrepreneurship*, 10.1007/s10843-016-0183-y

Toole, A. A., & Czarnitzki, D. (2010). Commercializing Science: Is there a university "brain drain" from academic entrepreneurship?. *Management Science*, *56*(9), 1599-1614.

Van de Ven. A. H., Hudson, R., & Schroeder, D. M. (1984). Designing new business startups: Entrepreneurial, organizational, and ecological comicroom. *Journal of Management*. 10(1). 87-107.

Table 1: Average percentage of time spent on research-related activities

	Mean	N	Range	Std. Deviation
Pre-project activity (e.g. proposal development, relationship organisation)	18.95	398	5-75	9.959
Research (e.g. project tasks, supervision of researchers) percentage breakdown of this time	48.01	397	10-85	15.764
Dissemination (e.g. paper/report preparation, conferencing, seminars)	21.88	397	5-60	10.187
Technology transfer (e.g. patent preparation, spin-off activities, consulting & technical services)	7.80	375	0-50	7.644

Table 2 Average percentage of time spent on research related activities – Time on research [mean, n, (standard deviation), {range}]

		Less than 50% of time on research activities	50% of time or more on research activities
Pre-project activity*	Mean	20.66 n=118 (10.916) {5-60}	18.22 n=279 (9.471) {5-75}
Research	Mean	45.92 n=117 (17.043) {10-85}	48.87 n=279 (15.172) {10-85}
Dissemination	Mean	22.49 n=117 (10.367) {5-60}	21.64 n=279 (10.136) {5-60}
Technology transfer***	Mean	5.91 n=108 (5.956) {0-25}	8.56 n=266 (8.130) {0-50}

* p<0.05
*** p<0.001
No other significance

Table 3: Primary type of research – Time on Research
[Count, percentage]

	Basic	Applied	Experiential
Less than 50% of time on research activities	41 35.0%	66 56.4%	10 8.5%
50% of time or more on research activities	83 29.6%	163 58.2%	34 12.1%

Chi-squared=1.78, df=2, p=0.411

Table 4: Primary type of research – Allocation of Research Time
[Count, percentage]

	Basic	Applied	Experiential

Less than 8% of time on TT	88 43.6%	101 50.0%	13 6.4%
More than 8% of time on TT	25 16.2%	106 68.8%	23 14.9%

Chi-squared=32.135, df=2, p<0.001

Table 5: Most common dissemination and knowledge transfer activities on selected project – Time on research [Count, percentage]

	Less than 50% of time on research activities	50% of time or more on research activities
Industry workshops	5	15
	4.60%	5.60%
Research symposiums and colloquiums	17	48
	15.60%	18.00%
Peer publication	57	123
	52.30%	46.20%
End of project reports	14	30
	12.80%	11.30%
Collaborative research with industry	4	22
	3.70%	8.30%
Contractual research for industry	1	6
	0.90%	2.30%
Consulting and technical services	5	4
	4.60%	1.50%
Licensing of intellectual property	2	11
	1.80%	4.10%
Spin-off enterprises	4	7
	3.70%	2.60%
Total	109	266

Chi-squared=8.809, df=8, p=0.359

Table 6: Most common dissemination and knowledge transfer activities on selected project [Count, percentage]

	Pre-project activities$_1$		Research$_2$		Dissemination$_3$		Technology Transfer$_4$	
	< Av.	>Av.	< Av.	>Av.	< Av.	>Av.	< Av.	>Av.
Industry workshops	9	11	7	13	15	5	10	10
	5.7%	5.6%	4.5%	6.4%	7.4%	3.3%	5.2%	6.8%
Research symposiums and colloquiums	27	36	27	36	41	22	35	23
	17.0%	18.2%	17.5%	17.8%	20.1%	14.5%	18.2%	15.6%
Peer publication	81	90	80	90	86	84	106	56
	50.9%	45.5%	51.9%	44.6%	42.2%	55.3%	55.2%	38.1%
End of project reports	19	22	12	29	24	17	19	19
	11.9%	11.1%	7.8%	14.4%	11.8%	11.2%	9.9%	12.9%
Collaborative research with industry	5	18	13	10	14	9	9	13
	3.1%	9.1%	8.4%	5.0%	6.9%	5.9%	4.7%	8.8%

Contractual research for industry	5	2	0	7	7	0	3	4
	3.1%	1.0%	0.0%	3.5%	3.4%	0.0%	1.6%	2.7%
Consulting and technical services	1	8	6	3	3	6	4	5
	0.6%	4.0%	3.9%	1.5%	1.5%	3.9%	2.1%	3.4%
Licensing of intellectual property	7	6	4	9	7	6	4	9
	4.4%	3.0%	2.6%	4.5%	3.4%	3.9%	2.1%	6.1%
Spin-off enterprises	5	5	5	5	7	3	2	8
	3.1%	2.5%	3.2%	2.5%	3.4%	2.0%	1.0%	5.4%
Total	159	198	154	202	204	152	192	147

[1] Chi-squared=12.129, df=8, p=0.142
[2] Chi-squared=14.835, df=8, p=0.062
[3] Chi-squared=15.447, df=8, p=0.051
[4] Chi-squared=18.777, df=8, p=0.016

Table 7: Importance placed on impact criteria – Time on research [Mean, n, {standard deviation}]

		Less than 50% of time on research activities	50% of time or more on research activities
Scientific publication	Mean	6.34	6.26
		n=111	n=268
		{1.124}	{1.289}
Technology transfer	Mean	4.06	4.76**
		n=110	n=263
		{1.936}	{1.872}
Political impact	Mean	3.86	4.22
		n=110	n=264
		{2.061}	{1.854}
Economic impact	Mean	4.25	4.55
		n=110	n=266
		{1.903}	{1.711}
Relationship impact	Mean	4.92	4.81
		n=110	n=262
		{1.676}	{1.702}
Scientific capital impact	Mean	6.05	5.87
		n=111	n=266
		{1.052}	{1.249}
Human capital impact	Mean	5.96	5.71
		n=111	n=264
		{1.243}	{1.455}
Market impact	Mean	3.33	3.94
		n=110	n=264
		{2.189}	{2.089}
Contract impact	Mean	5.51	5.69

	n=112	n=266
	{1.666}	{1.586}

** p<0.01
No other significance

Table 8: Importance placed on impact criteria – Allocation of research time
[Mean, n, {standard deviation}]

		Preproject activities		Research		Dissemination		Technology Transfer	
		<Av.	>Av.	<Av.	>Av.	<Av.	>Av.	<Av.	>Av.
Scientific publication	Mean	6.35	6.26	6.27	6.32	6.18	6.46*	6.46	6.09**
		n=162	n=200	n=157	n=204	n=208	n=153	n=194	n=148
		{1.128}	{1.312}	{1.346}	{1.142}	{1.276}	{1.158}	{1.134}	{1.345}
Technology transfer	Mean	4.51	4.57	4.54	4.55	4.85	4.12***	4.06	5.32***
		n=158	n=197	n=154	n=200	n=202	n=152	n=191	n=145
		{1.857}	{1.956}	{1.931}	{1.904}	{1.784}	{1.993}	{1.961}	{1.544}
Political impact	Mean	4.14	4.12	4.2	4.07	4.24	3.97	3.95	4.35
		n=159	n=197	n=153	n=202	n=204	n=151	n=190	n=147
		{1.827}	{2.029}	{1.941}	{1.944}	{1.936}	{1.93}	{1.995}	{1.868}
Economic impact	Mean	4.41	4.53	4.49	4.46	4.5	4.43	4.27	4.77**
		n=161	n=197	n=155	n=202	n=204	n=153	n=192	n=146
		{1.762}	{1.774}	{1.759}	{1.779}	{1.755}	{1.784}	{1.778}	{1.705}
Relationship impact	Mean	4.99	4.74	4.72	4.96	4.88	4.8	4.95	4.66
		n=160	n=194	n=152	n=201	n=201	n=152	n=189	n=145
		{1.528}	{1.795}	{1.689}	{1.677}	{1.728}	{1.62}	{1.654}	{1.75}
Scientific capital impact	Mean	5.94	5.92	5.97	5.92	5.99	5.86	6.03	5.82
		n=161	n=198	n=156	n=202	n=205	n=153	n=192	n=147
		{1.211}	{1.192}	{1.188}	{1.194}	{1.114}	{1.305}	{1.182}	{1.222}
Human capital impact	Mean	5.67	5.81	5.77	5.75	5.75	5.74	5.86	5.59
		n=160	n=197	n=152	n=204	n=205	n=151	n=192	n=145
		{1.426}	{1.418}	{1.485}	{1.365}	{1.314}	{1.56}	{1.396}	{1.484}
Market impact	Mean	3.62	3.79	3.75	3.69	3.99	3.33**	3.19	4.55***
		n=159	n=197	n=154	n=201	n=203	n=152	n=191	n=146
		{2.04}	{2.2}	{2.174}	{2.103}	{2.135}	{2.058}	{2.056}	{1.983}
Contract impact	Mean	5.63	5.61	5.59	5.65	5.71	5.48	5.58	5.73
		n=161	n=199	n=155	n=204	n=207	n=152	n=193	n=147
		{1.576}	{1.678}	{1.594}	{1.655}	{1.533}	{1.753}	{1.679}	{1.564}

* p<0.05
** p<0.01
*** p<0.001
No other significance

Table 9: Impact of projects in relation to impact criteria – Time on research
[Mean, n, {standard deviation}]

	Less than 50% of time on research activities	50% of time or more on research activities

Scientific publication	Mean	5.62	5.42
		n=111	n=262
		{1.342}	{1.459}
Technology transfer	Mean	3.47	4.03**
		n=110	n=260
		{2.008}	{1.847}
Political impact	Mean	3.79	4.13
		n=110	n=259
		{1.977}	{1.681}
Economic impact	Mean	4.34	4.72
		n=109	n=260
		{1.857}	{1.558}
Relationship impact	Mean	4.96	4.96
		n=110	n=257
		{1.597}	{1.661}
Scientific capital impact	Mean	5.81	5.72
		n=110	n=262
		{1.2}	{1.239}
Human capital impact	Mean	5.79	5.77
		n=109	n=260
		{1.248}	{1.225}
Market impact	Mean	2.89	3.42*
		n=110	n=258
		{1.955}	{1.911}
Contract impact	Mean	5.38	5.52
		n=109	n=261
		{1.586}	{1.526}

* p<0.05
** p<0.01
No other significance

Table 10: Impact of projects in relation to impact criteria – Allocation of research time [Mean, n, {standard deviation}]

		Pre-project activity		Research		Dissemination		Technology Transfer	
		<Av.	>Av.	<Av.	>Av.	<Av.	>Av.	<Av.	>Av.
Scientific publication	Mean	5.55	5.47	5.53	5.49	5.37	5.68*	5.65	5.3
		n=160	n=195	n=154	n=200	n=201	n=153	n=189	n=14
		{1.278}	{1.527}	{1.5}	{1.36}	{1.478}	{1.321}	{1.362}	{1.491
Technology transfer	Mean	3.95	3.76	3.75	3.91	4.15	3.43***	3.27	4.72**
		n=157	n=195	n=152	n=199	n=198	n=153	n=188	n=14
		{1.957}	{1.871}	{1.981}	{1.858}	{1.914}	{1.82}	{1.825}	{1.681
Political impact	Mean	4.09	4	4.14	3.96	4.09	3.97	3.85	4.35
		n=158	n=193	n=151	n=199	n=199	n=151	n=188	n=14
		{1.748}	{1.817}	{1.793}	{1.782}	{1.746}	{1.827}	{1.838}	{1.675
Economic impact	Mean	4.63	4.61	4.72	4.54	4.64	4.57	4.51	4.8
		n=159	n=192	n=151	n=199	n=199	n=151	n=189	n=14
		{1.537}	{1.772}	{1.73}	{1.62}	{1.55}	{1.809}	{1.731}	{1.559
Relationship impact	Mean	5.04	4.95	4.95	5.02	4.99	4.98	5.13	4.8

		n=157	n=193	n=151	n=198	n=197	n=152	n=187	n=14
		{1.473}	{1.731}	{1.704}	{1.558}	{1.6}	{1.646}	{1.636}	{1.568
Scientific capital impact	Mean	5.77	5.75	5.68	5.82	5.81	5.68	5.89	5.58
		n=160	n=194	n=152	n=201	n=201	n=152	n=190	n=14
		{1.139}	{1.313}	{1.354}	{1.141}	{1.142}	{1.35}	{1.23}	{1.255
Human capital impact	Mean	5.69	5.84	5.83	5.73	5.78	5.75	5.91	5.6
		n=158	n=193	n=150	n=200	n=200	n=150	n=187	n=14
		{1.256}	{1.229}	{1.214}	{1.267}	{1.187}	{1.316}	{1.211}	{1.292
Market impact	Mean	2.99	3.4*	3.28	3.16	3.51	2.82**	2.69	4.04**
		n=156	n=194	n=151	n=198	n=197	n=152	n=188	n=14
		{1.823}	{1.996}	{1.937}	{1.926}	{1.96}	{1.802}	{1.783}	{1.838
Contract impact	Mean	5.49	5.43	5.51	5.42	5.45	5.47	5.39	5.5
		n=160	n=192	n=152	n=199	n=200	n=151	n=189	n=14
		{1.578}	{1.54}	{1.46}	{1.631}	{1.472}	{1.665}	{1.658}	{1.47

* p<0.05
** p<0.01
*** p<0.001
No other significance

Table 11: Technology transfer strategy – Time on research [Mean, n, {standard deviation}]

	Less than 50% of time on research activities	50% of time or more on research activities
*The technology transfer strategy was deliberate and highly planned**	2.85	3.37
	n=112	n=262
	{1.909}	{1.921}

* p<0.05

Table 12: Technology transfer strategy – Allocation of research time [Mean, n, {standard deviation}]

	Pre-project activity		Research		Dissemination		Technology Transfer	
	<Av.	>Av.	<Av.	>Av.	<Av.	>Av.	<Av.	>Av.
The technology transfer strategy was deliberate and highly planned	3.21	3.19	3.19	3.2	3.51	2.77***	2.54	4.14***
	n=155	n=201	n=154	n=201	n=203	n=152	n=190	n=148
	{1.889}	{1.951}	{1.92}	{1.932}	{1.938}	{1.821}	{1.673}	{1.826}

*** p<0.001
No other significance

Table 13: Average number of partners on selected project – Time on research [mean, n, {standard deviation}]

		Less than 50% of time on research activities	50% of time or more on research activities
Academic Partners	Mean	2.14	2.29

		n=112 {2.674}	n=265 {2.890}
Public research organisations	Mean	.67 n=84 {1.302}	.96 n=192 {2.002}
Industry partners	Mean	.53 n=83 {1.417}	1.30* n=189 {3.068}

* p<0.05
Otherwise no significance

Table 14: Average number of partners on selected project – Allocation of research time [mean, n, {standard deviation}]

		Pre-project activity		Research		Dissemination		Technology Transfer	
		<Av.	>Av.	<Av.	>Av.	<Av.	>Av.	<Av.	>Av.
Academic Partners	Mean	2.27 n=156 {3.064}	2.28 n=202 {2.731}	2.14 n=153 {2.460}	2.39 n=204 {3.159}	2.44 n=211 {3.095}	2.03 n=145 {2.537}	2.34 n=195 {2.893}	2.21 n=143 {2.969
Public research organisations	Mean	0.82 n=123 {2.092}	0.98 n=139 {1.653}	.86 n=107 {1.370}	.94 n=155 {2.152}	.99 n=156 {1.726}	.78 n=106 {2.066}	.81 n=148 {2.088}	1.01 n=104 {1.586
Industry partners	Mean	0.74 n=117 {2.19}	1.43* n=142 {3.125}	1.19 n=106 {2.757}	1.07 n=152 {2.777}	1.44 n=156 {3.086}	.62* n=102 {2.092}	.78 n=138 {2.447}	1.50* n=112 {3.128

* p<0.05
Otherwise no significance

Table 15: Engagement in activities at the pre-proposal stage of selected project [mean, n, {standard deviation}]

		Less than 50% of time on research activities	50% of time or more on research activities
Direct consultation with industry endusers	Mean	2.64 n=115 {2.023}	3.2* n=278 {2.029}
Direct consultation with technology transfer offic	Mean	2.34 n=115 {1.854}	2.81* n=278 {2.049}

* p<0.05
Otherwise no significance

Table 16: Engagement in activities at the pre-proposal stage of selected project [mean, n, {standard deviation}]

		Pre-project activity		Research		Dissemination		Technology Tr	
		<Av.	>Av.	<Av.	>Av.	<Av.	>Av.	<Av.	>.
Direct consultation with	Mean	2.88	3.15	3.20	2.89	3.15	2.84	2.42	3.

industry endusers										
		n=167	n=207	n=160	n=213	n=218	n=154	n=200	n=
		{2.029}	{2.060}	{2.037}	{2.046}	{2.121}	{1.944}	{1.909}	{
Direct consultation with technology transfer office	Mean	2.40	2.83*	2.91	2.44*	2.83	2.34*	2.05	3.
		n=167	n=207	n=160	n=213	n=217	n=155	n=200	n=
		{1.898}	{2.030}	{1.985}	{1.960}	{2.091}	{1.789}	{1.636}	{2

* p<0.05
*** p<0.001
Otherwise no significance