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Evaluation of Science Foundation Ireland's Principal Investigator (PI) Programme

Final Report

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Executive Summary

This Report

This report presents the results and conclusions of an impact evaluation of Science Foundation Ireland's (SFI's) Principal Investigator (PI) programme. The aims of the study were to assess:

1. **The appropriateness of the programme**, given its rationale, objectives, its fit within the national research system, and the extent to which it was aligned with and contributed to the achievement of wider science policy objectives; and
2. **The effectiveness of the programme**, and the extent to which it achieved its core objectives of building critical scientific capacity and capabilities in key basic research areas.

Conclusions were also to be drawn on the allocation of resources to the programme, and recommendations offered for future programmes of a similar nature.

The PI Programme

The PI programme was established in 2000 to support well-established researchers with excellent reputations (from Ireland and explicitly also elsewhere), in the fields of science and engineering that underpin the biotech, ICT and energy sectors. It sought to build research capacity and capabilities through providing competitive grant funding for up to 5 years to individuals selected based on their excellence, and the excellence of the project they proposed.

From 2000 to 2011, SFI invested around €609m, or 39% of its overall funding during this period, in the PI programme, making it the largest scheme in SFI's portfolio. The programme awarded 398 grants to 281 researchers at 15 institutions in Ireland. Awards not only supported individual PIs, but also over 4,000 other individuals in the lead PIs' wider research and support teams.

The programme was merged with the Research Frontiers programme in 2011, to form the Investigator programme (IvP). This is a distinct programme that is out of scope for the evaluation, but which does include elements that closely reflect aspects of the PI programme.

Appropriateness of the PI Programme

Programme rationale and objectives - In 2000, Ireland had a very limited academic and industrial research base, a level of public and private sector investment in R&D that was low by international standards, a higher education system that focused almost exclusively on teaching not research, and little opportunity to advance from Masters to PhD level. The evaluation finds that the PI programme (as part of a wider set of initiatives) responded well to these challenges. It was wholly appropriate in its rationale and objectives in responding to the needs of Ireland at the time, and in contributing towards the ambition to move Ireland towards a higher skilled, knowledge-based economy, underpinned by a strong science and research base.

Programme fit within the national research system - The PI programme filled an important gap in Ireland's efforts to become an economy more focused on world-class research and innovation, which necessitated the attraction and retention of excellent researchers to build and develop research groups and activity. There was nothing of the size, scale and ambition of the PI programme in Ireland at the time, and so plenty of scope for it to play a unique and significant role within the funding landscape. Nevertheless, the coherence of the programme within the wider portfolio of policies and activities at the national level is well demonstrated, and the study was not pointed to any initiatives that were potentially duplicative or poorly aligned with the PI programme. Indeed, the PI programme was able to successfully build on a foundation laid by existing PRTL infrastructure funding, and then play an essential role in providing the necessary capacities and capabilities for CSETs to build on.

Programme approach and focus – The PI programme had a relatively flexible and open remit that allowed bottom-up development of capacity in a broad range of areas supporting biotech, ICT and (later) energy. This approach was well tailored to the needs of the time. The programme wanted to attract the best people, and to kick-start research activity first and foremost, in the hope that in many cases this would have a longer-term impact and relevance for Ireland and its economy. Because the work funded was often basic-oriented, the flow of benefits and impacts would emerge over many years, and so the programme was right not to be too prescriptive about the specific research (or research areas) that might be required.

Programme evolution and learning - The PI programme underwent subtle changes over the course of its lifetime, appropriately reflecting the learning of a newly established organisation (SFI), operating in a relatively immature system, and the changing context in which it operated. The gradual evolution of the programme appears to have been positive and well-judged. It also seems that the PI programme – at least in its original form – had come to a natural end-point after a decade. The context in which it operated had changed (in large part due to the achievements of the programme itself), and a re-designed, or new programme was required to better reflect the new reality. Having successfully built a broad base of capabilities and capacity, to then take advantage of this in a more targeted way to address current and future needs and to ensure the links with industry, seems appropriate.

Adequacy and balance of resources - The PI programme overall represented a significant, but justifiable investment in R&D over the programming period. It was the main instrument for fulfilling a key element of SFI's mission (developing capability and excellence), was ambitious in its scope and objectives, and was critical to wider Irish policy ambitions. There was some concern over the impact of the size of individual PI grants on the willingness and ability of PIs to secure other sources of funding, during and after award. While SFI tried to tackle this through changes to requirements and better communication, it is not entirely clear whether they were completely resolved. There is certainly evidence some of the benefits seen during PI awards could not be sustained post-award, and this was in part due to insufficient funding secured from other sources. However, there is probably little that the programme could or should have done to rectify this.

Effectiveness of the PI Programme

Although the PI programme has ended, many PIs are still operating under their grant period. The direct and immediate benefits of the programme are therefore still to fully unfold. However, the programme has already made significant contributions towards its objectives and to addressing the challenges that were faced in Ireland. It is one of many initiatives and factors contributing to the development of Irish research over the period, but was a core part of this mix – both in terms of its direct contribution, and the fact it has enabled and supported other activities and initiatives, that build on the programme's successes and achievements.

Building critical scientific research capacity - The PI programme has been successful in attracting and retaining leading researchers, and in establishing and expanding teams and research groups. This has been achieved both directly through funding PIs and team members, and indirectly through increasing the visibility and attractiveness of Irish research to others. The impact of the programme on Irish research capacity is therefore likely to continue.

Principle Investigators: The PI programme offered an internationally competitive opportunity significant enough to retain high-calibre individuals already based in Ireland, and to attract large numbers of leading researchers from other countries. The study has estimated that of the 281 PI grant holders, only 130 are likely to have come to / remained in Ireland at the time of their award without the PI grant. The success of the award in attracting/retaining individuals in Ireland is also likely to be sustained – with most PIs choosing to remain post-award.

Research teams: The PI awards also supported wider research teams (directly or indirectly) and provided opportunities to develop skills and knowledge in areas relevant to future needs of Irish academia and industry. The study has estimated that some 1,800 additional students and researchers involved in PI-funded groups are unlikely to have joined a research team in Ireland if it had not been for the PI programme. There is also a positive retention rate for these team members, though there are still a large number that have left Ireland post-award. For these individuals there was a perceived lack of suitable positions or job opportunities in Ireland, at least relative to opportunities offered elsewhere, and a lack of research funding available.

The ability to retain individuals post-award does clearly depend upon the availability of relevant (academic) positions. There is also a risk in building capacity from an international pool of researchers - who are internationally mobile and have strong links abroad – as there needs to be an internationally competitive 'draw' (salaries, opportunities, funding) to retain them. Most of those involved in PI awards claim that the skills and networks acquired have been important for their subsequent career and career progression – but for some this will reveal itself through their increased attractiveness in international labour markets.

Building capabilities (and quality) in key basic research areas - PI grants have had a significant impact on the size and scale of activities within individual PIs' research groups, and in particular on the number and quality of academic outputs. Bibliometric analysis suggests that increases in Irish publications and citations in the period compare very favourably, and show that Ireland managed to keep pace with leading comparator countries (a considerable achievement given the scale of R&D investment in these countries). Evidence also shows that the impacts on the size and scale of academic activities are also sustained or enhanced after the grant ended.

There has also been a very positive impact from the programme on the quantity and quality of research activity, and on the quality of training of students and postdocs more generally. The programme has improved the quality of training at institutions; the grant freeing PIs to devote more effort to leading and mentoring research groups. There is also evidence of very high quality early career investigators now emerging in the Irish system –in part due to the PI funded groups.

Wider impacts on Irish research and economy - Irish research is now more visible and better regarded internationally as a consequence of the PI programme. This is evidenced in part by the significant volume and quality of research activity and knowledge directly created by the PI programme. Those directly involved have also seen an increase in their international reputation and networks, and in the scale of their research activities and opportunities.

The programme has also contributed positively to the formation of clusters of excellence, which have expanded beyond just those directly funded through the programme. The Irish system is now building on a core of PIs and teams funded over a decade, with various areas of strength that can be traced back to the programme. However, there is more potential. The push model of the PI programme has created new capacity within the system, but there is a need to ensure that new clusters of excellence are sustainable and also well linked with industry.

Short-term commercial benefits were never a core focus or intention of the programme, however it has directly supported the development of a large number of pre-commercial outputs and had a significant impact on the degree of collaborative activity and other links with Irish and international companies. This is variable across the programme though, and overall academia-industry links were among the least cited impacts of the PI awards. The push nature of the programme was an important starting point, but now the links with the industrial base need to be further strengthened at the policy, programme and operational level.

Programme Performance in Relation to Similar Programmes Abroad

There are many examples of initiatives that *in part* reflect the approach employed by the PI programme, showing that a number of countries have sought to address similar challenges and objectives through grants and positions for leading researchers. However, there is no close comparator, and certainly not in a country of similar size and with a similar context to Ireland. The SFI PI programme is therefore unique in terms of its objectives, combining a strong focus on human capacity with retention of top talent in Ireland. The most closely comparable schemes are found to have operated effectively and efficiently and been successful in making progress against their objectives, providing some validation of the approach taken in Ireland

Recommendations for future programmes

As the PI programme has ended, stakeholders were more concerned with its current incarnation and the recent research prioritisation exercise, and how these might evolve. There was also a sense that issues encountered during the PI programme were specific to the programme and a point in time, and it might be difficult to transfer lessons to a different initiative and context. Nevertheless, the study sets out broad recommendations relating to programme design and the focus of objectives, and considerations when adapting future programmes. These include:

- Ensuring international excellence is included in objectives of capacity building programmes
- Adapting programme models to recognise the need to move from a push model to a pull/coupling model for creating impact on the Irish economy
- Focus on achieving critical mass in key areas of relevance for Irish research and innovation whilst still supporting the development of excellence elsewhere
- Managing the expectations of researchers through clear open communication
- Ensuring a well documented programme design phase with developed indicators

1. Introduction

This document is the final report for an impact **evaluation of Science Foundation Ireland's (SFI's) Principal Investigator (PI) programme**. The associated study was undertaken by Technopolis over the period May to August 2014, and was a full ex-post evaluation of the programme over the 2000-2011 period. The report was produced on completion of an intensive period of desk research and fieldwork, and presents the main findings and conclusions from this work.

1.1 Evaluation objectives

The overall aim of the study was to assess the **appropriateness** and **effectiveness** of the PI programme over its lifetime. To this end, the programme was to be evaluated in terms of:

- Individual programme performance, as regards its appropriateness and effectiveness
- Programme fit with other interventions in the national research system
- Programme performance in relation to the science policy context (2000-11)
- Programme performance in relation to similar schemes in countries of comparative size

Based on this, conclusions were to be drawn on resources allocated to the PI programme, and recommendations offered for future programmes of a similar nature. The full terms of reference from SFI for the study are presented in Appendix A.

1.2 Evaluation approach

The study began at the end of April, and was divided into a preparatory phase (May/June) and a period of fieldwork and analysis (June/July). Full details of the methodology employed and individuals consulted can be found in Appendix B and C, but are briefly summarised here.

Phase 1 – Preparatory phase: The study began with an initiation meeting between SFI and the study team, after which an intensive period of desk research, orientation interviews and preparatory work was undertaken. In this preparatory stage, a programme logic model was developed and the evaluation aims and objectives (set out above) were 'unpacked' into a more detailed set of evaluation questions, with associated indicators and sources of information. These were then used to establish a more detailed evaluation plan, and as a basis for developing the necessary research tools for the main phase of fieldwork to follow. Appropriateness questions would mostly be addressed qualitatively, based on desk research and oral testimony, while effectiveness questions would also be assessed through quantitative or quantifiable primary and secondary data. During this first period, existing data and information were also collated and reviewed, and necessary contacts and contact information established for use during the fieldwork phase.

An interim report at the beginning of June marked the end of this first 5-week phase of the study, and included finalised plans for the remainder of the evaluation.

Phase 2 – fieldwork and analysis phase: Following an interim meeting, at which the approach to the remainder of the study was agreed with SFI, the main phase of fieldwork and analysis began. This included tracking and consulting with many of the 281 PI programme award holders and their wider research teams. Two-thirds of PIs contributed to the exercise, as did nearly half of the Masters students, PhD students and postdoctoral researchers identified by the study team as working within the wider research teams of PIs during the period of a PI award. A selection of 10 PIs were also consulted further in order to develop short personalised case studies that explored their award experiences and subsequent benefits in more detail. Structured, in-depth consultations were also held with a small number of other stakeholders - including within PI host institutions, Irish-based industry, Irish funding bodies and government agencies - to collect views on the relevance, appropriateness, effectiveness and achievements of the programme from their perspectives. In addition, the study team reviewed and analysed centrally collected award data and relevant policy and strategy documents that set the context for the PI programme, identified and assessed comparator initiatives abroad, and undertook a bibliometric exercise.

This final report marks the end of this second six-week phase of the study.

1.3 This report

The remainder of the report is set out as follows:

- Section 2 – presents an **overview and introduction to the PI programme**, in terms of its rationale, aims and objectives, its main operating arrangements and activities, the awards made and funding provided, as well as an overview of the award holders and the wider research teams involved, plus details of the evolution of the PI programme itself.
- Section 3 – then considers the **appropriateness of the PI programme**, in terms of its relevance and fit within the wider Irish STI landscape. It addresses the appropriateness of the initiative within the broader science policy and funding context of the period, and considers its alignment with national strategy and other initiatives operating in Ireland at the time. It also provides evidence from the stakeholder interviews in relation to appropriateness and presents a brief review of international comparator schemes.
- Section 4 – addresses the achievements and **effectiveness of the PI programme** in relation to its aims and objectives. It presents a detailed analysis of the outputs, outcomes and impacts realised by the PI programme and its individual awards and award holders, drawing on formal reporting data and bibliometric analysis, as well as information and assessments collected from a large proportion of direct programme beneficiaries (award holders and team members) and other stakeholders.
- Section 5 - summarises feedback provided by those consulted during the study as to **lessons learned from the PI programme** in Ireland, and particularly where these might provide useful learning for future programmes of a similar nature.
- Section 6 – then presents the overall study **conclusions**, drawing selectively on, summarising and reflecting on the evidence and feedback presented in the previous sections of the report, in order to provide answers to the main study questions regarding the appropriateness, fit, effectiveness and performance of the PI programme, as well as recommendations for the future.

Supporting material are set out in a series of **appendices** at the end of the report, for the purposes of reference and providing additional detail on the evidence presented in the main body of the report:

- Appendix A provides the full terms of reference for the study
- Appendix B provides a more in-depth explanation of the methodology employed and research undertaken during the study
- Appendix C lists those who have been consulted and contributed to the study
- Appendix D provides a summary overview of relevant policy objectives that provide the wider context for the PI programme and its objectives
- Appendix E presents the full results of a bibliometric exercise, summarised in the main body of the report
- Appendix F includes a selection of short personal case studies of individual PIs and their PI programme experience, which highlight in more detail some of the specific achievements and impacts realised by the scheme
- Appendix G presents an assessment of comparable schemes to the PI programme, which are operating in other countries, detailing their key features and available evidence on their achievements

2. The SFI PI programme

Science Foundation Ireland (SFI) was established in 2000 with a mission to develop Ireland as a centre of research excellence, and to build and strengthen scientific and engineering research and infrastructure in the areas of greatest value to the country's long-term competitiveness. It was to invest in research likely to generate new knowledge, leading-edge technologies and competitive enterprises, in order to support Ireland's move to a knowledge-based economy.

SFI was therefore intended to have a key role (together with the new research councils) in strengthening Ireland's academic research base, as a foundation for industrial development. It established the Principal Investigator (PI) programme in 2000, as one of a suite of measures designed to help achieve this. It was SFI's longest running award (2000 – 2011), and its main instrument during the period for developing research capability and excellence in Ireland.

2.1 The aims and objectives of the PI programme

The stated objectives of the PI programme when it was established were: (i) **to build critical scientific research capacity** in Life Sciences and Information and Communication Technologies (ICT), specifically in areas of greatest strategic value to Ireland's long-term competitiveness and development; and (ii) **to build capabilities** in key basic research areas that would see translation into enterprise and industry.

Though not explicitly stated, a key objective of the programme was to develop the human capital needed to cultivate Ireland's scientific base and support Ireland's industrial base. This intent was made more explicit as the programme developed over the 2000-2011 time period. For example, the 2010 PI programme's "objectives" were stated as being:

- To offer funding opportunities that focus on developing and enhancing research talent in Ireland so that Ireland retains the finest researchers working in or attracted to the country
- To offer funding opportunities to help institutions in Ireland attract and retain researchers
- To stimulate broader investment in first-rate individual researchers and, through them, to attract and develop superb students through research opportunities
- To build interdisciplinary links among researchers and connect them appropriately to long-term industry research goals
- To fund a period of intensive research to enhance the candidates' research programmes and further encourage and promote Ireland's participation in international research
- To enable awardees, together with their teams, to carry out their work in Ireland's public research bodies, including universities and institutes of technology

The PI programme was intended to support well-established researchers with excellent reputations, and originally targeted the fields of science and engineering that underpin the biotechnology and information and communications technology (ICT) sectors. The programme's remit was later extended to include sustainable energy and energy efficient technologies. The PI programme provided grant funding to researchers, normally ranging from €100,000 to €1,000,000 direct costs per year, for up to five years. Researchers from abroad were very welcome, with the aim of strengthening and building capacity in Ireland.

The Principal Investigator Career Advancement Award (PICA), which supported outstanding researchers returning to active research after either a prolonged absence, or those within the early consolidating stages of their independent research career, was included in the PI programme after several years. The PICA scheme awarded its first grants in 2005, and this was the only year in which PICA applications were assessed separately and had a dedicated budget. When PICA resumed in 2008, candidates applying through this sub-programme were no longer differentiated from other PI applicants in the review and selection process.

Figure 1 presents a **logic model** for the PI programme, which was developed in the early stages of the study. The Programme Logic Model (PLM) is a representation of the logical sequence and causal relationships among: the programme's objectives; the resources (inputs) used and the activities undertaken; and the results (outputs) and changes (outcomes and ultimately impacts) that it is hoped or intended will be realised as a result. These achievements should in turn contribute towards addressing the initial challenges and objectives established for the programme.

The specific activities, outputs, outcomes and impacts that were identified in the development of the model, all fed into the elaboration of the evaluation approach at the beginning of the study. In particular, the survey questionnaires and interview guides, and the exploration of existing information and data, were all designed to gather evidence (where available) relating to the expected activities, results and achievements of the programme, as set out in the PLM (as well as to address other study questions). As a result, many of the findings presented in later sections of this report, align with and address elements of the assumed programme logic:

- **Inputs and activities:** Inputs are the resources — e.g. human and financial — used in the development and delivery of the programme, and which ensure it is possible to deliver the intended results. Activities on the other hand are the actions (awarding grants, establishing teams, undertaking research, etc.) associated with the delivery and achievement of programme goals. Section 2.2 of this report provides an overview of PI programme funding (inputs), as well as the PI awards and research teams (activities).
- **Outputs:** are the tangible and intangible products that result from the programme activities. They are the first level of results associated with the programme and its awards, and are direct and short-term in nature. In the case of the PI programme, they include various educational, academic, collaborative and pre-commercial results. A review of outputs realised by the PI programme awards is presented in Section 4.1.
- **Outcomes:** Outcomes are the second level of results associated with the programme, and refer to the medium-term consequences of its activities. They usually relate to the benefits that the programme is designed to deliver, and should be directly linked to its outputs. Effective indicators of the achievement of outcomes typically combine quantitative and qualitative measures, e.g. covering the number of beneficiaries and the nature of their benefit, which the study has sought to achieve through its mixed methods approach.
- **Impacts:** Impacts are then the third level of programme results or consequences, and refer to higher-level longer-term goals ('wider objectives') that it is hoped the programme will contribute towards (these are described in more detail as part of the discussion of the programme's wider context in Section 3.1.2). More often than not, it is very difficult to ascertain the exclusive impact of a single initiative, since several other activities and factors will be contributing towards the same goals. However, while impacts are largely beyond the immediate control or sphere of influence of a single programme, they should nevertheless be credible as the consequences of programme outputs and outcomes.

The achievement of outcomes and (where possible to infer) impacts of the PI programme are the focus of Sections 4.2 through 4.5, where we present feedback and evidence from different sources as to the benefits and achievements of the PI programme and awards against programme and wider objectives.

Figure 1 Programme logic model (PLM)

PI PROGRAMME OBJECTIVES: to build critical scientific research capacity in Life Sciences, ICET and Energy, to build capabilities in key basic orientated research areas that would see translation into enterprise and industry, and to develop the human capital needed to cultivate Ireland's scientific base and support Ireland's industrial base				WIDER OBJECTIVES
INPUTS	ACTIVITES	OUTPUTS	OUTCOMES	IMPACT
<ul style="list-style-type: none"> • SFI funding and administration • Host funding/support (e.g. provision facilities and support functions) 	<ul style="list-style-type: none"> • Grants awarded • Teams established / expanded • Research undertaken • Education provided (Masters, PhDs) • Networking, events, workshops, etc. attended • Technology transfer and commercialisation activities 	<p>Publications</p> <ul style="list-style-type: none"> • Refereed publications (academic only, joint with industry) • Conference presentations (international /national) • Books, chapters etc. • Publications in non-academic journals <p>Events/ networking</p> <ul style="list-style-type: none"> • Conferences/ events hosted by PIs <p>Linkages</p> <ul style="list-style-type: none"> • New industry-academic relationships and collaborations • New inter-HEI relationships and collaborations <p>Education</p> <ul style="list-style-type: none"> • MSc / PhD awarded • Trained researchers <p>Pre-commercial outputs</p> <ul style="list-style-type: none"> • Invention disclosures • Patents applications/ awarded • Licences • New products / processes/ services in development • New businesses created <p>Funding diversification / leveraged funding</p> <ul style="list-style-type: none"> • Further R&D funding (from variety of sources) 	<ul style="list-style-type: none"> • Research leaders (in biotech, ICT and energy) are developed, attracted to and/or retained in Irish academia • Irish researchers are developed and promoted to work in and lead teams in these fields • Research capacity is developed to feed academic expansion and to supply industry • Research quality and productivity are raised in specific areas of industrial relevance • Relevant parts of Irish academia become more competitive, productive and attractive, relative to competitor countries • Relevant parts of Irish academia achieve critical mass and adequate specialisation • Relevant parts of Irish academia are able to sustain themselves beyond the programme funding, and become more relevant to industrial growth in Ireland • Industry (MNC and indigenous) recruits research-trained staff and improves academic linkages • Irish industry becomes more competitive by attracting higher value, more R&D-based MNCs, and by those already in Ireland upgrading their activities • Irish industry becomes more competitive by indigenous development of knowledge-based industry (via start-up and upgrade of existing firms) 	<ul style="list-style-type: none"> • Increased RTDI capacity and capability in Ireland • An established international profile for Ireland as a premier location for carrying out world-class research and development • A transformational change in research undertaken by industry (directly and in collaboration with academia) • An enhanced contribution of research to economic and social development • Improved international competitiveness • National economic and employment growth

2.2 PI programme funding and awards

From 2000 to 2011, SFI invested around €609m, or 39% of its overall funding during the period, in the PI programme, making it the largest scheme in SFI's portfolio. The programme provided grants to 281 lead researchers at institutions in Ireland, including 17 PICA awards. In this section we present a brief overview of programme inputs and activities – i.e. the grants awarded, recipients of these awards, and the wider teams and host institutions – by way of introduction to the initiative, its size and scope.

2.2.1 PI award funding

The first PI programme call was launched in 2000, with the first awards made the following year. Over its lifetime the programme evolved from a rolling to a fixed deadline call, while the review process was continually developed and improved to respond to strategic requirements of the research landscape in Ireland. As explained above, other than in 2005, the PICA sub-programme formed part of the wider PI programme application and selection process.

In total, 389 awards were made by the PI programme between 2000 and 2011 (inclusive). This equates to 32 or 33 awards per year on average, although the actual annual figure varies considerably, between 6 (in 2001) and 63 (in 2002). Individual awards lasted for between 12 and 60 months (50 on average), and so the number of awards operating each year was significantly greater than the number of new awards made in that year. Although the programme has officially finished, in that no further grants have been given since 2011, a number of awards made in the later years of the programme are still ongoing.

The PI awards have a total value of €495.4m, or €1.3m per award on average. However, again there is considerable variation, with individual awards ranging from €146k to €11.1m in size (though some of the biggest are in fact 'cluster grants' involving more than one PI). Some of the largest individual grants were awarded in the first two years of the programme; all awards made in this period exceeded €1.6m. In subsequent years the average grant size was significantly smaller, and only a minority of individual awards (11%) fell in this €1.6m+ range.

The number and value of PI grants awarded each year is shown in the figure below.

Figure 2 Number and value of awards made per year

	Number of awards made	Total value of awards (€m)	Min Value (€m)	Max value (€m)	Average value per award (€m)
2000	11	€ 72.8	€ 3.0	€ 7.8	€ 6.6
2001	6	€ 23.3	€ 1.7	€ 6.3	€ 3.9
2002	63	€ 61.7	€ 0.4	€ 3.4	€ 1.0
2003	27	€ 50.4	€ 0.2	* € 11.1	€ 1.9
2004	25	€ 23.1	€ 0.1	€ 3.5	€ 0.9
2005	28	€ 20.7	€ 0.2	€ 3.4	€ 0.7
2006	31	€ 49.5	€ 0.3	* € 9.9	€ 1.6
2007	47	€ 63.0	€ 0.2	€ 4.5	€ 1.3
2008	50	€ 46.0	€ 0.4	* € 2.7	€ 0.9
2009	27	€ 20.1	€ 0.4	€ 1.4	€ 0.7
2010	44	€ 34.3	€ 0.2	€ 1.8	€ 0.8
2011	30	€ 30.5	€ 0.5	€ 2.2	€ 1.0
2000-2011	389	€ 495.4	€ 0.1	€ 11.1	€ 1.3

* The largest awards in 2003, 2006 and 2008 were 'cluster grants', involving multiple PIs

PI awards generally covered people, consumables and travel, with much of the funding directly supporting staff (students, research staff and, until 2008, the PI salary itself). In a small number of cases (particularly in earlier years), other costs such as equipment were also sometimes covered. SFI also paid a 30% overhead to the institution hosting the relevant PI.

Finally, of all 389 PI awards made throughout the period, just over half (56%) were made by the Life Sciences (LS) directorate (i.e. in the biotech focus area), while the remainder were made through the Information, Communications & Emergent Technologies (IC&ET) directorate (which includes the ICT and energy focus areas). Further classifications of the research fields of each award are not held.

2.2.2 PI award holders

Most awards were made to a single Lead Principal Investigator. However, there were 34 cases where awards were made to two, three, or even four lead investigators. There are also 10 grants where there were one or more co-PIs (21 co-PIs in total). As a result, there were effectively 454 lead- and co-PIs in total (not accounting for PIs holding multiple awards).

For the purposes of analysis however, SFI selected a single lead for each award, with details on origin, nationality, etc. provided only for this individual. Taking this lead PI for each grant, we find that there were in fact 281 *unique individuals* leading PI awards during the period (after de-duplication). The majority of these grant holders (68%) only held one award, while 71 (25%) held two, 17 (6%) held three, and one individual held four. It is important to note though that there was no guarantee of a follow-on grant, and those that were granted a second award had had to compete through the same process as all other applicants.

Based on the de-duplicated list of lead PIs (n=281), we can provide some basic profiling of the individuals involved:

- There is an uneven gender split between award holders. The great majority were men (83%), although the proportion was lower in the LS directorate (78%) than the IC&ET directorate (91%). By comparison, in 2003/04, the overall gender ratio among academic staff in Irish universities was more balanced (61% male to 39% female). An unusually high proportion of PI awards in 2005 (57%) went to women – largely due to the separate PICA awards that year, which happened to all go to women.
- The nationality of award holders (at the time of their first award) is known in over three quarters of cases (n=225). The majority (58%) were Irish, but 22 other nationalities were also represented. These included 35 Britons, 14 Germans, 10 Americans, 5 Russians, 4 Swedes, 3 Canadians, 3 Dutch, 3 Indians, 3 Italians, 2 Belgians and 2 French (plus others).
- In most cases (n=256), we also know the location of individuals (in terms of the organisation where they worked) at the time of their first award. Over 40 different institutions are represented, however the majority of individuals (86%) were located in Ireland - most commonly at Trinity College Dublin or University College Dublin. Indeed, most applicants were located in the institution that would be their host for their PI award.
- The awards related to 15 different research bodies (who hosted the grant holders), with half of awards accounted for by Trinity College Dublin and University College Dublin.

2.2.3 PI award teams

PI awards supported not only individual PIs, but also wider research and support teams. The support for relevant and diverse training of team members in skills relevant to Ireland's future needs (both in industry and in leading academic research) was a priority for SFI and was a criterion that SFI placed increasing emphasis on in the evaluation of PI awards over time.

SFI data (from award reporting) suggests that a total of 4,022 individuals were involved in the 389 PI awards across their lifetime (i.e. including new members that joined research teams during the lifetime of the award, as well as those that left). This equates to 10 people per award on average – though not necessarily all directly funded through the PI grant. In total across the awards, the data suggests that the teams comprised (average in parenthesis):

- 433 lead principal investigators (1.1 per award)
- 21 co-principal investigators (0.1)
- 1,205 post-doctoral researchers (3.1)
- 1,308 postgraduate PhDs (3.4)
- 166 postgraduate masters (e.g. MSc) (0.4)
- 293 undergraduates (0.8)
- 143 visiting researchers (0.4)
- 253 support and other staff (technician, admin, assistants, project managers) (0.7)

The team member identification and tracking exercise undertaken for this study (detailed in Appendix B.2), which focused on the PhD students, postdoctoral researchers and (smaller number of) Masters students involved in award teams, suggests that the above figures may be a slight underestimate. From information provided by PIs to the study, we have estimated that the total number of team members in just these three groups alone totalled 3,015, or 13% more than that identified from the SFI-held data above.

The results of our survey of PI team members (mostly reported in Section 4.3) provide further details on the construction of these award teams. They suggest that around 80% of team members only joined after PI awards were made, compared with just 20% who were already in place pre-award (and in a majority of these cases they expanded/extended the amount of time they spent in the group as a result of the PI grant). In addition, a majority (68%) of team members reported that their position within the PI award team was *entirely* funded through the PI grant, while a further 16% were *partially* funded through the award (the remainder used other local, national and European funding). The PI grant was therefore integral to the establishment and / or expansion of the research groups of the PIs being funded.

2.3 Recent developments

While the scope of this study is the 2000-11 period, it is worth briefly mentioning that in 2011, the PI programme was merged with the SFI Research Frontiers Programme (RFP), to form the Investigator Programme (IvP), which awarded its first grants in 2012. The IvP initially had two strands, the Investigator Awards and Investigator Projects, the former following closely on from PI programme grants in many respects. The programme sought to fund “outstanding people with innovative ideas and strategic partnerships”, in order to continue the development of world-class research capability and human capital in areas that would support and underpin enterprise competitiveness and societal development in Ireland. €60 million was invested in 83 research projects through the Investigator Programme in 2013.

3. Programme appropriateness

This section seeks to understand and assess the appropriateness of the SFI PI programme in relation to:

- Its rationale and objectives, and the wider policy context
- The adequacy and balance of resources allocated
- Other relevant interventions in the national research system
- Similar initiatives in other countries (international comparators)

It draws mainly on evidence from desk research and the wider stakeholder interviews, and uses the developed intervention logic and hierarchy of objectives (see figure 38, appendices) in order to assess the appropriateness of the programme. The desk research in particular provides evidence in relation to the programme's history and origins, and the context within which it was established, and its objectives were defined. The stakeholder interviews, combined with desk research provide further insight into the rationale and the relationship between the PI programme and selected other national initiatives. Finally, a desk-based review of other similar initiatives in other countries (their scope, objectives and perceived effectiveness) provides evidence of appropriateness as judged against other relevant programmes, as well as validation for deployment of the SFI PI programme in Ireland.

3.1 The appropriateness of the programme in relation to its rationale, objectives and the wider policy environment

SFI and the PI programme were both launched in the year 2000, not coincidentally at a point of change in the Irish economy and shift in its policy priorities. The rationale and objectives of the PI programme when it was established fell within the wider context and objectives of Irish government support for continued growth in the economy, with a particular focus on moving Ireland towards a knowledge-based economy and stimulating more businesses to operate in high-tech, high value-added areas. The objectives of most of Ireland's science and technology support programmes, under which the SFI and the PI programme fell, were to contribute to the development of a pro-innovation culture and an enhancement of Ireland's capacity and capabilities for research and innovation in academic and business sectors. Within this wider policy framework, the PI scheme had a particular focus on developing human capital, and building research capacity and capabilities in Ireland.

3.1.1 *The establishment of a rationale - the evolution of the Irish economy*

During the preceding decade (and on into the early- to mid-2000s) the Irish economy had experienced considerable growth due to its relatively low wages and high skills, low tax rate and its European location, making it a favourable destination for foreign direct investment. The economy was driven primarily by exports from high-tech industries, most of which were foreign owned, and as a result of the strong economic growth, Ireland had one the highest GDP incomes per capita in the OECD during the period. However, Eastern European countries started to replicate the successful Irish model, and their rapidly developing economies began to threaten Ireland's competitiveness. Consequently, national competitiveness became a pressing issue on the political agenda within Ireland in the latter half of the 1990s.

The 1996 White Paper on Science, Technology and Innovation and the Foresight study of 1999 identified that Ireland's recent growth would not continue because of wage increases compared to global competitors and a general increase in global competition, and therefore it needed to move towards a higher skilled, knowledge-based economy, underpinned by a strong science and research base. The Foresight study said that Ireland should develop into a knowledge society and identified technology as the key driver of growth.

However, even though more than two-thirds of its manufacturing outputs were in technology sectors, Ireland lacked significant research capabilities in science and technology. Irish post-graduate education focused at the Masters level, while PhD grants were few and small, and many of the country's leading graduates and academics had emigrated abroad during the economic hardships in 1980s. Consequently, Ireland had a very limited academic and

industrial research base, and public and private sector investment in research and development was low by international standards. Technopolis' evaluation of the Basic Research Grants programme in 1996/7, for instance, showed that it was spending only about IR£6m per year, while a lot of Ireland's technology research was being funded from the Framework Programme. This evidenced lack of research capabilities and expenditure supports the rationale for the establishment of the PI programme.

In addition, a particular challenge for Ireland was to address the dual nature of its manufacturing sector, where high-tech, high value-added industries were dominated by (footloose) foreign-owned firms, and low-tech, low productivity industry was mostly Irish owned. Although much of the MNCs' activity in Ireland was itself not R&D-intensive, they nonetheless dominated national business expenditure on R&D (BERD), and over time their activities were becoming more knowledge intensive.

3.1.2 The wider policy context for the PI programme

The investments in science, technology and research were a part of the broader National Development Plan (NDP) 2000-2006 that aimed to dramatically increase research and development by both government and industry. The challenge as perceived in the NDP (in place when the PI programme was conceived) was to support the continuation of this growth and to ensure a fair distribution of the outputs of economic success. The NDP objectives covered the broader spectrum of the economy and society and focused on: continuing sustainable national economic and employment growth; consolidating and improving Ireland's international competitiveness; fostering balanced regional development; and promoting social inclusion. Carrying out the NDP objectives required investments of €57 billion of public, private and EU funds. The NDP was in fact developed to fulfil the criteria needed to receive EU structural funds. As a part of these requirements, Ireland was requested to draft and submit a plan (the NDP) with defined investment priorities over the funding period from 2000-2006.

The NDP was comprised of seven Operational Programmes (OPs), including the Productive Sector. This OP was allocated 13% of the total NDP budget (€7.34 bn) and covered the manufacturing industry and natural resources in four priority areas: research, technological development and innovation (RTFI), industry, marketing (i.e. tourism), and sea fisheries development. Within the RTFI priority, seven additional areas were further highlighted which included: higher education, industry, agriculture, food, marine, forestry and the environment.

The higher education priorities emphasised basic support for research and electronic communications, including the necessary infrastructural supports for research in higher education. This also included support for researchers at the individual and project level, strengthening research capabilities with a strong emphasis on industry needs. These are themes that flowed through to the scope and objectives of the PI programme.

In the subsequent NDP (2007-11), there was an enhanced focus on developing research into commercial activity by indigenous enterprise, and increasing the quality and quantity of research, development and innovation activities, as was highlighted in the 2006 STI strategy.

The Strategy for Science Technology and Innovation (SSTI) (2006-13) set out a roadmap for Ireland to develop as a world-class research centre. It noted that under the 2000-6 NDP, the Government made a significant strategic decision to develop a world-class research system, and that investments in SFI had already fundamentally changed the scale and quality of research in Ireland, with exceptional results in a short time. However, it also acknowledged that building a world-class system required dedication, persistence and commitment.

The vision set out by the SSTI, was that Ireland by 2013 would be internationally renowned for the excellence of its research, and at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture. It aimed to achieve this through a marked increase in participation in the sciences, increased numbers of people with advanced qualifications, an enhanced contribution by research to economic and social development, a transformational change in the quality and quantity of research, an increased output of economically relevant knowledge, increased trans-national research, an international profile for Ireland, and greater coherence and exploitation of national/international synergies.

Of particular relevance to the PI programme, the SSTI sought to deliver quality by increasing the number of research teams led by internationally competitive principal investigators, and to increase investment in ‘fourth-level’ (PhD) education through initiatives such as SFI. The strategy was therefore a major driving force behind the second phase of the PI programme.

Drawing on the priorities of these wider strategies, Appendix D presents a summary of the relevant high-level challenges and policy objectives to which the PI programme might have been expected to contribute, in the form of an ‘objective hierarchy’. This shows how the objectives of the programme can be linked back to, and fit within wider policy objectives.

3.1.3 The establishment of SFI and the Principal Investigator programme

Following the foresight exercise at the end of the 1990s that proposed a focus on biotechnology and ICT, the government set up a fund of over €630 million (2000-2006) to develop the country’s research capacity. The National Strategic Research Foundation was also established to support research strategies in ICT, biotech and other key scientific areas. In 2000, this Foundation set up an Advisory Group on Implementation to carry out the identified strategic aims. The Advisory Group supported the objectives set by the newly established Science Foundation Ireland (SFI), and confirmed that this new organisation should fund research programmes to develop world-class research capabilities.

Science Foundation Ireland’s (SFI) mission was to develop Ireland as a centre of research excellence, and to build and strengthen scientific and engineering research and infrastructure in the areas of greatest value to Ireland’s long-term competitiveness and development. It was to invest in research fields likely to generate new knowledge, leading-edge technologies and competitive enterprises, to support Ireland’s move towards a knowledge-based economy.

SFI was intended to have a key role (together with the new research councils) in strengthening Ireland’s academic research base, as a foundation for industrial development. The Principal Investigator (PI) programme was established in 2000, as one of a suite of measures designed to help achieve this, and was the first programme operated by SFI after its establishment. It was SFI’s longest running award (2000 – 2011), and its main instrument for developing research capability and excellence in Ireland during the period.

The establishment of the PI programme was welcomed within the Irish research community. Interviews with PI host institutions showed that the PI programme had been a highly relevant initiative, which had filled a critical gap in the Irish research system at the time. The general view from these institutions was that the PI programme, together with the PRTL (a concurrent Higher Education Authority scheme), addressed the difficult situation that Irish research was in prior to 2000, injecting much-needed funding from national sources. Specifically, the programme:

- Provided a substantial national source of research funding
- Enabled high performing researchers at Irish higher education institutions to build their research groups and expand the scale of their research operations,
- Built up the underpinning expertise and research community that was necessary to feed the more strategic research strands supported by SFI.

A number of specific comments from the host organisations highlighted issues such as the ‘severely under-resourced’ research landscape in Ireland pre-2000 and the fact that many higher education institutions at the time were focused almost exclusively on teaching (rather than research). Some interviewees mentioned that the training available for PhD students was often of low quality, with students “toiling away, isolated in their laboratories”. Elevating the level of research via the PI programme, they felt, helped address these various shortcomings.

Feedback from other stakeholders (SFI, Forfás and DJEI) regarding the relevance and fit of the PI programme, and its appropriateness within the wider Irish STI context and landscape, was also broadly positive, echoing the comments made by the host institutions.

This group of interviewees confirmed that prior to SFI and the PI programme (in the 1990’s), the money available for science and technology was very limited, that there was very limited funding available for PhDs, and that there were not large funding programmes providing

sizeable grants. They reported that Ireland was losing key people, and was not able to attract others, and that there were no mechanisms in place to properly address these issues.

Stakeholders highlighted that the Foresight exercise in 1999 formally recognised this need to build and develop human capital, and established that the key to achieving this goal would be to find (in Ireland and elsewhere), develop and fund research leaders. The PI programme was felt to have addressed this challenge, as it focused primarily on the recruitment and retention of excellent researchers, and on building capacity from a small base or entirely from scratch. It was seen to have had an appropriate and relevant focus in terms of its objectives. One interviewee commented that ‘everything ultimately relies on people, and so a bottom-up approach was appropriate for SFI at the time’.

The PI programme was set up with no themed calls, but open to all areas in biotech and ICT (and later energy), which were themes emerging from the Foresight exercise. ICT in particular was felt to have been very broad in terms of what could be funded. The interviews support this approach and were not critical of the breadth and openness of the programme; as one interviewee put it “it was about getting people in and off the ground”. The feedback provided was that the openness of programme funding was probably the most appropriate route to take at this early stage, given the low base that was being built from.

3.2 Adequacy and balance of resources allocated to the PI programme

SFI invested around €609 million, or 39% of its overall funding during the period, in the PI programme, making it the largest funding scheme in SFI’s portfolio during the period. This equates to around 8% of State investment in R&D (GBAORD) over the period, and so represents a significant part of the research funding landscape in the country. It is also larger than most of the comparator schemes that we have identified (see Section 3.4) – though this is reflected in the scale of the programme’s ambition and objectives, compared with these other initiatives. As SFI’s longest running award (2000 – 2011), and its main instrument for fulfilling one of the key elements of its mission - developing research capability and excellence in Ireland – it appears to be entirely appropriate that the investment made through the PI programme was of such a scale.

The large, multi-million Euro grants that were a feature of the programme at its inception created an initial ‘big bang’ that served a purpose in attracting national and international attention and people. However, such sizeable grants were arguably unsustainable, and perhaps also less appropriate in the longer term, and so during the course of the PI programme (and into the IvP) there was some reduction in the scale of individual awards. This was a gradual shift that seems to have been entirely appropriate.

The grants clearly provided a key source of funding for award holders. Often they were able to shift focus from sourcing and managing multiple grants to concentrating on conducting top-level research at scale, and supporting and developing a wider team. This allowed them to focus on, and develop their teams and research, which enabled the various beneficial achievements and impacts discussed in this report.

The study has identified some concern over the impact of PI grants on the willingness and ability of PIs to secure other sources of funding, both during and after their award. This risked creating an over-dependence on SFI (or at least expectations of follow-on funding) and a sudden stop to activities at the end of awards. While SFI recognised these issues, and tried to tackle them through changes to requirements and better communication, it is not entirely clear whether they were completely resolved. For example, around half of PIs reported that post-award, SFI and other Irish public sources, rather than EU, international or industry sources, provided the majority of their funding. There is also evidence from PIs that some of the benefits seen during PI awards could not be sustained at the same scale post-award because of an inability to secure sufficient funding. However, this is only true in a minority of cases, and more often than not reflects a reduction in activities, rather than a complete halt.

For around half of PIs consulted, their SFI grant became their dominant funding source during their award. However, the dominance of the PI grant within the mix is not surprising given the relatively large size of individual grants, and the intention that it would provide sufficient funding to increase capacity. It is also important to note that most (if not all) PIs maintained a

wider portfolio of not-insignificant funding during the period of their award. In fact, data provided in annual reports to SFI suggests PI teams leveraged significant additional funding (beyond their PI award), which equated to nearly double the total award value (approximately €1.67 was leveraged for every €1 of PI grant funding). Much of this additional funding was from Irish public sources, but around a quarter came from industry and international sources. For most PIs, the PI programme has also then been essential in their subsequent ability to secure funding post-award, both domestic and international.

More generally, stakeholders have reported that from FP6 to FP7 there was a tripling of performance in Irish draw down of funds. Budget cuts resulting from the economic crisis have also further encouraged Irish researchers to look internationally for funding. We therefore believe that any displacement caused by the PI programme was, if anything, only a temporary issue, and not particularly widespread.

3.3 Appropriateness in relation to other Irish initiatives

Before, and shortly after the PI award was established, several other important and closely related initiatives were launched in Ireland. Four with particular relevance to the programme, and which stakeholders have mentioned during the study, are introduced below.

In 1998 the Higher Education Authority (HEA) launched the Programme for Research in Third-Level Institutions (PRTLTI), in order to provide capital funding for third-level research infrastructure, national shared facilities and current expenditure funding to support a range of research programmes. Through investments in human and physical infrastructure, the PRTLTI aimed to strengthen national research capacity and capability, thereby developing critical mass in key research areas, and enhancing collaboration and coherence across Ireland's research system. The programme drew on public funds, assisted by the European Regional Development Fund and private funding through a public/private financial framework. It supported research in humanities, science, technology and the social sciences. Programme funding was provided both for capital (e.g. buildings and equipment) and current (research programmes and people) expenditure. The programme continues today, and has so far completed 5 award cycles, through which it has allocated a total of €1.22 billion to Irish HEIs.

The PRTLTI therefore had similar high-level objectives to the subsequent PI programme, in its aims to strengthen research capacity and capability, and develop critical mass in key areas (though a broader set of focus areas than the PI programme). It funded people as well as infrastructure, but concentrated more on building up departments, and supporting an increase in research technicians and students, rather than focusing on individual research leaders and their research programmes (as in the PI programme). Also, institutions - rather than individuals - would apply for funds and then distribute these internally.

The PRTLTI was repeatedly mentioned by the stakeholders in interview and considered by all consulted during this study to have been complementary to the PI programme. According to one, it had begun to create an 'energy' around universities, in terms of the broad expansion and updating of human and physical infrastructure, that the PI programme could then build on in a targeted way. The development of infrastructure and purchase state-of-the-art equipment is reported to have played an essential part in making these institutions attractive to top research talent when coupled to funding for research groups through the SFI PI programme. Thus the programmes could build capacity in a coherent manner.

The SFI Research Professorship Programme was established in 2002 with the aim of attracting outstanding researchers with particularly distinguished international reputations to Ireland. The purpose was to build up Ireland's research and enterprise base, and enhance Ireland's reputation as a centre of excellence for research. The programme offered world-leading researchers Professorial Chairs at Irish HEIs in research areas targeted by SFI. It was open to individuals with a strong background in industry, and could also be used to fill directorship roles in established (public) research centres. Proposals had to be submitted by a senior member of the host institution and clearly state how the strategic goals of the nominating institution and the recruitment of the nominated candidate align. The programme provided €40M in funding over the 2002-2006 period (6% of funding committed by SFI). At that time, the programme provided up to €500k per annum for a two year period; this changed over the

lifetime of the programme, with current funding levels of up to €5M over 5 years for support of the individual, research team and research costs. Between 2003 and 2008, 18 professorships were awarded, most of which were completed by July 2014. No further awards have been made, but a new call for proposals was released in June 2014.

In July 2014, SFI also launched the Targeted Research Professorship Recruitment Awards programme, in partnership with the seven universities and the Irish Universities Association (IUA). Through the initiative, each university will focus its recruitment strategy on a number of specified target areas, aligned with national and institutional strategic priorities. The grant conditions correspond to those of the Research Professorship awards.

The SFI Research Professorship programme is therefore one of a number of programmes (including the PI programme) that was aimed at developing research capability in Ireland in the ICT and biotech focus areas, and was primarily intended to assist Irish research institutions to attract researchers with an international reputation to Ireland. The Programme complements other SFI programmes which seek to develop Irish researchers, and is regarded by the stakeholders consulted during this study as a potential supporting / feeder programme to the PI programme, and therefore complementary.

The Stokes Professorship and Lectureship Programme was launched in 2006/7, with the objective to facilitate more flexible and proactive strategic recruiting of key research personnel at junior and senior levels by Ireland's HEIs. It allowed research institutions to strategically plan staffing, to integrate quality research staff into the current base of staff and to add to the School's pool of expertise, increasing the number of research active faculty members in the short term. In 2007, 58 awards were made, of which 26 were still active in July 2014. Candidates were nominated by their potential host institutions, and had to have a track record of internationally-recognised independent research as well as at least two years of independent research experience post-Ph.D. SFI provided direct funding amounting to €180k for Professorships and €90k for Lectureships; funding was awarded for up to five years.

Again, this programme was seen by all stakeholders consulted to be complementary to the PI programme, both in supporting award teams, and potentially providing future PI candidates. In particular, the Stokes lectureship grant was mentioned as an important grant for a first career step. Stakeholders reported that when the grant was followed by an SFI PI grant, researchers were able to significantly build up their groups and become research leaders. Therefore it can be seen as an important complementary initiative for the PI programme.

The Centres for Science Engineering and Technology (CSETs) programme involved joint academic-industry research centres located within universities focused on longer-term use-oriented basic research. By conducting high quality academic research oriented to applications and industry needs, the CSETs aimed to better align public investments with longer-term industrial needs, while improving linkages and knowledge flow within the innovation system. CSETs could be funded at a level of between €1-5 million per year in direct costs. SFI funded up to 70% of the overall budget, while a minimum of 30% had to be secured from industry partners. Funding could support a range of research staff including PIs, post-doctoral researchers and PhD students, plus centre managers, commercialisation/ business development staff and technicians. The CSET programme has now ended, but in 2012, 9 CSETs were in operation. The total funding awarded by SFI to these centres was €316M, attracting an industry contribution of €77.4M. The average annual funding per centre was in the range €2.8M - €4.9M. The number of researchers directly linked to CSETs was around 580, with another 950 staff associated with the centres.

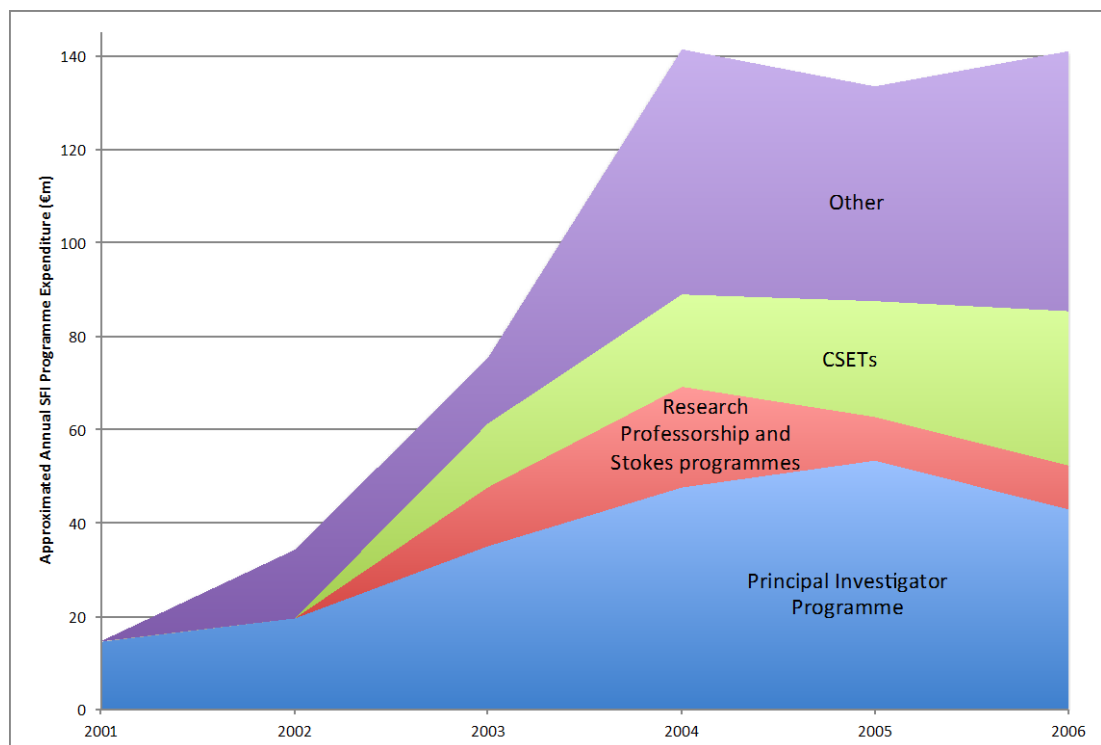
The CSET programme was in operation from 2002, but grew in scale and importance over time. It tended to be regarded by stakeholders during the study more as a follow-on from the PI programme, building on its achievements in developing capacity and capabilities in key research groups, which then supplied these centres. Indeed, the relative freedom of PI awards enabled individuals and groups to explore and pilot new, risky avenues of research, which would not have been possible if all funding had been channelled through collaboration-dependent centres, but which could ultimately justify the establishment of such centres subsequent to PI-funded activity. There was always an intention that the basic oriented research funded through the PI programme would eventually lead to industry applications, but

this was a long-term aim and not an immediate key focus for the PI programme. As such, the CSETs were a natural accompanying measure, feeding on research capacity and capability created by the PI scheme, and bringing this closer to industry.

More recently (2012) SFI launched the Research Centres programme, in order to create (or extend the activity of) a set of world-leading, large-scale research centres, and to provide major economic impact for Ireland. Building on the CSET programme, the Research Centres link scientists and engineers in partnership across academia and industry to address crucial research questions, foster the development of Irish-based technology companies, attract industry, and expand educational / career opportunities in science and engineering in Ireland.

As a visual aid to the evolution of SFI's early funding programmes, the following figure presents approximated annual spend on the PI programme in the context of total SFI expenditure on programmes (including the Research Professorship programme, Stokes programme and CSETs) during the initial six years of SFI operations. It shows the dominance of the PI programme within the funding mix throughout the period, but also the increasing number and scale of other complementary initiatives evolving over time.

Figure 3 SFI annual expenditure on the PI and other programmes



Therefore, while some stakeholders reported that there was the potential for duplication of effort, with the creation of a significant new body (SFI) with a mandate of enterprise and innovation within an existing system, they also felt that this issue had not been realised, and that the PI programme had played a unique and significant role within the wider funding landscape. Other programmes mentioned by stakeholders were seen as complementary to the PI programme, even if their scope or objectives overlapped. For example, the PI programme and the Research Professor Programme both aimed to recruit additional leading researchers, while both the HEA (through the PRTL scheme) and the PI programme both funded equipment. In both cases, the programmes were not seen as directly duplicative, and there was felt to be sufficient space for the two sets of investment.

3.3.1 Recent developments

The Irish economy contracted considerably from 2008 as a result of the global economic downturn, and economic policy shifted to budget cuts and deficit reduction measures. This did not, as far as we are aware, impact overly on the funding levels of the PI programme directly,

but it did significantly change the economic context from that under which the original PI programme rationale and objectives were defined. Since 2001, there had also been an evolution and growth in the wider Irish research system, creating the need to reassess science policy, objectives and priorities more generally. This evolution in the programme environment is something that the Irish Government and SFI responded to.

The government set up a Research Prioritisation steering group in 2010, tasked with making recommendations to Government on focus areas for the next phase of Ireland's science, technology and innovation strategy. Its findings report, in 2012, concluded that policy in the area of research and innovation had served the country well, and that the broad areas around which budgets had been oriented (e.g. ICT and biotechnology) had been appropriate for building a broad base of expertise in fundamental, underpinning science and technology.

However, it also concluded that it was now appropriate to move towards a more top-down, targeted approach, and to focus investment so as to have critical mass in areas that link more precisely to current and likely future societal and economic needs. Specifically, it set out 14 areas for the Irish Government to steer its €500m scientific research budget in order to ultimately translate innovative scientific research into jobs. Another key recommendation of the group was a stage-gate process, whereby researchers will have to demonstrate both the scientific *and* the economic significance of their work before they could get funding.

At the same time the future of the PI programme was being considered by SFI, and in 2011 it was merged with the Research Frontiers Programme (introduced above). The resulting **Investigator Programme (IvP)** awarded its first grants in 2012 and covered research priorities in biotechnology, ICT, sustainable energy, and energy-efficient technologies. The IvP initially had two strands, the Investigator Awards and Investigator Projects, which offered opportunities for more substantial funding for established researchers. The Investigator Awards are larger (max €2.5m), and in some ways represent a follow-on initiative from the PI programme grants. The Investigator Projects provided funding for smaller projects (formerly covered by the RFP) up to €300,000. The PICA scheme was also integrated into the new IvP under the Investigator Career Advancement (ICA) programme.

The IvP has evolved somewhat over its first few years, particularly in response to the findings and recommendations of the research prioritisation exercise. The IvP in 2013 comprised two components: the first in line with the prioritisation areas identified in the 2012 "National Research Prioritisation Steering Group" report; the second based on the collaboration with Teagasc and covering areas highlighted in the report "Future Agri-Food". The current IvP (2014) is now based on a 'themed call' and all research proposals are required to fall under 14 thematic areas. It supports the expansion of educational and career opportunities in science and engineering and encourages new collaborations. It also aims to prepare the research community to win and lead Horizon 2020 research projects and other non-exchequer (industry and international organisation) programmes. The subsequent 2015 IvP programme is expected to be an open call possibly with broader criteria based on both the National Research Prioritisation areas as well as other areas of economic interest.

3.4 Appropriateness - International comparators

The study was tasked with also considering the PI programme in relation to other similar programmes outside of Ireland. SFI wished to understand whether other countries, of similar size and context, had deployed a model or initiative akin to the PI programme, what the objectives and role of these comparable schemes were, and whether they were considered to have been successful in relation to their missions. The intention was that this might help to understand whether the PI programme was an appropriate programme to have run, and provide some validation for its deployment in Ireland at the time.

The study team reviewed a large number of schemes from around the world, focusing on those that targeted established researchers (as with the SFI PI programme), rather than the numerous schemes aimed at supporting up-and-coming young research talent (but that also have some similarities to the PI programme objectives). Ultimately the study had to conclude that the SFI PI programme appears to be unique in terms of its objectives, combining a strong focus on human capacity with retention of top talent in Ireland and alignment of Ireland's

academic research direction with industry interests. There were many examples of initiatives that do *in part* reflect the approach employed by the PI programme, showing that a number of other countries have sought to address similar challenges and objectives through providing grants and positions for leading researchers. However, we have been unable to identify a close comparator, and certainly not in a country of similar size and with a similar context to Ireland.

Nevertheless, we did identify a small selection of 12 programmes and initiatives in other countries that were most similar to the PI programme, and covered a subset of its objectives. Each scheme was reviewed, and its key features and characteristics summarised (presented in tabular form in Appendix G). Many of these schemes sought to attract excellent scientists from abroad (9), while a smaller number sought to retain excellent researchers in country (6) – including 5 that sought to do both. Half of the initiatives had a clear objective to increase capacity or expand the country’s skilled workforce, while the same number sought to increase participation in international research. Most schemes applied to all scientific fields, but some were more selective, and just 2 explicitly sought to align research with industry needs.

All of the selected schemes are ongoing, and have so far been running for between 6 and 22 years. Annual budgets (approx.) vary between €1.2m and €210m (if we exclude the European example), and average €46m across those selected. The PI programme (at €55m per year) is slightly above this average. In fact, only two of the national initiatives selected were larger than the PI programme in terms of their average annual spend. Furthermore, if we take account of the relevant country size (population), the PI programme annual spend (€12 per member of population) is the largest of those assessed.

A selection of these programmes, for which evaluations were publicly available, were assessed in more detail, in order to better understand their objectives, budget, activities and (assessed) achievements. Details are provided in the appendix, but in the box below we extract some of the key similarities and differences between each and the PI programme, to highlight some possible ‘variations on the theme’ that can and have been employed elsewhere.

Figure 4 Selected similarities and differences between PI programme and ‘comparators’

The Canada Research Chairs Program - Assigns Chairs across HEIs, for which individual institutions nominate candidates. Once the appointment is made, universities administer the grant. Universities also need to provide a strategic research plan alongside Chair nominations to ensure that the appointment supports the building of strategic clusters within the system. Awards are fixed, and capped at a lower level than PI awards; however, universities can apply for an infrastructure grant alongside the CRCP application (around €100,000 per Chair).

Catalan Institution for Research and Advanced Studies (ICREA) - While both ICREA and the PI programme aimed to build scientific excellence and research capacity, the primary rationale behind ICREA was to circumvent the rigidity of the Spanish civil service hiring process. ICREA offers permanent, research-only, tenure-track positions from the outset. It does not aim to retain existing talent – in fact, researchers who hold a position at an institution in Catalunya are not eligible to apply (as they have already ‘mastered’ the Spanish HEI hiring process). A separate funding scheme was launched to even out this situation: the ICREA Academia programme, offering top-up funding to researchers with positions in Catalunya.

The Danish National Research Foundation, Centres of Excellence Scheme - While the programme funds research centres, rather than individuals, much emphasis is put on the qualifications of the proposed centre leader when assessing applications. Centres may differ in size and mode of organisation, depending on their subject and scope. Some become rather large during the grant period, employing more than 60 people divided into several research teams, while others have fewer than 15 members. As such, some of the resulting “research units” may be very similar to SFI PI-funded groups. Both CoE and PI have objectives of research training and internationalisation of research groups. However, the CoE programme does not have a specific aim to attract top researchers to Denmark – and since the salary of centre leads continues to be paid by the host institution, applicants already need to have a position at a Danish university. In order to attract foreign talent, D NRF offers a separate funding track - the Niels Bohr Professorship scheme.

The Canada Excellence Research Chairs programme - Requires 100% matched funds from host institutions. The upper level of funding provided by funding bodies is comparable to the PI programme (<€1M / year), but the match funding then doubles this.

South African Research Chairs Initiative (SARChI) - As with the Canadian Research Chair Programme, the SARChI allocated a fixed number of chair appointments to individual institutions across the HEI system. The programme focused on research talent with existing strong (personal) links to South Africa, but did not exclude 'new' researchers.

Innovational Research Incentives (Veni Vidi Vici) scheme, the Netherlands - The 'Vici' component of the programme funds senior researchers that have capacity to independently develop a research field and function as supervisors to younger researchers, but it does not specifically aim to attract foreign research talent.

Differences between the objectives, inputs, activities and intended outputs and outcomes of each of the schemes (and compared with the PI programme), combined with the limitations of information obtainable through publicly available evaluations, and the lack of consistency in data collection between the schemes, do not allow for meaningful benchmarking of performance between the SFI programme and comparator initiatives.

However, we can say broadly that the available evaluation material paints a positive picture of each of the selected schemes, with programmes found to have operated effectively and efficiently and been successful in making progress against their respective objectives. This apparent success of the comparator schemes is reflected in the fact that they all continue, and have often run for many years. Details of evaluative material are provided in the appendix, but below we extract some of the key findings relating to the effectiveness of the comparator programmes, to give a sense of the range and extent of their achievements.

Figure 5 Evaluations of comparator schemes – key findings on effectiveness

The Canada Research Chairs Program - The programme has been well implemented, created a research environment that was conducive to the long-term retention and attraction of top researchers, and continues to be relevant and effective. Chair-holders produced a greater number of peer-reviewed papers, were cited more frequently, and more often published in high-impact journals than comparable groups of leading researchers. The programme fulfilled its objective to contribute to the training of highly qualified personnel, with large numbers of students and postdoctoral scholars trained. Informants agreed that in 2010 Canada was much better positioned with regard to research, nationally and internationally, compared to 2000 when the programme was launched.

Catalan Institution for Research and Advanced Studies (ICREA) - All ICREAs had significant international experience, and the opportunity of a permanent position provided by ICREA was seen as a main factor in their decision to relocate. ICREA Professors outperformed comparator groups of researchers at all levels (Catalunya, Spain, ERA, global) with regards to publication outputs. ICREAs also attracted significant levels of research funding (€34.6 million in 2009 for example), with over 50% of funding from non-Catalan or Spanish sources. Awardees had an exceptionally high success rate in winning prestigious ERC grants, while its share of national R&D investment (public and private) was only 21%. ICREA had a strong impact on the establishment of new research lines and research groups in Catalunya. By 2010, 150 new groups had been created, comprising of between 650 and 750 researchers and PhD students. ICREAs tended to have the most impact when they were clustered into small research institutes (standalone centres or distinct institutes within universities), where they made up a large proportion of senior research staff and had more influence over research strategy, management and content. However, informants indicated that ICREA had not yet led to sustainable behavioural or systemic change in the Catalan research system – if ICREA funding were stopped, many of the benefits achieved to date would cease. ICREA was an effective mechanism meeting a well-defined need and should continue in the same form.

Odysseus Programme, Research Foundation Flanders (FWO) - A particular hurdle to recruitment was the low salary offered at Flemish universities. The programme was also relatively unknown outside of Belgium, limiting the number of potential candidates. The evaluation did not look at the scientific output of awardees.

The Danish National Research Foundation, Centres of Excellence Scheme – COEs strongly contributed to raising the quality of research in Denmark and the international profile of Danish research. The publication record of CoEs was on a par with the highest-performing universities in Europe. An international review panel judged 4 (out of 16) CoE to have achieved world-leader status. The CoE scheme contributed strongly to the training of students and staff, with 8% of all PhD students and 16% of all postdocs in Denmark (2011 and 2012, respectively) working at a CoE. A large proportion of these were recruited from abroad, with a third of postdocs remaining at Danish universities post-CoE award.

While the evaluation commended the Niels Bohr Professorships as a successful additional instrument to recruit excellent researchers from abroad that should be continued, it did not recommend extending the scheme - judging the international visibility of the CoEs and the flexibility of the DNRF's funds which allow the CoEs to seize opportunities of hiring researchers from abroad as the best instruments for internationalising Danish research.

South African Research Chairs Initiative (SARChI) - The programme had been successful in attracting and retaining talented researchers, increasing numbers of graduate students (masters, doctoral and postdoctoral) and enhancing research outputs such as publications. The SACHI had also resulted in the development of significantly improved research capacity at host institutions and created and reinforced nodes of excellence at research universities. This base should be built on moving forwards, with Chairs grouped together into critical mass clusters of excellence.

Innovational Research Incentives (Veni Vidi Vici) scheme, Netherlands - Vici-researchers conducted more innovative/frontier research, had elevated status in the research community, and published more frequently in high-impact journals than the national average. There were concerns about the requirement of universities to submit an integration plan for Vici researchers at the proposal stage – as this could slow the application process, and limited the negotiation position for a long-term appointment after the grant had come to an end. Several negative effects of the matching requirement were noted - institutions discouraged researchers from applying to ensure they only received a 'manageable' number of applicants, and it limited researcher mobility between Dutch institutions (the requirement was dropped in 2009). The receipt of a Veni Vidi Vici-grant enhanced the probability of a successful career in science. Grant recipients were more likely to remain in academia, to become a full professor and to receive follow-up grants.

3.5 Overall finding on the appropriateness of the PI programme

This section has provided evidence and assessment relating to the appropriateness of the PI programme, through consideration of its rationale and objectives, policy context and allocation of resources, as well as other initiatives within the Irish research system and elsewhere.

Reviewing the evidence presented from the desk research, the intervention logic, interviews and the international comparison, the PI programme can be seen to have been wholly appropriate in its rationale and objectives and responding to the needs of Ireland over its programming period.

The coherence of the programme with a wider portfolio of policies and objectives at the national level is well demonstrated through the literature review and the interviews. It is also shown to have been coherent and complementary to other related initiatives in the national research system at the time, and institutions in Ireland have been using the programme mix to attract top research talent and ensure career progression can be facilitated.

The PI programme focused on enhancing Ireland's capacity and capabilities for research and innovation through the development of human capital in particular. The broad focus of the programme was the right approach at the time, allowing bottom up development of capacity in the broad areas of biotech and ICT (and later energy). Subsequent changes in the economic and policy context have led to a greater prioritisation and focus, which is an appropriate response. The approach taken by the PI programme was especially well tailored to address the needs at the time the programme was instigated, and there was a positive and well-judged gradual evolution of the PI programme, to reflect learning over time and changing needs and priorities.

The funding of the PI programme, although large in comparison to some other programmes identified, represented a necessary significant investment in an underdeveloped area in Ireland. It facilitated the shifting of focus from sourcing and managing multiple grants to concentrating on conducting top-level research at scale, and supporting and developing strong research groups and teams. The initial large investment to attract and retain talent served its purpose, although issues of over-dependence are highlighted in the evaluation, some of which appear to be overstated if looked at in relation to the leverage effect.

The SFI PI programme is uniquely tailored to address the Irish context. Although there are international programmes that *in part* reflect the approach employed through the PI programme, there are no close comparators. The evaluations of these other programmes (where available) point to their own effectiveness and efficiency, adding further weight to the judgement of the PI programme as an appropriate approach to address its objectives.

These overall findings on the appropriateness of the PI programme feed into the summary and conclusions, presented in Section 6.1.

4. Programme effectiveness

This section addresses the effectiveness of the PI programme in relation to its aims and objectives, and in particular its achievements in building scientific research capacity and capabilities within Ireland. It presents an analysis of outputs, outcomes and impacts realised by the programme and its individual awards and award holders, drawing on formal reporting data as well as information and assessments collected during the study from direct programme beneficiaries themselves (PIs and team members), host institutions and wider stakeholders.

4.1 Programme outputs

High quality, high impact publications are seen by SFI as a cornerstone of the PI programme. However, a wider set of educational and collaborative outputs, resulting from PI awards, are also important. There is also an expectation that the research emerging is converted into real economic return. Industry collaboration and technology transfer are both tangible indicators of this conversion, as are other pre-commercial outputs such as licensing agreements, patents, spinouts, and other technology transfer activities.

SFI collected data on these various outputs through PI annual reporting requirements, and the following figure presents an aggregation of this information from across the programme period (based on data reported to SFI by individual award holders). The three columns show:

- The number of award holders who reported the production of a given output (e.g. 102 PI awards resulted in at least one MSc degree)
- The total number of a given output reported across all awards (e.g. 195 MSc degrees resulted across all awards)
- The average number of a given output produced per award, assuming an even distribution across all PI awards (e.g. on average each award resulted in 0.5 MSc degrees)

Because of changes to reporting requirements, data on some outputs is only available for the pre-2006 period (as indicated in the table). As a result, averages are calculated based on the total number of awards in the relevant period only.

Figure 6 Reported outputs from PI awards

Number of... educational outputs	Number reporting output	Total outputs reported	Avg. per award in period
MSc degrees awarded	102	195	0.5
PhD degrees awarded	218	540	1.4
Number of... academic outputs			
Journal Refereed Research Papers published	383	6,766	17.4
Journal Refereed Review Papers published	112	280	0.7
Refereed Conference Proceedings	204	1,572	4.0
Other publications (e.g. books)	239	1,108	2.8
International Presentations (pre-2006)	195	5,733	35.8
National Presentations (pre-2006)	79	568	3.6
Scientific Awards Won (pre-2006)	103	460	2.9
Conference workshops hosted (pre-2006)	31	76	0.5
Number of... collaborations			
Collaborations with Irish academic institutions	234	626	1.6
Collaboration with international academic institutes	342	1,814	4.7
Industry collaborations (Irish)	169	425	1.1
Industry collaborations (international)	182	525	1.3
Number of... pre-commercial outputs			
Invention Disclosures	<i>(unknown)</i>	189	0.5
Patent Applications	118	271	0.7
Patents Awarded	37	55	0.1
Licensing Agreements Signed	25	33	0.1

Averages are based on 160 awards (pre-2006), and 389 awards (all).

In addition to the above outputs, SFI data shows that 13 spinouts are known to have been created, from six different HEIs. Further to this, 26 researchers are known to have collaborated with Enterprise Ireland spinouts.

Finally, in terms of programme outputs, data provided through annual reports (see below) suggests that PI award teams were able to leverage significant additional financing from other sources during their award, which will have enhanced the opportunities enabled by the PI grant. Specifically, the data suggests that for every €1 awarded in PI grants, an additional €1.67 was leveraged from other sources during the award (including approximately €0.95 of Irish public funding, €0.36 of international funding, and €0.09 of industry funding).

Figure 7 Funding leveraged

	Number reporting funding	Total funding	Avg. per award in period
PI programme funding (award amount)	389	€ 495,425,620	€ 1,273,588
Funding leveraged from other Irish public sources	308	€ 299,966,308	€ 771,122
Funding leveraged from other international sources (€ exchange rate for data of award used)	219	€ 175,958,935	€ 452,337
- Funding leveraged from EU-only sources (included within international above)	164	€ 136,684,377	€ 351,374
Funding leveraged from industry	86	€ 43,060,795	€ 110,696
Other SFI funding (pre-2006 awards only)	140	€ 170,215,491	€ 1,063,847
Funding leveraged from other (2006+ awards)	6	€ 606,705	€ 2,649
Total funding leveraged		€ 826,492,611	€ 2,124,660

Annual reporting data. Averages based on 160 awards (pre-2006), 229 awards (2006+), 389 awards (all)

4.1.1 Bibliometric analysis

The study team undertook a bibliometrics exercise in order to further explore the quantity and quality of relevant academic outputs – at national and programme level – during the period of the PI programme. The analysis is shown in full in Appendix E, and summarised here.

Irish and peer country publication activity in ICT and Biosciences

The study first considered Irish publications generally in selected ‘proxy’ fields for the PI programme focus areas of ICT and life sciences over the period of the programme, and then placed this in an international context, by comparing against peer countries of a similar size.

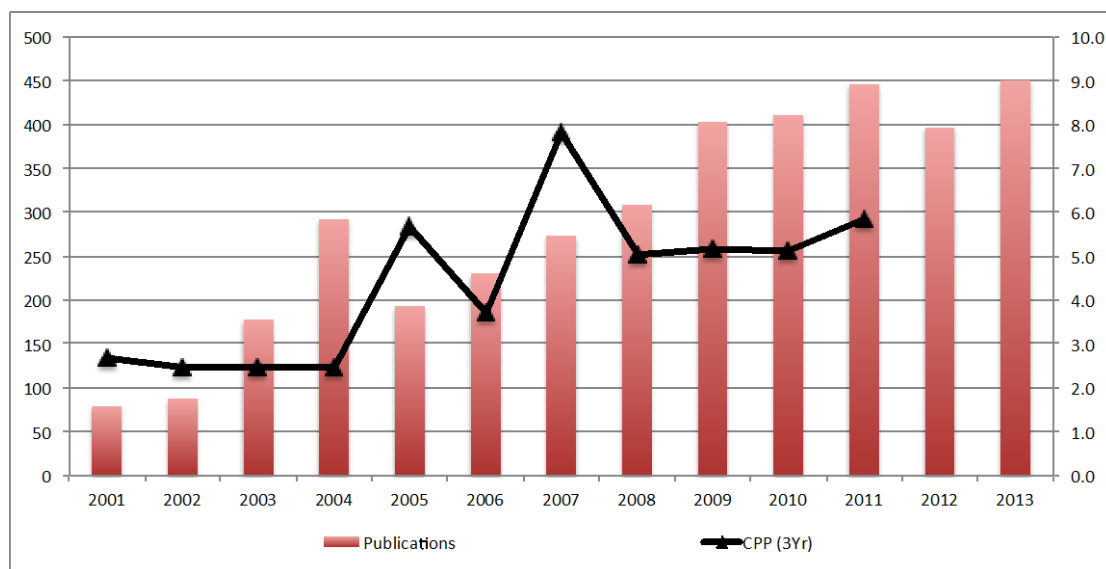
The ICT area within the PI programme actually encompasses elements of a broad range of disciplines (physics, chemistry, materials science, engineering, applied mathematics etc.), and it was not possible to cover the full breadth of this remit within our analysis. The field of **computer sciences** was therefore analysed as an (imperfect) indicator for ICT – and it cannot be assumed that this offers a good reflection of the wider programme area of ICT.

Ireland’s contribution to the global publication of articles and reviews in computer sciences is relatively small. There were 3,750 publications with an Ireland-based author in the field from 2001 to 2013, ranking it 36th among producing countries. However, as can be seen in Figure 8, during this period the number of computer science publications per year with an Irish author increased dramatically – from around 80 in 2001 and 2002 to around 400 per year from 2009. The average annual growth rate in publications across this period was therefore 15.6%.

In 2002, there were only 11 Irish authors with two or more publications (one of whom went on to be a PI). By 2003 (just a year later), there were already 52 authors with two or more publications (including 13 current or future PIs).

The average number of citations per publication (CPP) (based on a 3 year citation window) for each of the years 2001 to 2011 is also shown in the figure (the window for later publications is not yet complete). This suggests a gradual increase in the citation rate of publications over the period, from a rate of 2-3 CPP in the first four years, to a rate of 5-6 CPP in the latter four years covered. This equates to a near-trebling in the (short-term) citation rate of Irish computer science publications during the 10-year period.

Figure 8 Evolution of Irish publications and citations per publication in computer sciences



Data: Scopus, Calculation: Technopolis

The figure below compares Irish computer science publication metrics with those of five selected ‘peer’ countries. As can be seen, Ireland started from a very low publication base in 2000, but experienced a high growth-rate over the following decade. As a result, its total publications during the 2001-13 period came close to that of Norway and Denmark, and well above that of Slovakia and Hungary. Almost 90% of Irish publications from 2001 were cited over the subsequent decade (including self-citations), which compares well with the other countries shown. However, Irish publications from 2010 have so far obtained less attention relative to other countries in the shorter 3-year citation window.

Citations are not only an indication of quality but also a signal of how well researchers are connected in their respective communities. In order to be noticed – or one’s publication to be cited – it helps to have international co-authorship and to have large networks. Peers cite each other more often when they also know each other. Of the countries shown, Ireland has seen the second biggest increase (after Norway) in the proportion of international co-publications between 2001 and 2010. In terms of international co-publications, the US and the UK are the preferred partners of the Irish authors. About 10-12% of the total 3,750 Irish publications have co-authors from these two countries. Germany, France, Spain, Italy and China follow. Gaining US co-authors tends to be an asset for being more widely cited, and we see Irish co-authorship with the US increase significantly from 2003 onwards.

Figure 9 Computer science publications (2001-13) for Ireland and peer countries

	IE	DK	FI	NO	SK	HR
Total publications (articles, reviews)	3,745	4,862	6,856	4,453	1,322	1,196
Average annual growth rate (in %)	15.6	12.1	9.5	12.6	10.5	10.5
% of cited documents 2001	87.5	80.0	80.0	82.4	79.3	40.0
% of cited documents 2010	58.2	68.4	62.3	66.8	60.7	51.0
% of int’l co-publications 2001	26.8	38.7	26.0	31.0	44.8	7.5
% of int’l co-publications 2010	49.0	59.4	46.7	53.7	50.4	28.8

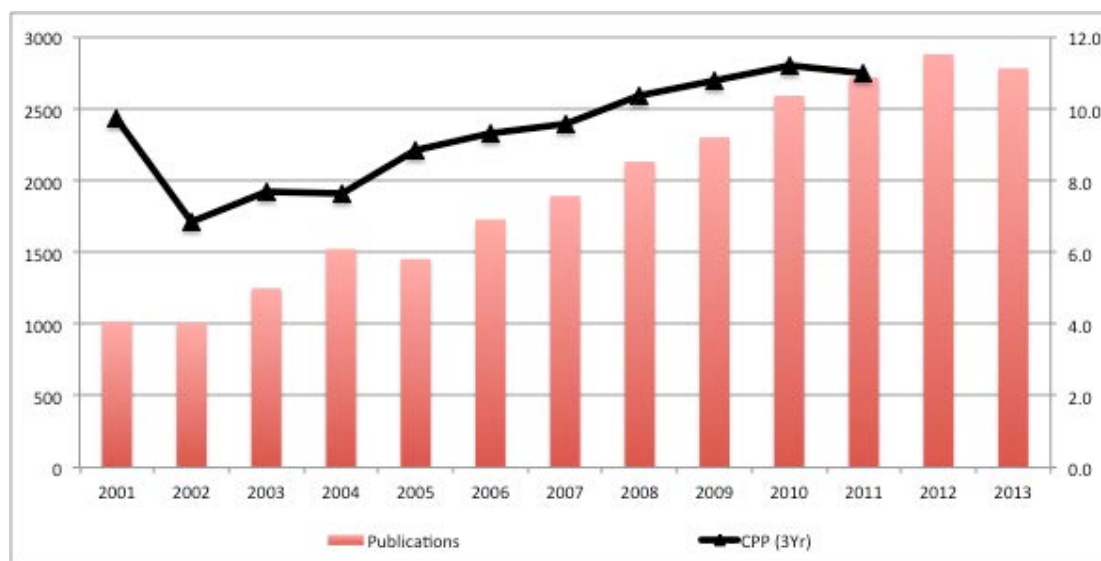
Sources: Scopus; Scimago. Calculations: Technopolis, Scimago

Over the same 2001-2013 period, Irish publications in the broader field of **life sciences** grew by 8.7% per year on average, from 1,000 publications in 2001 to over 2,500 in 2013 (see Figure 10 below). This compares very favourably to an average global annual growth rate during the period of 5.2%. It is also higher than the growth rate in any of the five comparator countries.

The average number of citations per publication (based on a 3 year citation window) for each of the years 2001 to 2011 is also shown. This suggests a gradual increase in the citation rate of publications over the period, from around 7 CPP in 2002 to around 11 CPP in 2011.

The high CPP rate in 2001 can be attributed to *Nature* paper ‘Initial sequencing and analysis of the human genome’, which was cited over 3,000 times in the 3-year citation window. Without this publication, the CPP for the year would be 6.5, and therefore in line with the general trend.

Figure 10 Evolution of Irish publications and citations per publication in life sciences



Sources: Scopus; Scimago. Calculations: Technopolis, Scimago

Within the life sciences globally, ‘Biochemistry, Genetics and Molecular Biology’, ‘Agricultural and Biological Sciences’ and ‘Medicine’ are the largest sub-fields. We compared various metrics in these fields between Ireland and the five comparator countries. Full tables of data are shown in the appendix, but in summary the information suggests that:

- Biochemistry, genetics and molecular biology - between 2001 and 2010, Ireland saw the biggest absolute increase in publications amongst the comparator countries (except Denmark) and the biggest relative increase overall. Its percentage of cited publications also compares well in both years. Its international co-publication rate remains similar to the Nordic examples, and above the Eastern European examples across 2001 and 2010.
- Agricultural and biological sciences - a similar pattern was found. Again, Ireland saw a significant increase in the number of publications per year over the period, and a citation rate similar to the Nordic comparators. Its international co-publication rate though did not see the increases evident in some of the other countries assessed.
- Medicine - Ireland has seen the largest increase in the number of publications 2001-10 of the countries assessed. Its citation rate compares favourably in both years, and its international co-publication rate has remained similar to most other countries assessed.

Overall, what we can see from the international bibliometric comparison with three Nordic and two eastern European countries of a similar size is that Ireland managed during the ten year period of the PI programme to keep pace with the acknowledged leaders among small countries - though not to outrun them – and to pull ahead of the two late developers assessed. This is a considerable achievement given the scale of investment in R&D in the Nordic countries considered, where R&D was 1.5%-4% of GDP during this period. The PI programme, as a major funder of research in life sciences (in particular biotechnology) and ICT, will have contributed considerably to this progress.

PI publication record

The study also used bibliometrics to explore in more detail the individual publication records of three samples of PIs (106 individuals in total) taken from different periods of the programme. This analysis – presented fully in Appendix E.1 – attempted to look at the change in publication, citation and non-citation rates for these individuals before and after the award of their PI grant, as well as longer term citation patterns for some of the earliest award holders.

Factors such as the differences between the length of individual PI awards, variance in the (general) publication patterns of different scientific fields covered by the programme, and time-lags in the publication process, all add to the difficulties of undertaking and interpreting such analysis, and the results emerging from the bibliometric exercise undertaken often did not show particularly clear patterns and trends. Nevertheless, the analysis does suggest:

- An increase in the publication rate (on average) for the samples of PIs over a six year period that is broadly centred around the PI grant award date.
- And in particular, a substantial increase in the average publication rates for each of the three samples from the period immediately prior to the PI award to the period in which the award was made (by 20%, 13% and 43% respectively).
- An increase in the number of citations per PI (3 year citation window) for the same six years of publications, and in particular between pre- and post-award.
- However, there is no clear or consistent trend in (3 year) citation rates per publication across the samples – suggesting that the increase in publishing rates has dampened the increase in citations somewhat.
- A decrease in the proportion of un-cited papers over the 6 year publication window.

For our earliest sample of PIs (those funded in 2003-4), we compared short (2003-6) and long (2003-11) citation windows for their publications from the time of their PI grant award (2003-4). This showed that increasing the length of the citation window increases the average citation rate per publication for this group considerably, from 9 to 22 citations per publication on average (an increase of 139%). The proportion of uncited publications also more than halves from 21% to just 8% of the 271 total publications when the citation window is extended. This suggests that over time, the citation analysis for the other groups may also change considerably, potentially providing a different outcome to that presented above.

Counterfactual

SFI specifically requested an additional bibliometric exercise to compare a sample of PI award holders with a sample of applicants that only just missed out on funding. However, while this analysis revealed a larger publication history among the funded recipients (which could just reflect the age / seniority), there was little difference in the indicators of quality / impact between the two groups – at least at the aggregate level. This is perhaps not surprising, given that we were looking at borderline (fund / do not fund) applicants.

Further details of the counterfactual bibliometric analysis are provided in Appendix E.3 .

4.2 Programme outcomes and impacts for PI award holders

All PI award holders were invited to participate in a short online questionnaire about their experiences as a PI award holder. This explored the achievements of the programme in attracting, retaining and developing these individuals, and assessed the outcomes and impacts of the grant and programme on the award holders and their research activity, both during and after the award. In this section we analyse the results and feedback provided by these beneficiaries, alongside evidence collected from other stakeholders.

4.2.1 Motivations to apply

As the PI programme sought to attract and retain high-calibre research leaders by offering an internationally competitive opportunity, the questionnaire explored with the funded PIs their motivations for applying to the PI programme. Specifically, respondents were asked to select what was most attractive to them about the PI grant that might not have been available to them otherwise – and therefore also assess the importance and uniqueness of the programme.

For most respondents, the main attractions of the programme were the length of the grant and the funding security this provided (76%), and / or the significant size of the grant (70%) – both key features of the PI awards. The fact that the grant provided funding for postdoctoral researchers, PhD students and consumables were also each seen as key attractions in a number of cases (44%-57% of respondents in each case).

One in five respondents pointed to another main attraction of the grant, beyond those listed in the questionnaire. The most commonly cited ‘other’ factor was the flexibility of funding, or what specifically could be funded through the grant (which included travel, new / specialised equipment, PI salary / reduced workload, overheads to the host university, new lab start-up, and other infrastructure). Another commonly mentioned attraction was the fact that the size and scale of the grant enabled internationally competitive research and critical mass (visible in increased productivity and networking, bigger teams, larger and more ambitious research, and meaningful collaborations). Others pointed to the general flexibility of the programme and its relatively lightweight bureaucracy, the fact that it funded basic research, and the recognition gained from a peer-reviewed award based on excellence.

Two more detailed elaborations of the motivations for specific individuals are provided below.

“The grant would allow flexibility and continuity, and the possibility to maintain a more ambitious long-term research programme. This in turn would ensure that the postdocs and PhD students could acquire high quality training and publications, enabling them to compete for academic and industry positions.”

“The award would allow me for the first time to focus my research on one specific area, and to expand the research team. We would also not have to focus all our attention on obtaining the next grant. As a result of the focused research effort we could develop meaningful new research collaborations with academic institutions and companies, and the award could serve as a platform around which other projects could be clustered.”

4.2.2 Location and position of PI grant holders

Given the intended mobility aspect (attract, retain) of the PI programme, award holders were also asked about their location and employment before and after their PI award(s).

Immediately prior to their (first) award, three quarters of the responding PIs (76%) were already based in Ireland, almost all within academic institutions. The remaining quarter were based abroad, again within academia in nearly all cases. Both groups were asked to rate (on a 1-5 scale) how important the SFI PI grant award was to their decision to take up (or remain in) a position at an academic institution in Ireland (see figure below). On average respondents gave a rating of 3.9, which indicates that the PI award was generally considered very important to this location decision. Half of respondents said that it was critical, with a further 16% rating it as highly important (rating of 4). For only 9% was it not at all important.

Figure 11 Importance of PI grant to taking up / remaining in Irish academia (n=176)

1 = Not at all important	2	3	4	5 = Critical	Average Rating
9%	9%	16%	16%	50%	3.9

When asked what they would have done if not awarded a PI grant (‘counterfactual’), only 45% of respondents said that they would have remained in/moved to Ireland. More specifically:

- Of 129 respondents already based in Ireland, 40% felt that they would have left the country if they had not been awarded the grant (in a handful of cases additional comments were provided suggesting that these individuals were aware at the time of specific opportunities / offers in another location, or are likely to have returned to their native country)
- Of 44 respondents based outside of Ireland, only 5% felt that they would have taken a position within Ireland without the PI award

These responses suggest that the PI award has been hugely important in both attracting and retaining the individuals that it has funded, at least at the time when the award was made. Assuming the responses are broadly representative of the wider PI population, then we can estimate that **of the 281 total awardees, only 130 are likely to have come to / remained in Ireland without the PI programme grant.**

At the time of writing, just under half of PIs responding to our survey were still being funded through the PI programme. Those whose grant had ended were asked where their work is now primarily based. A small number (4%) have now retired, but of the remainder, 89% are still based in Ireland, while 11% are primarily based abroad. This suggests that the immediate success of the award in attracting/retaining individuals has been largely sustained in the longer term – with **nearly all PIs having chosen to remain in Ireland post-award.**

In the small number of cases (n=11) where respondents have left Ireland after their PI award, these individuals were asked what their main reasons were for leaving. Some pointed to negative features of Ireland, while others highlighted positive features of their alternative location. A summary of their comments is provided below.

Figure 12 Main reason for leaving Ireland after PI award

<ul style="list-style-type: none"> • Changes in the funding scenario in Ireland • Lack of Irish funding for particular field of Health • Lack of Irish funding for area of fundamental research • Felt like a foreigner and not wanted • Forced retirement at 65 in Ireland • Lack of funding available for salary • Lack of research career track in Irish Universities • Overall economic situation 	<ul style="list-style-type: none"> • More interesting challenges and supportive environments • Position offered outside Ireland significantly more competitive • Offer of a tenured professorship with long-term prospect of research funding • Family reasons
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The same small group of PIs were asked whether / what research links they still maintain with academic institutions or industry in Ireland. Most pointed to ongoing or ad hoc collaborations with Ireland, as well as informal interactions with ex-colleagues and collaborators, while one respondent reported that they held a visiting professorship within Ireland. Therefore, even when PIs have moved away, they have all retained links and working relationships with Ireland, in addition to any wider legacy that they may have left behind.

4.2.3 Funding and funding sources of PI grant holders

PI award holders were also asked about funding, and specifically how their research was funded before their (first) award and (if their award(s) had finished) after their (last) award. The importance of the PI grant for securing follow-on funding was also explored.

Immediately prior to receiving their (first) PI award, most respondents reported that they received a substantial proportion of their research funding from Irish public sources (see figure below). In a small number of cases (18%) this was from SFI, but for most respondents it was another Irish funder. One third of respondents stated that they received a substantial proportion of their funding from public sources in other countries, and a third pointed to EU funding. A small proportion (23%) sourced much of their funding from industry. Other funding sources (mentioned by 15%) included charities and foundations (e.g. Wellcome Trust), international funders (e.g. NATO) and internal (university / company) funding. In a handful of cases, respondents reported that they did not have funding before their first award.

Figure 13 Main sources of research funding prior to PI award (n=171)

Main funding sources	Response
Grant from non-SFI public sources (Ireland)	54%
Public funds from other countries	32%
EU grant	31%
Funding from industry	23%
Other SFI grant	18%
Other	15%

Note, that respondents were asked about the source for the majority of their research funding, but were able to select more than one option, so responses sum to more than 100%

Most respondents reported that during their PI award period, this grant provided much of their research funding. For 41% it accounted for more than two-thirds of all funding, while for a further 45% it accounted for between one-third and two-thirds of the total. For only 16% of respondents was the PI award a relatively minor source of funding (<33%). The dominance of the PI grant within the mix is not surprising given the relatively large size of individual grants, and the intention that it would provide sufficient funding to increase capacity. However, it is interesting to note that most (if not all) PIs maintained other not-insignificant funding during the period of their award. This may have been important in aiding a smoother continuation of activities after the PI award, rather than a ‘cliff-edge’ at grant end.

Annual reporting information to SFI on funding leverage (presented earlier in Section 4.1) supports this assessment, suggesting that for every €1 awarded in PI grants, €1.67 was leveraged from other sources during the award period.

At the time of writing 43% of PIs responding to our survey were still being funded through the PI programme. Although the final round of applications was in 2011, many awards started the following year, and still have a further year or two to run. Those PIs whose (last) award had ended were asked how the majority of their research was funded after the PI grant. A quarter stated that it was through another SFI grant (not the PI programme), while a further 23% pointed to another Irish public source as their subsequent main source of funding. EU grants were the main source for 16%, and grants from other countries were the main source for 10%, while industry was the dominant funder in 7% of cases.

Those not selecting an option (10%) reported that this was because they had retired, they had not yet obtained any further grants, they relied on internal (university/company) funding, or that their funding was split relatively evenly between a number of sources.

Respondents no longer funded through the PI programme were also asked how important (on a scale of 1-5) they felt that their PI grant had been for securing other (follow-on) funding from either Irish or other sources. As can be seen in the next figure, a majority of respondents regarded the PI programme as “essential” in securing both Irish and international funding.

The ‘average’ response in both cases was a little over 4, which we can interpret as meaning that the PI grant was considered ‘very important’ to securing follow-on funding from both domestic and international sources. Only a very small proportion of respondents (4-5%) felt that their PI grant had not been important to securing follow-on funding.

Figure 14 Importance of PI grant for securing follow-on funding from... (n=104-106)

	1 = not at all important	2	3	4	5 = essential	Avg. Rating
From Irish sources:	4%	5%	9%	28%	55%	4.3
From international sources:	5%	8%	9%	28%	50%	4.1

4.2.4 Impacts on the grant award holder

Respondents were asked more broadly to assess the extent to which their PI award(s) had had a positive impact on their own subsequent activities and experiences. The response across all eight areas (shown below) is extremely positive, with at least two-thirds of respondents giving a high rating (4 or 5) to the impact in all areas (except links to industry - where only around half gave a high rating). Impacts on the scale of research activities and on national/international reputation were particularly high / widespread.

Figure 15 Impact on PI's subsequent activities and experiences (n=173-175)

	1 = no impact	2	3	4	5 = large impact	Avg. Rating
Your national and international reputation	3%	2%	8%	29%	59%	4.4
The scale of your research activities	2%	5%	14%	28%	51%	4.2
Your national and international networks	3%	3%	18%	42%	33%	4.0
Your research direction	6%	2%	20%	37%	35%	3.9
Your ability to access and secure funding	6%	6%	17%	35%	36%	3.9
Your ability to attract high-calibre team members	6%	6%	18%	39%	29%	3.8
Your career progression and opportunities	10%	8%	16%	31%	35%	3.7
Your links to industry	15%	11%	21%	31%	22%	3.4

When offered the opportunity to provide further information, many PIs responding to the survey chose to highlight the importance of the PI award to their research and career, and to give thanks to the opportunity provided. A selection of their comments is shown below:

I am very grateful for the funding. My current research successes are largely based on the body of work completed through my PI award.

The PI award has helped elevate my centre to being one of the foremost such groups in the world.

My grant was an enormous help to my research career.

Prior to the PI scheme, the best applied mathematicians left Ireland to find work. The PI scheme made it possible to build a team and retain excellent students in Ireland.

The award of a PI grant has had a major benefit on my research outputs. The team effort has transformed my outputs and allowed planning of research programmes that will compete on an international stage.

The PI Award has enabled my group to tackle significant problems of scale.

The PIs grants I've been awarded have been absolutely essential in providing the core funding for my research group for basic research, and have provided leverage for additional EU and US funding

The recognition from SFI at this point in my career was important for subsequent career development

It has had an extremely positive impact on my research and reputation in the field and played an important role in my being promoted to a Professorship

I would like to express my highest gratitude to SFI for giving me the possibility to develop my own research agenda successfully as well as enabling me to carry-out critical fundamental research, and experience and build links to applied research involving industrial partners

My original PI grant was instrumental in bringing a significant team of 6 senior industry researchers. Since that time the group has grown to around 30 people and has established one of the leading photonic systems labs in Europe. The group also seeded and led the development of the Photonics Centre at Tyndall, which now comprises 130 researchers. None of this would have been possible without the strategic vision and funding supplied. As a result of SFI, Ireland now has a national research capability that is able to compete on the world stage.

The PI grant was a huge break in my career in 2005. SFI had never funded drug delivery before and it was previously regarded as low-grade pharmaceutical industry science. I am very grateful for it and I believe I used it well to open doors to subsequent SFI and EU consortia grants. It was also appreciated by UCD and was an important factor in facilitating promotions in 2005 and 2006.

Without the PI award in 2003 I would not have my research group here in Ireland and so Ireland Inc. would have lost all my industry collaborations (~3M€ since 2005), the 50+ papers since 2003 etc. In essence an open PI scheme is for all intensive purposes an ideal vehicle for tenure track recruitment of high quality academic staff into the universities

Building on this, a selection of ten PI award holders were also interviewed by the study team, to discuss in more depth some of the key achievements and impacts made possible by their PI grants, as well as explore personal perspectives on the PI programme. Mini cases studies for each individual are presented in Appendix F, which include:

- **Dr. Thomas Ritter**, at NUIG, whose PI awards allowed him to build a strong and stable team and focus on core research. The grants enhanced his local and international status and reputation, enabling him to form international collaborations and access significant funding

- Professor Dermot Diamond, at DCU, who believes that a decade of PI awards has had a very positive impact on the research scene in Ireland, building capacity in the research base in terms of the PIs themselves, but also a wider population of future research leaders
- Professor Louise Kenny, at UCC, whose PI award helped accelerate scientific progress and draw attention to her research, leading to a spin-off company and investment in a new research centre, plus approaches from multi-national companies
- Professor Mike Lyons, at TCD, whose group has been able to develop a world-leading reputation and work towards an ERC application off the back of a PI award. Their work on facilitating the splitting of water into hydrogen and oxygen at lower cost and higher efficiency has made the economics of water splitting more realistic
- Professor Paul Moynagh, and NUIM, who was able to move from small-scale fragmented project work to a more focused, impactful programme of research because of his PI awards, with a strong team and critical mass that has enabled the development of a strong international reputation. The long-term nature of the PI funding has meant that he has begun working on translating earlier fundamental work in collaboration with industry
- Professor Douwe van Sinderen, at UCC, who believes the PI programme has been able to quickly raise the knowledge base in Ireland, enabling it to become a global leader in many areas, including his own. He has been able to build critical mass that has attracted industry funding, that is already of an equivalent scale to the initial PI grant input
- Professor Ian Robertson, at TCD, whose PI grant first allowed him to establish and run an fMRI imaging programme, which has helped take cognitive neuroscience in Ireland from a small dispersed base into a new era of inter-disciplinary critical mass, where top young international talent is attracted to work in Ireland
- Professor Chris Dainty, at NUIG, who used his PI award to shine a light on the university and Ireland, and to reach out to industry. Having helped to improve the reputation of optics and photonics research in Ireland, Chris has now retired, but the strong group that is now in place continues to develop its expertise and international reputation
- Dr Paul Hurley, at Tyndall National Institute, who went from a small team of himself and a PhD student undertaking lots of disconnected projects in an effort to secure sufficient funding, to a team of 11 people who were able to focus their efforts and build a strong research group with international reputation, while Paul is able to spend a more manageable proportion of his time on administration and identifying funding opportunities
- Professor James Gleeson, at the University of Limerick, who stayed in Ireland rather than moving back to the US because of his PI award. He has been able to build a group and fund a number of promising PhD students who would otherwise have left the country

Evidence from the interviews with host institutions supports the assessment provided by the individual PIs. All host institutions agreed that PI funding had allowed grant holders to significantly improve the quality and quantity of their research outputs, their visibility and reputation within the research community, and their access to high-level national and international collaborators.

They reported that prior to the SFI PI programme, the researchers concerned often had to spend a great deal of their time applying for funding, generally from the EU or the Wellcome Trust (life sciences). This was a particular issue for PIs who were trying to establish new research groups, and led to a long lag time between the start of an appointment and their ability to conduct top level research at a significant scale. Interviewees felt that by freeing up time and providing generous resources, PI awards moved grant holders' research "up a level". For example, one interviewee pointed out that papers in the highest impact journals had been few and far between pre-2000, whereas now these were no longer an exception to the rule. This is further corroborated through our bibliometric analysis.

Host institutions also reported that PI grants conferred prestige on the PIs, which enhanced their ability to forge collaborations with top researchers, nationally and internationally. For example, one interviewee said that the SFI PI grant had helped a researcher at his institution to expedite and formalise a research partnership with one of the established CSETs.

4.3 Programme outcomes and impacts for PI award team members

Known PI award team members (Masters students, PhD students and postdoctoral researchers at the time) were also invited to participate in a questionnaire about their experiences in a PI award team, and in particular to provide assessments of the outcomes and impacts of the grant and programme on their training, skills and development, and their career opportunities and direction. In this section we analyse the results and feedback provided by this group.

4.3.1 Introduction to the PI team members consulted

Over half of respondents to the survey (54%) were PhD students in their PI funded group, while just 5% were Masters students. The remaining 41% of respondents were postdoctoral researchers; split relatively evenly between first-time and more experienced postdocs.

Most respondents (68%) had their position within the team entirely funded through the PI grant, while 16% were partially funded in this way. Only 16% reported that their position had been entirely funded by other means (most commonly IRCSET, EU funding, university/college grants and fellowships, the Health Research Board, and foreign public funding).

Most team members responding to the survey (80%) had joined the PI award team after the SFI PI grant was awarded, while the rest were already part of the group. These two groups were asked slightly different questions, based on their different experiences / perspectives.

4.3.2 Team members joining once the PI grant was awarded

The 80% of respondents joining their team once/after the PI grant was awarded were asked about their prior locations and reasons for joining the group.

Just under half (45%) of these team members lived in Ireland before joining the group, while slightly over half (55%) were living abroad – in 30 different countries; most commonly Germany, the UK, Italy, China, France and India. This is a clear indication of the international attractiveness of the grant-funded groups in Ireland.

They were asked why they decided to join the PI-funded group. Of the four options given:

- 80% agreed that the research topic fitted closely with their interests or expertise
- 52% agreed that the strong reputation of the group’s research was a draw
- 35% agreed that the offer of studentship / salary attracted them
- 27% agreed that the location was important (they wanted to remain in / move to the location of the PI host institution)

A small number specified other motivations for joining the group, which included the reputation of the relevant PI and the specificities of the opportunity offered (e.g. its duration).

These team members were then asked what they were likely to have done instead, if they had not been able to join the PI-grant funded group. Their responses are shown below. Most indicated that they are likely to have joined another research group instead - in Ireland or, more likely abroad. A smaller number would not have pursued a higher degree / continued in academic research, or not continued in science research at all (and chosen a different career altogether). Again, this counterfactual assessment provides a clear indication of the impact of the PI grant in attracting/retaining individuals and building scientific research capacity.

Figure 16 Likely outcome if had not been able to join PI-grant funded group (n=221)

Likely outcome	Responses
Joined a research group outside of Ireland	59%
Joined another research group in Ireland	29%
Not pursued a higher degree (Masters, PhD) or not continued in academic research	6%
Not continued in science research and chosen a different career altogether	5%

Excludes ‘don’t know’ responses

Unsurprisingly, ‘joining another research group in Ireland’ was a much more likely scenario amongst those already living in Ireland (51% of this group), than amongst those living abroad (8%). However, in both cases the results suggest that a significant number of individuals

would not have come to / remained in Irish research without the PI award – and most likely would have joined a research group abroad instead.

Applying these results to the full 2,412 Masters students, PhD students and Postdocs that we estimate joined PI teams after the grant was made (3,015 minus the 20% already in place), we can make some broad estimates of the impact of the grant on this group. We estimate that around 530 of the 1,080 already living in Ireland would not have joined an Irish research group had it not been for the place in the PI-funded group, and that 1,220 of the 1,330 previously living abroad would not have joined another Irish research group instead. **In total, this suggests that 73% of joiners, or 58% of all Masters students, PhD students and Postdocs involved in PI-funded research groups are unlikely to have joined a research group in Ireland without the PI award. This equates to some 1,700 – 1,800 additional people in total.**

4.3.3 Team members joining before the PI grant was awarded

The 20% of respondents who were already within the team before the PI grant was awarded, were asked whether the award affected the amount of time that they spent in the group. In a majority of cases (58%) they reported having extended their position *because* of the PI grant. In nearly all cases this involved additional funding from the PI grant itself, but in a small number of cases team members reported that funding from other sources was used.

Because these individuals had experienced the research team and its activities both before and once the PI award had been made, they were asked to assess about the extent to which the grant had impacted on their experiences within the group, compared to the situation before the award. Specifically, they were asked to rate the degree of impact the award had on their research progress and their networks.

Their responses (shown below) suggest that the grant had a significant impact on most team members, both in terms of providing additional funds that enhanced their research progress, and by allowing the expansion of internal and external networks.

Figure 17 Impact of the PI grant on team members’ experiences (n=56-60)

	Not at all	To a small extent	To a medium extent	To a large extent
<u>It enhanced my research progress</u> through additional funds for research materials, research services, and purchase of / access to advanced equipment	0%	3%	35%	62%
<u>It expanded my network of connections</u> through increased group size, links and collaborations with other groups, links with industry, international links	0%	16%	34%	50%

These team members were also asked whether the grant had had any other positive impacts on their experiences within the group. A number of specific points were highlighted, which covered the following groups of impact (number of responses in parenthesis):

- Funding of and access to more and better resources, equipment, and facilities (6)
- Additional teaching/training of students to enable them to reach a higher level (5)
- More extensive and successful collaborative links established (4)
- Ability to participate in international meetings, conferences and networks (4)
- Improved quality of research and more challenging and successful projects (3)
- Security, stability and ongoing opportunities for those in the group (3)
- Increased professionalism, international competitiveness and reputation (2)
- Increase in the size of the group / lab (2)
- Increased diversity (nationality / background) of group (2)
- Funding for experienced / high quality team members who can support others (2)
- Personal development in various forms (2)
- Opportunity to present to and meet world leading international experts (brought in by SFI for mid-term evaluation of grant) (1)

4.3.4 Impact on team members' subsequent careers

At the time of the survey, just over a third of the responding team members were still part of the same research group that received (or was still in receipt of) the PI grant. In most cases they were postdoctoral researchers, or PhD students (see below).

Figure 18 Current position of team members still working in PI grant group (n=120)

Current position within PI grant team	Response
Postdoctoral research in HEI	48%
PhD student	34%
Lecturers/Permanent researcher in HEI	8%
Research Assistant in HEI	7%
Masters student	2%
Science/Engineering Private Sector (R&D role)	1%
Technician in HEI	1%

The remaining two-thirds of team members had now left the research group that received the PI grant. They were asked to specify their first destination, and current position (if different), so that we might better understand what happened after their involvement in the PI programme. The following table summarises their responses.

The majority went on to further academic positions with HEIs, most commonly postdoctoral positions or permanent research/lectureships. Even in the relatively short time period in question, there is already evidence of career progression between the first and current locations (e.g. increasing % holding professor posts and permanent research/lecturer posts, and declining % of postdoctoral researchers). Roughly one quarter of team members moved into the private sector, into a range of roles, but often in science / engineering and involving R&D. Only 2% of respondents were unemployed currently or after leaving their PI team.

Figure 19 Position of team members that have since left the PI grant group (n=205)

Response	First location	Current location
Professor / assistant professor in HEI	2%	4%
Lecturers/Permanent researcher in HEI	16%	21%
Postdoctoral research in HEI	45%	32%
Research Assistant in HEI	1%	1%
Research administration / management in HEI	0.5%	3%
Technician in HEI	0.5%	1%
PhD Student	3%	2%
ACADEMIA TOTAL	68%	65%
Scientist / researcher in other public sector	3%	2%
Research administration / management in other public sector	1%	1%
Teaching (Primary/Secondary)	2%	1%
OTHER PUBLIC SECTOR TOTAL	6%	4%
Science/Engineering Private Sector (non R&D role)	2%	7%
Science/Engineering Private Sector (R&D role)	14%	15%
Other Private Sector (not science/engineering) (non R&D role)	5%	3%
Other Private Sector (not science/engineering) (R&D role)	0%	1%
PRIVATE SECTOR TOTAL	21%	27%
Unemployed	2%	2%
Unknown	2%	1%
OTHER TOTAL	4%	4%

Of all respondents, most are still based in Ireland (59%) – including those still involved in the same PI group. By comparison, 41% reported that their work/study is now primarily based abroad. The proportion of respondents leaving Ireland is broadly the same for PI awards funded through the life sciences directorate (43%) and the IC&ET directorate (40%).

The proportion of team members leaving Ireland (41%) compares favourably with the counterfactual assessment above, where 59% of team members suggested that they would have gone abroad if they had not got a position within a PI-funded group. **The PI programme has therefore been successful at both attracting and retaining a much wider group of individuals than just PIs, both during awards and in the longer term.**

Those who had left their PI award group, but remained in Ireland, were asked whether the PI grant had affected their decision or ability to stay. Two thirds (62%) said that it had, and in most of these cases (80%) the award was felt to have had a 'significant effect'. They were asked to explain further how the grant had contributed to them staying in Ireland, and many provided further details. A varied selection of these personal insights are given below.

Figure 20 How did the PI grant affect your decision/ability to stay in Ireland afterwards

Working in a world-class lab without having to leave the country has allowed me to stay with my family in Ireland and secure a position in another world-class lab in Ireland.

Without this funded PhD position I would definitely have gone abroad to pursue further my studies

Within a year of leaving this group I was awarded a HRB postdoctoral fellowship and an SFI Stokes Lectureship, both of which were facilitated by the training / research experience during my PhD.

A really amazing industry position opened up (which hadn't previously existed) and I left my SFI-funded project to take up that opportunity.

The training I received significantly enhanced my CV making it easier to secure employment in Ireland

It gave me a network of people so that I could use my skills in other areas and my ability to do my current role is directly related to the network of people I built up while working in the PI group.

I was funded for 5 years on this grant. During this time, I settled in Ireland and also made valuable connections that resulted in me wanting to and being able to pursue a career in Ireland.

I came into contact with my current research group during my previous four years and therefore decided to stay when a position opened up

I doubt the permanent position I moved to would have opened if it wasn't for the original PI's success.

I had greatly improved my English skills as well as broadened my scientific knowledge

My research under this PI award made me a strong candidate for my current position

Those who have moved on from their PI award research group, and are now working / studying in another country, were asked to explain what their main reasons were for leaving Ireland. There were a number of recurrent themes in the responses, which have been summarised below (number of relevant responses in parenthesis):

- There were a lack of permanent positions / job opportunities in Ireland (30)
- For family / personal reasons / wanted to return home (29)
- A good opportunity arose elsewhere (20)
- There was a lack of research funding available in Ireland (19)
- Wanted to broaden international experience / widen exposure (10)
- There was a lack of activity in specific field within Ireland (8)
- The economic climate in Ireland was poor / unstable (5)
- There was no clear career ladder in Ireland (2)
- There were few relevant industry opportunities in Ireland (2)
- Connections / networks in field where better available elsewhere (1)
- Salary levels in Ireland were lower than elsewhere (1)

While there are clearly a significant number of these individuals who were drawn away from Ireland for personal reasons, or a desire to experience working in other countries, the majority of explanations given for leaving the country broadly relate to a (perceived / relative) lack of opportunities available to them in Ireland. While this feedback relates to a minority of all team members involved in the PI programme, it is still an important finding for the ongoing ability of Ireland to attract, retain and grow its R&D capacity and capabilities.

Those that have left their PI award research group were also asked about the impact on their subsequent career of their time in the group (and of the PI award more generally). More specifically, they were asked about the importance of the skills they acquired and networks built on their subsequent career and its progression.

The responses (below) show that two-thirds of team members felt that the skills they acquired during their time in the PI group were ‘essential’ for their subsequent career. The network of connections made was less frequently felt to have been essential to career progression, but a majority of team members still rated this aspect as highly important (a rating of 4 or 5).

Figure 21 Importance of time in PI-funded group to subsequent career (n=201-202)

	1 = not at all important	2	3	4	5 = essential	Avg. score
How important were skills acquired during your time in the group for your subsequent career?	1%	2%	11%	18%	66%	4.4
How important was the network of connections you acquired for your career progression?	8%	11%	18%	24%	38%	3.7

They were further asked how their time in the group affected the speed of their career progression after leaving. Nearly all (86%) felt that it accelerated their career progression, including 58% who said it accelerated it ‘*considerably*’.

Finally, all team members were asked to assess the extent to which their time within the PI-funded group had had a positive impact on their subsequent activities and experiences in a number of key areas. The largest and most wide-spread impacts were felt in terms of career / research direction, progression and opportunities. Significant impacts on networks and reputation were also commonly seen. A more mixed response was given in relation to the impact on team members’ ability to secure funding and their links to industry.

Figure 22 Importance of time in PI-funded group to subsequent career (n=201-202)

	1 = No impact	2	3	4	5 = Large impact	Avg. Rating
Your research or career direction	5%	5%	16%	26%	48%	4.1
Your career progression and opportunities	7%	4%	19%	27%	43%	4.0
Your national and international reputation	8%	9%	21%	32%	30%	3.7
Your national and international networks	7%	11%	23%	33%	27%	3.6
Your ability to access and secure funding	24%	7%	27%	22%	20%	3.1
Your links to industry	34%	15%	26%	14%	11%	2.5

The responses of award team members have therefore provided a clear indication of the international attractiveness of the PI grant funded groups in Ireland, and confirmed that the PI programme has played a very important role in attracting, retaining and developing a much wider group of individuals than just the PIs, both during awards and in the longer-term. The PI programme experience is seen very positively by these wider team members, and is felt to have had a significant impact on the skills, research, networks and career progression of these individuals.

4.4 Impacts of the SFI PI grant on the research group and institutions

The survey of PI award holders also explored the impacts of the programme on the wider research groups and research activities that these individuals lead. This was corroborated in discussion with the institutions hosting PI award holders.

The award holders were asked to consider their situation prior to their (first) PI award, and to assess whether the PI grant had had a positive impact on aspects of their research group (from 1=no impact, to 5 = larger impact). The responses are shown in the figure below. The most wide-spread and large impacts related to the scale of activity, in terms of the size of the research group and the number and quality of academic outputs it produced. A majority of respondents also gave a rating of 4 / 5 to both the impact on their groups' collaborations with international research groups and on the calibre of applicants for positions in the group.

In the other four areas listed (collaborations with local and international companies, the production of pre-commercial outputs and access to international facilities), a majority (75%+ in each case) cited some degree of impact, but respondents were more evenly spread as to whether they rated the impact in these areas as small or large.

Figure 23 Impact of the PI grant on research groups (n=171 – 178)

	1 = no impact	2	3	4	5 = large impact	Avg. rating
The number and quality of academic outputs (publications, conference proceedings, prizes, etc.) of your group	3%	1%	8%	37%	50%	4.3
The size of your research group	4%	1%	11%	31%	53%	4.3
Your group's collaborations with international research groups	6%	3%	19%	35%	37%	3.9
The calibre of applicants for PhD student and postdoctoral researcher positions in your group	7%	6%	22%	36%	28%	3.7
Your group's collaborations with international companies	18%	14%	24%	22%	21%	3.1
Your group's links and partnerships with Irish industry	20%	11%	25%	23%	21%	3.1
The number and pre-commercial outputs (patents, licensing agreements, etc.) of your group	25%	9%	26%	23%	17%	3.0
Your group's access to international research facilities	22%	20%	24%	17%	17%	2.9

Nineteen respondents indicated there were other important impacts on their group (beyond those listed), and were asked to explain further. They pointed to four main impacts:

- Increased international competitiveness, visibility and renown
- Increased ability to secure other funding (competitiveness)
- Expanding into new research areas
- Increased ability to collaborate internationally

Where PIs had stated there had been a significant impact (rating of 3+) on an aspect of their research group (and where their PI grant had ended), these respondents were further asked whether these benefits had been sustained after the completion of their (most recent) SFI PI award. The responses are shown in the figure below.

In each of the areas listed, a majority of respondents reported that the benefits created by the PI grant had been sustained to some degree after the award. In fact in all areas, at least half of respondents reported that the impact had been sustained to the same, or a greater extent. The two areas where benefits were least likely to be sustained/ enhanced were the size of research groups and the number of pre-commercial outputs.

There is however considerable variation between the experiences of the different PIs. For instance, where a PI grant had had a significant impact on the size of research groups, after the grant had ended this was sustained: not at all (in 23% of cases), to a lesser extent (27%), to the same extent (29%) and to a greater extent (22%).

Figure 24 Whether impacts on research groups were sustained (n=44 – 81)

	No	Yes, to a lesser extent	Yes, to the same extent	Yes, to a greater extent	Total
The calibre of applicants for PhD student and postdoctoral researcher positions in your group	6%	14%	68%	12%	69
The number and quality of academic outputs (publications, conference proceedings, prizes, etc.) of your group	6%	23%	48%	22%	81
Your group's collaborations with international research groups	10%	12%	49%	29%	69
Your group's links and partnerships with Irish industry	10%	18%	40%	32%	50
Your group's access to international research facilities	11%	11%	55%	23%	44
Your group's collaborations with international companies	13%	11%	48%	28%	46
The number and pre-commercial outputs (patents, licensing agreements, etc.) of your group	18%	14%	44%	24%	50
The size of your research group	23%	27%	29%	22%	79

Respondents were asked to explain further why some or all of the benefits they had seen during their PI award could not be sustained afterwards. From a suggested list given, 41% selected 'I could not secure sufficient funding from other sources', while 10% selected 'I moved abroad'. No-one reported that there was an issue with not being offered an ongoing position within their host institution.

Representatives from institutions with a significant number of PI grant holders agreed that the PI programme had allowed them to retain already established researchers, as well as attract new world-leading research talent. Because SFI grant holders were well funded, these institutions were able to significantly increase the quality of their research, and the scale of their research operations within SFI focus areas. One interviewee went so far as to say that SFI had made a real impact on the Irish landscape over the last 10-15 years, contributing to a change in OECD ranking for Irish research and technology.

There was broad agreement that the PI programme had led to increased capacity at the host institutions, and several interviewees commented favourably on the PI programme's effect in developing clusters of expertise. One interviewee, for example, explained that the SFI PI programme had allowed a number of departments at their institution to reach 'critical mass', with more than 20 grant holders in related research fields. Each of these groups now made up more than 'the sum of its parts' by sharing expertise, collaborating, and joint purchasing of equipment, which in turn has enabled the development of leading research clusters. Another interviewee explained that 'satellite clusters' of researchers not funded through SFI had developed around SFI PI-funded groups. Host institutions also reported that in general, interest in their institution from researchers located overseas had also much improved, and attributed this mainly to the combination of excellent research leaders (enabled by the PI programme) and research infrastructure (funded by the PRTLTI).

All interviewees from host institutions with significant numbers of awardees agreed that the PI programme had improved the quality of training at their institution. They felt that the top researchers, supported through PI grants, attracted the best students and postdocs. The PI programme (and wider system reforms) was also felt to have had a marked effect on training practices: as the PI grant freed PIs from spending large amounts of time seeking other funding sources, they were able to dedicate more time to leading and mentoring their research groups.

Coupled with the higher calibre of researchers attracted/retained by the SFI PI programme, and improved infrastructure and equipment provided through the PRTLTI, this was felt to have significantly lifted the quality of teaching and training. One interviewee expressed the view that students leaving Ireland's research groups today obtained better positions in industry than was the case 10-15 years ago, providing a clear sign of improvements in quality.

4.5 Impacts of the PI programme on the research community

PI award holders were finally asked to consider the extent to which the PI programme had impacted on their research community more generally. From the responses (see below) it would appear that the largest and most widespread impacts were felt to relate to enhancing the international reputation of specific Irish research communities and raising the quality of research conducted by these communities. Next most significant was felt to be the impact on the communities’ international links and the expansion of the size of the research community within Ireland. Inter-Ireland academic links, and links between academia and industry were the least commonly / highly cited impacts – though for most respondents some degree of impact was still perceived in these areas.

Figure 25 Impact of the PI programme on the wider research community (n=175-176)

	1 = no impact	2	3	4	5 = large impact	Avg. Rating
The SFI PI programme enhanced the international reputation of the Irish research community in my area of research	2%	4%	9%	21%	63%	4.4
The SFI PI programme raised the quality of research conducted in Ireland in my area of research	3%	2%	8%	24%	62%	4.4
The SFI PI programme increased links in my area of research between researchers in Ireland and abroad	2%	5%	15%	36%	42%	4.1
The SFI PI programme expanded the size of my research community within Ireland	3%	10%	15%	29%	44%	4.0
The SFI PI programme increased links in my area of research between academic researchers in Ireland	5%	5%	26%	39%	26%	3.8
The SFI PI programme increased links in my area of research between industry and academia	9%	10%	19%	31%	30%	3.6

When offered the opportunity to provide further comment, a number of PIs highlighted some of the strengths of the PI programme, and the impact that it had had in Ireland. A selection of their comments is shown below:

As a result of SFI, Ireland now has a national research capability able to compete on the world stage. PI awards where basic research can be done are critical to our ability to develop applied research.

The size of the grant, the security of funding and the hitherto limited constraints on the research direction/prioritization are amongst the most valuable elements of the SFI PI award.

One of the main advantages of the PI grant is to allow a small team to work in a co-ordinated and cohesive manner on a research problem. This is a major advance on project awards that are typically based on 1 PhD or postdoc per project.

The PI grants have had a tremendous impact on Irish research. For the first time, Irish researchers were able to compete internationally and to conduct research at the highest level. I believe that the concept of the PI program represents far better value-for-money than any grant program SFI has launched since.

The SFI PI Awards helped to put Ireland on the scientific map. Before SFI, Ireland was a backwater for science and engineering.

The SFI PI grant programme is an excellent scheme, which enables groups to run a research programme of scale, over a reasonably long period, and employing postdoctoral researchers, which can be difficult to fund otherwise.

The SFI PI grants greatly benefited science teaching in Ireland, by employing higher calibre academic staff, and also higher calibre postdocs and PhD students who greatly help in teaching, especially in undergraduate student projects.

The original PI scheme was open to postdoctoral researchers and thus provided a route for ambitious young researchers to establish a research group with a greater degree of freedom.

Stakeholders also reported that the PI programme (and scale of funding attached) had made a statement about Ireland and Irish research that was visible internationally, and had been very successful in terms of promoting Irish research and researchers and “putting Ireland on the

map". They felt that Irish research leaders and groups funded through the programme became recognised internationally, and were as a result better able to collaborate and secure funding. One commentator pointed to the role of Irish researchers in European Framework Programme projects as an example, where the country had previously been seen as a peripheral collaborator mainly useful for securing EU funding, but now more often took a central or coordinating role within many FP projects.

Stakeholders were clear that the PI programme has been successful at bringing people in to / back to Ireland, and at attracting and retaining world-class researchers for the research community. The size of the grants (particularly in the earlier years of the PI programme) was seen as critical to this achievement. The grants were also seen as successful in enabling the expansion of teams and the establishment of research groups, which then led to benefits to wider groups of people beyond the individual PIs funded through the programme. One stakeholder commented that early career investigators in Ireland are now of very high quality, due to developments in the research system in general, but also often due to PI funded individuals and groups.

Stakeholders highlighted that the volume of knowledge created through the PI programme was considerable, and that this showed growth in the research system and also contributed to Irish research's increased presence and visibility internationally. One stakeholder pointed to current citation indices as evidence of the considerable growth in the competitiveness of Irish research, which they felt could be traced back in part to PIs and the PI programme. Another suggested that the Irish research system was now one of the top twenty in the world, and that it would be hard to imagine that this would be the case without there having been the PI programme, or something like it. Indeed, the current research system in Ireland was felt to be somewhat dependent on the core of PIs funded over a decade by the PI programme, and that this funding stream had also enabled subsequent funding initiatives to be (more) successful. Finally, one stakeholder commented that where Ireland now has scientific strengths, this tends to be traceable back to specific PIs and the PI programme.

4.6 Programme achievements in supporting enterprise and industry

As has been reported above, the PI awards involved hundreds of collaborations with Irish and international industry, directly resulted in a range of pre-commercial outputs, and enabled the leveraging of significant amounts (€43m) of industry funding. Individual award holders gave a varied assessment as to the impact of their grant on the links between their research group and industry, and on their production of pre-commercial outputs. However, where PIs had seen significant benefits in these areas, they also tended to report that their links and collaborations with industry were sustained or further enhanced after their award.

Indeed, a majority of award holders reported that their grant had a significant impact on their subsequent links to industry, and that the PI programme more generally had increased the links between academia and industry in their wider research community. Most team members also reported that their time in a PI-funded group had had a positive impact on their subsequent links to industry. In fact, around one quarter of team members that have now left their PI research group have moved into private sector roles, often involving science / engineering and R&D.

Stakeholders consulted through the study took a balanced view in relation to the links between the PI programme and Ireland's industrial base. The PI programme was seen to have funded a wide range of individuals and topics – and that the connections with industry and its research goals therefore also varied as a result. They suggested that some more established researchers already had good links to industry, but were able to grow and enhance these relationships because of the step change in quality, quantity and critical mass enabled by the PI programme. For other PIs the PI programme formed a basis for future work, enabling them to reach the level and quality of research that would allow them to more easily connect with industry. Certainly stakeholders felt that the PI programme and the individuals funded provided a beacon for companies to notice, that is likely to have led to greater interest in collaborating with Irish academia.

However, stakeholders took the view that while there had been considerable collaboration with industry through PI grants, the flow of individuals from the programme into the industrial research base in Ireland was felt to have been more limited than expected.

There were concerns that despite an increase in MNC R&D in Ireland, there is still a lack of a strong research base in much of Irish industry, and therefore a lack of demand for new capacity and capabilities emerging from the PI programme. This, combined with a significant increase in academic funding was felt by stakeholders to have resulted in PI team members remaining within academia post-grant, rather than transferring to industry.

Some stakeholders also suggested that there was anecdotal evidence to suggest that the PI programme had had an over-emphasis on biomedical research, resulting in too many graduates in this space, while at the same time creating too few ICT graduates for the employment opportunities then available. However, our survey of team members did not provide strong support for this assertion. The proportion of respondents involved in PI awards funded through the LS directorate that have now left Ireland (43%), is only slightly higher than the proportion funded through the IC&ET directorate who have left (40%).

4.7 Overall finding on the effectiveness of the PI programme

This section has provided evidence and assessment as to the effectiveness of the PI programme, and the extent to which it contributed towards its own (and wider) objectives through the outputs, outcomes and impacts achieved by those in receipt of awards.

Reviewing the evidence presented from the surveys and the stakeholder interviews, a number of outcomes and impacts have been observed, some of which can be directly attributed to the programme and others that are also likely to have been affected by the programme, to a lesser degree, but where the programme can be seen as a key enabler.

The PI programme has clearly been successful in attracting and retaining leading researchers, and in establishing and expanding teams and research groups, both directly through funding PIs and team members, and indirectly through increasing the visibility and attractiveness of Irish research and Irish research opportunities to others. The PI programme has also improved training provision and has developed and promoted a much wider group of Irish researchers to work in and lead the next generation of research activity.

The programme grants have had a significant impact on the size and scale of activities within individual research groups, and in particular on the number and quality of academic outputs produced. Publications and citations in the period compare very favourably internationally and Ireland managed during the ten year period of the PI programme to keep pace with acknowledged leaders among small countries - though not to outrun them – and to pull ahead of the two late developers considered by the study.

PI award teams also leveraged significant additional financing from other sources during their award, which will have enhanced the opportunities enabled by the PI grant.

Irish research, researchers and institutions are now more visible and better regarded internationally as a consequence of the PI programme. The programme has also contributed positively to the formation of clusters of excellence. This increases Ireland's attractiveness as a destination for top research talent, for collaborative activity and for research funding.

The programme has also had some impact on the degree of collaborative activity and other links with Irish and international companies. However, these links to the industrial base can be judged as variable and a longer-term goal. More established researchers with existing links to industry were able to strengthen industrial links through the programme, while other PIs reported establishing a good basis for creating more links in the long term.

These overall findings on the effectiveness of the PI programme feed into the summary and conclusions, presented in Section 6.2.

5. Feedback on lessons learned from the PI programme

In this section we summarise the evidence presented in terms of any lessons that can be taken from the PI programme, and particularly where these might provide useful learning for future programmes of a similar nature. Inevitably, as the PI programme has ended, stakeholders were much more concerned with its current incarnation (the Investigators Programme) and commenting on how this might evolve – though these reflections often related to learning and experiences gained from the PI programme.

SFI has grown and matured positively over the course of the PI programme

Many stakeholders commented on the fact that SFI was a new organisation when the PI programme was established, and it therefore had to move up a learning curve. It was generally considered to have grown, matured and evolved positively over the course of the PI programme, and that this was then reflected in a gradual evolution of the PI programme itself – both from a management/administrative and a strategic perspective. Small lessons had been learned by SFI continuously, and those consulted were complimentary about a number of subtle changes that the PI programme underwent as a result over the course of its lifetime, such as gradually placing more emphasis on funding leverage, tightening the rules around application and re-application to the programme, and improving the review process.

The reduction in the size of grants helps to reduce reliance on single funding sources and increase sustainability

The size of PI grants was a common issue raised in this evaluation. The earliest grants in particular were very large by Irish and international standards. This was generally seen as a positive aspect of the programme, as it served a purpose of creating a ‘big bang’ that attracted attention and kick-started the programme. However, the appropriateness and sustainability of such large grants over the longer term was questioned, and the slight scaling back of award size over time was seen as an appropriate shift. However, there were still some concerns that the PI grants attracted individuals to a system that could not maintain them (and the scale of activities they established) in the longer term, and that grant holders could become too dependent on a single source of funding, creating a ‘cliff-edge’ scenario post-award when a large core source of funding suddenly ended. Indeed, suggestions indicate that the programme could have gone further in providing a larger number of smaller grants, which would then have provided an attractive career pathway for younger local research talent, and provided a smoother transition to post-award funding sources.

Stakeholders regarded PI programme grants as a key source of funding for the award holders. Indeed, SFI almost explicitly encouraged a focus on research during the award period, using the PI grant as a core source of funding. The grant was felt to enable high performing individuals to ‘anchor’ their research activities – the funding providing a strong and stable platform for core research activity, from which new research directions, collaborations, and other funding avenues could be explored. However, some concerns were raised that the PI grant may have become *too* key as a funding source for PIs, who became dependent on it as their only source of funding, and for example reduced applications to EU funding. This risked exposing the researchers to potential future national budget cuts, and hindered the process of ‘maturation’ that comes with securing funds from diverse sources. Indeed, some PIs responding to our survey did indicate that impacts achieved during PI awards (in particular the scale of research activities) had not been sustainable after the award had ended. For many, this was because they could not secure sufficient funding to maintain the same level of activity. Stakeholders commented that those PIs that have been successful in the longer term are those that established a good portfolio of funding, and were therefore more sustainable over time.

Also, because the PI programme became core funding for some academics, it may be something of a ‘sacred cow’ that was difficult to stop. There were felt, on occasions, to be inappropriate expectations from PIs that they could continue to get funding (an example was given of a PI contacting SFI about a ‘renewal grant’) – and the system of rolling calls and allowing those declined funding to apply again straight away – exacerbated this. There appears to have been some difficulty during the programme in understanding that the PI programme is providing project funding, and that projects have a start and an end date. The

(in many ways) positive close relationship between SFI and those it funded, perhaps made this worse. It could come across more as an employer than a (competitive) funding body. This could cause problems when applications for a further grant were turned down.

In response SFI placed more emphasis from 2007/8 on encouraging funding leverage, and also tightened up the rules around re-applying, to discourage dependence on follow-on PI grants.

Ensuring PIs priority themes are well articulated externally

Feedback from stakeholders suggests that there may have been some issue over how well the PI programme's priority themes were articulated to the outside world. There was perhaps a lack of clarity in explaining what was in scope and why – which may have created confusion at the time. However, this was not seen to be a big issue. There are also repercussions of the openness of PI funding themes being felt now, within the context of an increasingly focused and targeted approach to research funding. It may take some time for the community to adjust to this shift in approach, and some stakeholders felt that with hindsight it may have been better if this re-education process had begun a little earlier.

SFI still plays an important role in supporting the growth and maturation of Ireland's research system

Some stakeholders commented on the fact that the wider community (individuals and institutions) had had to evolve and mature over the period of the PI programme (as SFI had), to reflect and cope with the advancement of the Irish research system. In the earlier years of the PI programme there was a sense that SFI had to do quite a lot of 'hand holding', which resulted (for good and bad) in a close relationship between the funder and those it funded. There is now seen to be a need for more maturity in the wider system – something we were told that international reviewers also tended to notice and comment on. Ireland is not felt to be quite there yet, and SFI is trying to support and encourage this evolution; it is trying to be an agent of change in the wider system. To take a specific example, during the PI programme SFI very actively promoted the PI grant (and Ireland) internationally. This is now less the case, partly because SFI wants to encourage the wider system / institutions to do more.

The shift from the PI programme to the IvP programme matched the needs of the research environment in Ireland and continues to evolve

There was little change in the relevant policy priorities for the first half of the PI programme, according to stakeholders consulted, and the challenges and rationale that led to the establishment of the PI programme continued to exist. As such, it was generally felt to be appropriate for the PI programme to continue – and in largely the same form – for a number of years. However, it is thought by many of those consulted that by the latter half of the programme period, there had been sufficient shift in the wider context and rationale for the programme, in policy priorities and in the development of other initiatives, for there to have been a strategic stock take of the rationale and objectives of the PI programme and its future direction. This is not to suggest that stakeholders felt that the programme should have ceased, just that Ireland had come a long way in the previous decade, and the programme may have no longer been the most appropriate in its exact scale and form. However, stakeholders reported that the economic crisis then hit and budgets were cut, and so focus was shifted to how to sustain funding in general, rather than on how to improve existing instruments or develop new ones. This perhaps delayed a more strategic review of SFI funding mechanisms, and an eventual merger of the PI programme into a new Investigators Programme (IvP).

At least in its initial form, this IvP programme was seen by those consulted to be largely a continuation of the original PI programme, though with smaller grants and a less open thematic remit. However, it is felt to have subsequently evolved further to better reflect national priorities and strategy, and the current wider funding landscape. The original PI key criteria of 'excellence of the researcher' combined with 'excellence of the project proposed' remain in the IvP, but with an additional requirement for impact. We were told that in the PI programme, applicants were always asked about strategic impact, but this wasn't a stringent requirement – and so this marks an important change in the IvP. The IvP has also begun to actively encourage industry involvement in the programme. There is some concern from some stakeholders consulted that this could go too far and essentially create 'mini-Centres' around

the investigators being funded, resulting in a blurring of the IvP and the recently established Research Centres programme.

Although the IvP does maintain some open calls, it is much more focused and targeted in its funding decisions than the PI programme was, in order to reflect the national research prioritisation exercise. Views on this shift were mixed.

The PI programme had a strong and important focus on excellence, which should not be lost in subsequent programmes

There was a recognition that a comparatively small country like Ireland had to be strategic in its research in order to maximise the benefit of publicly-funded research to society and the wider economy, building critical mass and capabilities in focused areas of future importance and existing capability. This was seen as part of the next step in a maturing system. However, one of the strengths of the PI programme was seen to be its overriding focus on excellence in broadly defined disciplines. This allowed individuals to climb to the highest level of achievement in their own specific field – which might not have been possible if they had been forced to fit their research into a narrow thematic priority – and that it was the quality and quantity of research output resulting from this that had knock-on beneficial effects on retention, quality, and reputation of research and researchers in Ireland.

The answer to these competing needs, according to most stakeholders, is probably some careful balance between the two – a more targeted approach to take forward certain areas, combined with a more open funding mode that supports excellence wherever it exists. It was felt that it is now perhaps time to relook at the positives of the PI programme and ensure that important aspects are maintained within the mix of current funding options.

The PI programme was seen by stakeholders to be SFI's 'main stay' programme. They felt now that the IvP remains important and central in its portfolio of activities, but is becoming relatively less so as emphasis shifts over time (e.g. to the Research Centres). This is not necessarily seen as a bad thing by those we consulted – indeed it is broadly thought to be appropriate - so long as this process does not go too far. There is felt to be a continued need to support basic research, to develop human capital, and to build up critical mass (particularly in areas not yet ready for a centre), even if this is not done at the same scale as was the case in the 2000's through the PI programme. There was concern evident in discussions with some stakeholders that as the strategic focus shifts towards (short term) impact, it can become more difficult to justify fundamental research (or easier / less risky to justify something more applied), and that it is important not to lose sight of the longer term.

Stakeholders were also clear that there is a need to continue to support the 'pipeline' of next generation researchers and research. Several interviewees indicated that while the expertise in Ireland had grown, the community in its entirety was not yet sufficiently large, or indeed sustainable without continued investment in the research base. It is of key importance, they felt, to provide sustained research funding to the community, and to de-risk career pathways for young talent in order to influence their decision to stay in Ireland and research.

6. Summary and conclusions

In this section we draw on the wealth of evidence, feedback and testimony presented in the previous sections of the report, in order to address the main study questions on the appropriateness, fit, effectiveness and performance of the Principal Investigator programme.

6.1 Appropriateness of the PI programme

In this first section we present conclusions on the appropriateness of the PI programme, addressing the following study questions:

- The appropriateness of the programme, given its rationale, objectives, and the extent to which it was aligned with and contributed to the achievement of national public policy objectives in relation to the changing science policy context
- The ‘fit’ of the PI programme, in terms of complementarities and / or overlap with other interventions in the national research system
- The adequacy and balance of resources allocated to the PI programme

The PI programme set out to support well-established researchers with excellent reputations (from Ireland and explicitly also elsewhere), in the fields of science and engineering that underpin the biotech, ICT and (later) energy sectors. It sought to build research capacity and capabilities in these areas to support Ireland’s long-term competitiveness and development. It set out to do this through providing competitive grant funding of €100k-€1m direct costs per year, for up to 5 years, to individuals who had been selected based primarily on an assessment of their excellence, and the excellence of the project they proposed.

6.1.1 Appropriateness of programme rationale and objectives

The PI programme can be seen to be wholly appropriate in its rationale and objectives, responding to the needs of Ireland over its programming period.

The evaluation highlights how the PI programme responded to the needs of Ireland from the period of 2000 onwards, where Ireland had a very limited academic and industrial research base, a level of public and private sector investment in R&D that was low by international standards, a higher education system that focused almost exclusively on teaching not research, and little opportunity to advance from Masters to PhD level.

More specifically, the programme logic, formalised as part of this study, clearly shows how the activities funded through the programme were intended to lead to outputs and outcomes (and ultimately impacts) that were aligned with and would contribute to the intended objectives of the programme. The study has also shown as part of the development of an objective hierarchy how the programme, and its objectives, fitted neatly within the wider context, and contributed to the wider objectives of the National Development Plan and the STI strategy, via the objectives of the intermediate organisation (SFI).

This clear alignment in objectives is perhaps not surprising given that the PI programme and SFI were established in part as a result of, and in response to, the 1996 STI white paper and 1999 national foresight study, which clearly set out a rationale and need that would go on to be addressed through the programme, and other initiatives. Nevertheless, it is still worth commending the clear logic and fit of the scheme’s objectives within the priorities and wider objectives of the time.

6.1.2 The fit of the programme in the overall national research system

The coherence of the programme with the wider portfolio of policies and activities at the national level is well demonstrated.

The programme filled an important gap in Ireland’s efforts to become an economy more focused on world class research and innovation, which necessitated the attraction and retention of excellent researchers to build and develop research groups and activity.

There was the potential for duplication or confusion when creating a significant new body (SFI) with a mandate of enterprise and innovation within a pre-existing system, in which other actors were already operating. However, there are no indications that such problems arose. Essentially, given the limited scale of existing activities when the PI programme began (including no large funding programmes providing sizeable grants), issues of ‘fit’ within the national research system were not very relevant – at least in the early days of the programme. There was nothing of the size, scale and ambition of the PI programme, and so there was plenty of scope for it to play a unique role within the funding landscape.

The PRTLI in particular appears to have been an integral part of the (success) story of the PI programme, having pre-dated the initiative and concurrently provided mainly capital (and human) infrastructure funding that, with the PI programme, enabled the expansion of capacities and capabilities within Irish Universities and Institutes. The focus of PRTLI on allowing HEIs to develop the infrastructure and purchase state-of-the-art equipment played an essential role in making institutions attractive to top research talent when coupled to funding for research groups provided through the PI programme. There is some cross-over between the two programmes – in the sense that both the PI and PRTLI schemes provided funding for both capital and staff – and it may have taken a little while for the two programmes to accommodate and coordinate their respective activities – but ultimately the additional investment was most important, and some minor cross-over in scope does not appear to have detracted from this.

The PI programme was also important (if not essential) for some initiatives that emerged subsequently, providing the necessary capacities and capabilities for these schemes to build on. In particular, the CSETs and (more recently) the Research Centres have often built on a part of the research base that was established or expanded through the PI programme, and have then helped to bring this work closer to industry and socio-economic impact.

The study was not pointed to any initiatives that were potentially duplicative or poorly aligned with the PI programme during its period of operations. There was some concern for the ‘fit’ of the (subsequent) Investigators programme, and the direction that this might take relative to other initiatives. This programme is outside of the scope of this study, but is discussed briefly below in relation to lessons that can be learnt from the PI programme.

6.1.3 Appropriateness of the approach and focus of the PI programme

The approach taken by the PI programme was well tailored to address the needs at the time the programme was instigated.

The broad focus of the programme was the right approach at the time, allowing bottom up development of capacity in the areas of biotech and ICT (and later energy). This openness and freedom was an appropriate response to the objectives of the programme and the challenges that Ireland faced. The programme wanted to attract the best people, and to kick-start research activity first and foremost, in the hope that in many cases this would have a longer-term impact and relevance for Ireland and its economy. Because the work funded was often basic-oriented, the flow of benefits and impacts would emerge over many years, and so the programme was right not to be too prescriptive about the specific research (or areas of research) that might or might not be required. Given the lack of pre-existing areas of research strength (in international terms), it was appropriate for the programme to ‘spread its bets’ in this way, take the best people and ideas that were available, and then enable them to develop teams in Ireland working in areas that might have a strong relevance to the future needs of the wider Irish economy and society.

Given the low starting point, and the objectives of the programme, this was (even with hindsight) an entirely appropriate approach to take – at least in the early years of the programme. However, it is worth noting that this openness and broadness may now also have a downside in creating a culture and expectations that have to be managed to align with the greater prioritisation in funding that has emerged in recent years. This, though, is not a criticism of the programme and the approach taken at the time.

6.1.4 *The evolution of the programme in relation to the context (key learning)*

There was a positive and well-judged gradual evolution of the PI programme, to reflect learning over time and changing needs and priorities.

Small lessons were learnt by SFI continuously, and the PI programme underwent subtle but positive changes as a result over the course of its lifetime. These included evolving from a rolling to a fixed deadline call, and a continual development and improvement to the review process to respond to strategic requirements of the research landscape in Ireland. This gradual and subtle evolution appropriately reflected the learning of a newly established organisation (SFI) operating in a relatively immature system, and the changing context in which it operated. The gradual transition that the programme has seen appears to us to have been well judged.

It also seems that the PI programme – at least in its original form – had come to a natural end-point after a decade. The context in which it operated had changed (in large part due to the achievements of the programme itself), and a re-designed, or new programme was required to better reflect the new reality. Indeed, there are some indications that a rethink may have been appropriate earlier than 2011/12, but that the economic crisis drew attention towards trying to maintain a reasonable level of research funding generally, and away from strategic thoughts about the specific design of individual initiatives.

Assessment of wider policies and strategies are beyond the scope of this study, but it does seem appropriate, having successfully built a broad base of capabilities and capacity, to then take advantage of this in a more targeted way to address current and future needs and to ensure the links with industry. A re-invention or replacement of the PI programme after ten years of operations, and adjustments to the mix of funding offered by SFI therefore seems appropriate.

While the subsequent IvP programme appears to be a positive evolution, and a logical next step from the PI programme, there are some concerns in the research community about its future direction – and in particular that it is becoming more prescriptive, narrow and targeted in what it funds. However, a proper assessment of the IvP is beyond the scope of this study.

6.1.5 *Adequacy and balance of resources*

The PI programme overall represented a significant, but justifiable investment in R&D over the programming period.

As SFI's longest running award (2000 – 2011), and its main instrument for fulfilling one of the key elements of its mission - developing research capability and excellence in Ireland – it appears to be entirely appropriate that the investment made through the PI programme was of such a scale. It was larger than most of the comparator schemes that we have identified – but this can be explained by the more ambitious scope and objectives of the PI programme.

There was some concern over the impact of PI grants on the willingness and ability of PIs to secure other sources of funding, during and after their award.

This risked creating an over-dependence on SFI, expectations of follow-on funding, and a potential sudden stop to activities at the end of awards. While SFI recognised these issues, and tried to tackle them through changes to requirements and better communication, it is not entirely clear whether they were completely resolved. There is ample evidence to suggest that most (if not all) PIs maintained a wider portfolio of not-insignificant funding during the period of their award and PI teams leveraged significant additional funding (beyond their PI award), which equated to nearly double the total award value (approximately €1.67 was leveraged for every €1 of PI grant funding). However, there is also evidence from PIs that some of the benefits seen during PI awards could not be sustained at the same level post-award, and that this was in part due to insufficient funding being secured after the PI grant ended.

6.2 Effectiveness of the PI programme in relation to its objectives

In this section we present conclusions on the effectiveness of the PI programme, and the extent to which it met its objectives, in terms of building critical scientific capacity, building capabilities (and quality) in key basic research areas, and achieving wider impacts on Irish research and the Irish economy and society.

The PI programme awarded 398 grants to 281 researchers at 15 HEIs in Ireland over the course of a decade. Indeed, many PIs are still operating under their grant period, and will continue to do so for several more years. The direct and immediate benefits of the programme are therefore still to fully unfold. However, the programme has already made significant contributions towards its objectives and to addressing the challenges that were faced in Ireland when the programme was established. It is one of many initiatives and factors contributing to the development of Irish research over the period, but was a core part of this mix – both in terms of its direct contribution, and the fact it has enabled and supported other activities and initiatives, that build on the programme’s successes and achievements.

6.2.1 Building critical scientific research capacity

The PI programme has been successful in attracting and retaining leading researchers, and in establishing and expanding teams and research groups.

This has been achieved both directly through funding PIs and team members, and indirectly through increasing the visibility and attractiveness of Irish research and Irish research opportunities to others.

For award holders, the PI ‘offer’ was clearly attractive to high-calibre individuals already based in Ireland (though not necessarily Irish), who made up the majority of PI award holders. However, the programme also offered an internationally competitive opportunity significant enough to attract large numbers of leading researchers from other countries. Over 20 nationalities are represented within the 281 award holders, demonstrating the programme’s ability (and success) in drawing on a truly global pool of talent. The study has estimated that of the 281 PI grant holders, only 130 are likely to have come to / remained in Ireland at the time of their award without the PI grant. The success of the award in attracting/retaining individuals in Ireland is also likely to be sustained in the longer term – with most PIs choosing to remain in the country post-award.

The duration and scale of PI grants were particularly key attractions for those applying to the PI programme, as was the fact that the grant could in turn support the building of critical mass and the undertaking of larger, more ambitious research projects, than might otherwise be possible. The openness and flexibility of the PI funding to support the specific needs of individuals also comes across as very important.

The PI awards also supported wider research teams (either directly or indirectly) and provided opportunities to develop skills and knowledge in areas relevant to the predicted future needs of Irish academia and industry. There is evidence that many team members (national and international) were attracted by the research topic or the strong reputation of the group and were *unlikely* to have joined a research group in Ireland without the PI award. The study has estimated that some 1,700 – 1,800 additional Masters students, PhD students and Postdocs who were involved in PI-funded research groups are unlikely to have joined a research group in Ireland if it had not been for the PI programme.

There is also a good level of retention of researchers (compared with prior intentions) and an indication that the PI grant-funded group had contributed to their decision (or their ability) to stay. However it is worth noting the significant number of team members involved in the PI programme that have subsequently left Ireland. For some, there were personal or family reasons for this decision. But for many there was perceived to be a lack of suitable positions or job opportunities in Ireland, at least relative to opportunities offered elsewhere, and a lack of research funding available.

The ability to retain individuals post-award does clearly depend upon the availability of relevant (academic) positions. There is also perhaps a risk in building capacity from an international pool of researchers - who by their very nature are internationally mobile and

have strong links abroad - in that there needs to be an internationally competitive 'draw' (salaries, opportunities, funding) to retain them beyond the initial scheme that attracted them to Ireland. Most of those involved in PI awards claim that the skills and networks acquired have been important for their subsequent career and career progression – but for some this will reveal itself through their increased attractiveness in international labour markets.

In addition to supporting a large number of individuals who were able to forge successful research careers in Ireland – helping to retain established researchers and attract new world-leading talent – the programme has also helped in making Ireland an attractive destination for top research talent in the future. The impact of the PI programme on capacity is therefore likely to continue.

6.2.2 Building capabilities (and quality) in key basic research areas

PI programme grants have had a significant impact on the size and scale of activities within individual PIs' research groups, and in particular on the number and quality of academic outputs produced.

PIs have reported in excess of 6,700 journal refereed research papers being published during their PI awards, as well as over 1,500 conference proceedings and 1,400 other publications. In addition, PIs gave ~10,000 national and international presentations, hosted over 100 conference workshops, and won in excess of 500 scientific awards. In addition the evidence shows that the impacts of the programme on the size and scale of their activities were also sustained or enhanced after the grant ended.

The bibliometric analysis suggests that increases in publications and citations in the period compares very favourably to an average global annual growth rate and Ireland managed during the ten year period of the PI programme to keep pace with the 'front runners'. This is a considerable achievement given the scale of investment in R&D in the Nordic countries (a comparator). The PI programme, as a major funder of research in life sciences (in particular biotech) and ICT, will have contributed considerably to this progress.

The analysis of the individual publication records of over one-third of PIs also suggests an increase in average publication rates either side of their award date, an increase in citations per PI, and a decrease in the proportion of un-cited papers.

Host institutions have similarly seen a very positive impact from the programme on the quantity and quality of research activity and outputs, and on the quality of training of students and postdocs more generally. The programme has also improved the quality of training at their institution; the grant freeing PIs from spending time seeking other funding, enabling them to devote more effort to leading and mentoring research groups. There is also evidence of very high quality early career investigators now emerging in the Irish system – which will in part be due to the PI funded individuals and groups.

6.2.3 Wider impacts on Irish research

Irish research is now more visible and better regarded internationally as a consequence of the PI programme.

This is evidenced in part by the significant volume and quality of research activity and knowledge directly created by the PI programme. Those directly involved have also seen an increase in their national and international reputation and networks, and in the scale of their research activities and opportunities, both within and beyond the programme.

The programme has contributed positively to the formation of clusters of excellence.

This includes examples where a number of PI funded groups in related areas are sharing expertise and collaborating, or where there are satellite clusters of researchers (not funded through the PI programme) forming around PI groups.

The Irish system is now building on a core of PIs and teams funded over a decade, with various areas of strength that can be traced back to PIs and the PI programme. However, this is an area where there is more potential. The push model of the PI programme has created new capacity

within the research system, but there is a need to ensure that new clusters of excellence are sustainable and also well linked with industry, which will feed back into the research system and the focus of research programmes.

More generally, the PI programme has expanded the size of Irish research communities, enhanced their reputation, visibility and links, and has increased the quality of research conducted and training provided within them.

6.2.4 Wider impacts on the Irish economy / society

The programme has had a significant impact on the degree of collaborative activity and other links with Irish and international companies, which is then often sustained or enhanced beyond the period of individual grants.

Short-term commercial benefits were never a core focus or intention of the programme, however it has directly supported the development of a large number of pre-commercial outputs, including at least 189 invention disclosures, 270 patent applications (and 55 patents), and a further 33 licencing agreements.

There is variation across the programme in the links made with the industrial base, in part due to the broad focus of the programme, but overall, academia-industry links were among the least cited impacts of the PI awards. Established researchers are more likely to report stronger links with the industrial base due to existing relationships. For others, it was earlier days, and the programme helped to form a base that enabled them to reach the level and quality to be able to go out and talk to industry. As highlighted the push nature of the programme was an important starting point but as it evolves, the links with the industrial base need to be further strengthened, and in a coherent manner at the policy, programme and operational level.

A number of students and researchers involved in PI teams have also subsequently been directly employed by industry. Our survey found that on leaving PI groups, one-quarter of team members went to some form of private sector role – usually an R&D role within a science or engineering context – and as a first destination, the private sector accounted for around 21% of leavers in total. This is in line with SFIs funding programmes more generally, where the average rate going into industry as a first destination is currently around 20%. It is a substantial number of individuals, but perhaps below expectations, and certainly short of SFIs current ambitious target (set after the PI programme) of 50% of those leaving SFI programmes going to industry.

Although R&D in MNCs in Ireland has started to increase, there remains a lack of a strong research base within much of Irish industry (the main exception being pharmaceuticals), which may have created a lack of demand for new capacity and capabilities emerging from the PI programme, or the research system more generally. Combined with the expanded funding for academia over the past decade, this may mean that more programme beneficiaries remained in academia, rather than transferring to industry, than was originally hoped. There is significant potential for the greater links and impact on the industrial base to be a focus of subsequent programmes and policies. A technology-oriented programme is more relevant when the industrial base is ready to take up research.

6.3 Programme performance in relation to similar programmes abroad

Programme performance in relation to similar programmes in other countries
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The SFI PI programme is unique in terms of its objectives, combining a strong focus on human capacity with retention of top talent in Ireland and alignment of Ireland’s academic research direction with industry interests.

There were many examples of initiatives that *in part* reflect the approach employed by the PI programme, showing that a number of countries have sought to address similar challenges and objectives through grants and positions for leading researchers. However, there was no close comparator, and certainly not in a country of similar size and with a similar context to Ireland.

Of those programmes reviewed, taking into account their partial coverage of the objectives and approach taken by SFI (and non-comparable evaluation data), there is a significant level of

success noted. The programmes are found to have operated effectively and efficiently and been successful in making progress against their respective objectives. The apparent success of these schemes is reflected in the fact that they all continue to operate today. These examples therefore provide some validation of the approach taken in Ireland.

6.4 Recommendations for future programmes

Recommendations for future programmes of a similar nature

There was a sense that many of the issues encountered during the PI programme are likely to have been specific to the programme and to a point in time, and that it might therefore be difficult, or inappropriate to try to transfer lessons to a different initiative, set within a different context. Also, as the PI programme has ended, stakeholders are more concerned with its current incarnation (the Investigators Programme) and the more recent research prioritisation exercise, and commenting on how these might evolve – rather than a past programme and a historical context – making it difficult to gather a view from the community.

However, this section contains some recommendations related to the programme design and the focus of objectives and considerations when adapting future programmes.

Ensure that international excellence is included in the key objectives of research capacity building programmes

The focus on international excellence in this programme has been an important thread which has run through from the objectives to the activities of the PI programme and led to significant impact on Ireland in terms of international researchers and its reputation on the international stage. Future programmes that include aspects of research excellence should always recognise this dimension.

Adapting programme models - Recognising the need to move from a push model to a pull/coupling model for creating more impact on the Irish economy

The Irish research and innovation system is maturing and with it a need to ensure that programme models adapt to the need to bring stakeholders together from research and industry. It may be that the CSETs and the new IvP programme are better addressing the needed links between the research base and industry, but there is potential for this to be done at a number of levels, helping people to come together collaboratively and to feedback into the research programmes to increase industrial relevance in key sectors.

Adapting programme models – ensuring sustainability of research agendas

There were some concerns around whether the scale of awards had been pitched quite right, and whether the size of PI grants may have created over-dependency on one source of funding and the potential for a boom and bust in research activity. In this programme, the size of individual grants was broadly appropriate for the time and for the objectives of the PI programme, but if the programme had continued, a greater number of smaller grants would have been a more appropriate approach moving forward.

Focus on achieving critical mass in key areas of relevance for Irish research and innovation whilst still supporting the development of excellence elsewhere

A comparatively small country like Ireland has to be strategic in its research in order to maximise the benefit of publicly-funded research to society and the wider economy, building critical mass and capabilities in focused areas of future importance and existing capability. This is part of the next step in a maturing system. However, one of the strengths of the PI programme was its overriding focus on excellence in broadly defined disciplines. This allowed individuals to climb to the highest level of achievement in their own field – which might not have been possible if they were forced to fit their research into a narrow thematic priority – and that it was the quality and quantity of research output resulting from this that had knock-on benefits for the retention, quality, and reputation of research and researchers in Ireland.

The answer to these competing needs is probably some careful balance between the two – a more targeted approach to take forward certain areas, combined with a more open funding mode that supports excellence wherever it exists. Certain aspects of the PI programme will be

important to maintain within this mix of future funding options. In addition, while it is appropriate for the centrality and importance of the IvP within SFI / Ireland's portfolio of funding mechanisms to be adjusted down from that of the PI programme, this should only go so far. There is an ongoing need to support basic research, to develop human capital, and to maintain and develop critical mass (particularly in new areas). There is also a need to continue to support a pipeline of next generation researchers, and to de-risk career pathways for young talent. As such, the core objectives and role of the PI programme should not be forgotten.

Managing the expectations of researchers through clear open communication

There are some issues with the Irish research community adjusting to and accepting an increasingly targeted approach to funding. Certainly some discontent was expressed from the research community about the recent research prioritisation exercise and the (potential) implications of this for certain areas of research. The openness and flexibility of the PI programme, and the close support provided by SFI to grant holders, may have in some way encouraged the community to have inappropriate expectations of ongoing support and opportunities to pursue areas of their choosing. However, there is probably little that the PI programme could or should have done to rectify this, and rather it is just a feature of an evolving and maturing system. Clear and open communication here is key – but this goes beyond the scope of a specific initiative.

Well documented programme design phase with developed indicators

Although the PI programme had a well developed rationale and objectives, there is no evidence of developed indicators. Indicators can be used effectively in programme planning by selecting achievable outcomes and then determining the logical pathway for arriving at the outcomes. Indicators are also very useful in the assessment of whether a programme is on track and also to see if adaptations should be made (and new indicators derived). Finally indicators are very useful in evaluation in assessing the extent to which the ultimate goals of the programme have been achieved. It helps with the creation of a hierarchy of objectives, translating intended global impacts into programme specific impacts, which can be measured.

Evaluation of Science Foundation Ireland's Principal Investigator (PI) Programme

Appendices

Appendix A Study Terms of Reference

The 'outline of requirements' for the study, from the request for tender, is presented below.

A.1 Objectives of the Evaluation

The aim of the evaluation is to assess the **appropriateness and effectiveness** of *Science Foundation Ireland's PI programme*. In this context, the programme will be evaluated in terms of:

- Individual programme performance;
- Programme fit in terms of complementarities and/or overlap with other interventions in the national research system;
- Programme performance and impact in relation to the science policy context that applied during the time period under review;
- Programme performance and benchmarking in relation to similar programmes in nations of comparative size.

Conclusions should be drawn on the adequacy and balance of resources allocated to the PI programme and recommendations should be offered for future programmes of a similar nature, taking into consideration the current policy framework in operation.

A.2 Scope of the evaluation

The evaluation will examine the objectives of the PI programme, and will be an ex-post evaluation of the programme and the funding awarded during the period 2000–2011.

A.3 Methodology

A full evaluation of the programme will be carried out, following 5 key steps:

Step 1: Define evaluation objectives and describe the programme. This first step will provide details on the programme to be evaluated and will inform many subsequent aspects of the evaluation. It will record the characteristics of each element of the programme, from objectives through to outcomes.

Step 2: Identify appropriate methodology for analysis: This will entail selecting a set of appropriate analytical techniques that can relate inputs and activities to outputs and outcomes to identify whether programme objectives have been met. This will include the identification of a suitable counterfactual.

Step 3: Identify data requirements: Identify the metrics of interest for each aspect of the programme under review. Data requirements on each of these metrics should be identified and collected. Where desired data are not currently collected, alternative data should be considered and recommendations made regarding appropriate data capture and management systems, to enable future evaluations.

Step 4: Evaluate the programme: The evaluation will seek to identify programme appropriateness and effectiveness. The programme will be evaluated in terms of individual programme performance (including, where possible, counterfactual analysis, quantitative and qualitative/behavioural measures of additionality); programme fit in terms of complementarities and/or overlap with other interventions in the national research system; programme performance and impact in relation to the science policy context that applied during the time period under review; programme performance and benchmarking in relation to similar programmes in nations of comparative size.

Step 5: Report and review the evaluation: This will involve drawing detailed conclusions from the evaluation regarding programme performance and effectiveness. Recommendations will then be formulated, including recommendations for future efforts to develop human capital and address the needs of Ireland's research system and the Irish economy.

Tenderers will be required to outline their approach on how each of the 5 steps will be conducted, given the nature of the programme being evaluated. Tenderers should note that there are significant levels of quantitative and qualitative data associated with the PI programme and should factor adequate resources for data analysis into their proposal.

It is envisaged that a mixed methods methodology will be applied, featuring a combination of quantitative and qualitative research. At a minimum, it is expected that the methodology will include the following:

- Review and analysis of existing reports and data on the programme (quantitative and qualitative). These will be provided to the consultants after appointment.
- A representative sample of relevant stakeholders will be interviewed to assess whether the supported projects have resulted or are likely to result in the achievement of the programme's objectives, and to establish whether the operation of the programme worked in practice. This will include SFI, the Department of Jobs, Enterprise and Innovation (DJEI), individual researchers, academic and industry collaborators involved in the PI programme.
- Performance should also be analysed with reference to the international context, to allow the programme's performance to be considered in light of performance of similar schemes in other comparable locations.

A.4 Outputs

The successful vendor will be required to produce a written report including an executive summary. The report should address the issues outlined above. The successful vendor may also be required to present the key findings to SFI.

Appendix B Detailed study approach and methodology

The study was essentially divided into two main phases – a preparatory phase (in May / June) and a period of fieldwork and analysis (June / July). This section details the various methods employed and activities undertaken during these two periods.

B.1 Phase 1 – Preparatory phase

B.1.1 Initiation meeting

The study began with an initiation meeting between Technopolis and SFI in Dublin on 29th April 2014. Technopolis presented an overview of the proposed evaluation, after which a wider discussion took place relating to various aspects of the study. In particular SFI provided further explanation of the origins and objectives of the PI programme, as well as further guidance on the objectives and scope of the requested study. SFI also explained the preparatory work that had been undertaken internally to assemble existing data on PI awards and award holders. Full notes from the meeting, summarising the main points of discussion and highlighting specific actions agreed, were circulated by Technopolis after the meeting and served as a checklist for follow-up actions over the following days and weeks.

B.1.2 Data collection and review

At the initiation meeting and in the subsequent note of discussions, a number of specific elements of data and information were requested from SFI – much of which had already been assembled in preparation for the study. Two main tranches of information were transferred to Technopolis in the first week of May, including a core database of information on grants, grant holders, and reported outputs, which had been assembled from various sources by SFI. Following a first review of this information, a small number of questions and points of clarification on the contents were discussed with SFI via email, and during an additional teleconference held on 20th May, where these remaining issues were resolved.

Information was extracted from the documents and data provided by SFI and assembled by the study team as part of the preparations for various elements of the study, and as inputs to analysis in this report. In particular, information on the background/context to, and objective/ activities/ outputs of the PI programme within the reports and databases provided has fed into different parts of this report (overview of programme, objectives and logic). In addition, details provided of individual grants and grant holders, as well as team members, host organisations, and industrial collaborators, has formed the basis for initial tracking exercises and the development of contact databases (see section B.1.4), and used for the various consultation exercises. The data also fed into the bibliometrics work.

B.1.3 Data analysis

SFI extracted and collated a significant amount of (mainly quantitative) data relating to SFI PI awards as inputs to this study. Because of changes to reporting and data collection over the period of the programme, a number of different sources (proposals, Census data, award annual reports, PSOP indicators) were used and combined to provide as complete as possible coverage for the lifetime of the programme. However, this did mean that there were some gaps in the data and potential issues of double-counting and incomparability. For some 'metrics', data was not readily available at all. For other metrics, data was only readily available for one period of the programme. For example, the number of international presentations was captured in pre-2006 award annual reports but not through the Census for later awards. An analysis of PI programme data (inputs, activities and outputs) is shown the main report.

B.1.4 Establishing contacts and contact information

Six main groups of stakeholder were identified during the first phase of the study, who could then be consulted in some form during the main phase of fieldwork. These were:

- **SFI / PI programme officials** - SFI officers responsible for the PI programme, and / or who might have a view of the role and place of the PI programme in the wider efforts of SFI and others to cultivate Ireland's scientific base and support Ireland's industry. Three key individuals in this group were identified by SFI, and relevant contact details provided.

- Host institutions - representatives of HEIs that hosted PI award holders and their teams during the lifetime of the programme. The study team identified a relevant contact in each of the host institutions – the VP for research, or an equivalent, who had held a senior position within the institution during the 2000-11 period – and these were approved by SFI at the interim study meeting.
- PI grant holders – all former and current PI programme grant holders. From data provided by SFI, the study team identified 281 *unique* award holders (lead PIs) during the period 2000-2011 (i.e. after de-duplication). A majority held just one award, but a significant minority held two, three or even four PI grants (there were 389 awards in total). A contact email address from the time of the award was provided in each case, which the study team sought to verify through an initial tracking exercise (see phase 2).
- PI grant team members - other individuals (e.g. PhD students and Post-docs) working within the research groups of PI award holders during the period of the award. Summary data provided by SFI suggested that over 4,000 individuals were involved in the 389 PI awards across their lifetime (i.e. including new members joining during the lifetime of the award, as well as those that left). This equates to around 10 people per award on average, and includes PIs, co-principal investigators, post-doctoral researchers, PhD students, Masters students, undergraduates, visiting researchers, support staff / technicians and others (though not all will have been funded through PI grant money). Whilst available data provided the number of team members (and leavers in some years), *identifying* these individuals (i.e. their names), and obtaining their contact details (email) proved to be a more difficult task than was originally envisaged. An extensive tracking exercise was therefore undertaken by the study team, which is explained as part of phase 2.
- Relevant industrial representatives - representatives from industry that have either formed partnerships with PI programme-funded researchers, are users of research in the disciplines supported by the programme, and/or have employed talent developed in PI programme-funded groups. SFI data detailed over 1,000 instances of companies collaborating with PI award holders. From this, the study team identified eight Irish-based companies, or subsidiaries, with at least 10 collaborations with PI award holders over the period. As no contact names or email addresses were included, SFI agreed to contact relevant PIs to verify the collaborative links and provide the names of relevant individuals. Through this route, 22 individuals across the eight companies were identified during the course of June, which the study team could then use to seek contact information.
- Other Irish agencies - representatives from Government and / or organisations responsible for other schemes in Ireland. SFI provided details of two relevant individuals; one from the Department of Jobs, Enterprise and Innovation, and the other from Forfás.

B.1.5 Development of PLM and detailed evaluation planning

Having collected and analysed available documentation and data, and held initial conversations with SFI officers, the study team constructed a ‘hierarchy of objectives’ for the PI programme. This provides a representation of the relevant high-level challenges and policy objectives to which the PI programme was expected to contribute, and shows how the objectives of the PI programme can be linked back to – and fit within – the wider objectives of the NDP, SSTI and SFI. This wider context for the PI programme is discussed in Section 3.1.2, while the full hierarchy of objectives is shown in Appendix D.

The study team then developed a ‘logic model’ for the PI programme. This flows from the hierarchy of objectives, but focuses on the objectives, inputs, activities, outputs and outcomes of the PI programme specifically. This provides a representation of the logical sequence and causal relationships among: the programme’s rationale and objectives; the resources (inputs) used and the activities undertaken; and the results (outputs) and changes (outcomes and ultimately impacts) that it is hoped will be realised as a result. The model is presented and discussed in more detail in Section 2.1.

Using the PLM, the study team developed a more detailed evaluation plan. This involved ‘unpacking’ the evaluation objectives (appropriateness and effectiveness) into a series of more detailed evaluation questions to be addressed by the study and identifying the appropriate method for analysis. This more detailed list of evaluation questions is presented in the

following two figures. Based on this orientation work the remaining worksteps of the study were slightly redesigned.

Figure 26 Unpacking the ‘appropriateness’ objective

Area of investigation	Evaluation question	Data sources and analysis
Appropriateness of programme in relation to its rationale and objectives	<ul style="list-style-type: none"> • What were the original rationale and objectives for the PI programme? How did these evolve? • Was the PI programme (in principle) a relevant and appropriate response to the original needs and objectives identified for the programme? • Has the programme adapted appropriately to reflect changes in its rationale and objectives? 	<ul style="list-style-type: none"> • Desk research • Surveys of PI grant holders • Interviews with SFI and other agencies • Interviews with Hosts and industry
Appropriateness of programme in relation to wider policy context and objectives	<ul style="list-style-type: none"> • What was the wider science policy context, within which the PI programme was first established? How did this evolve? • What public policy objectives were of relevance to the PI programme (or that it explicitly sought to address) during its lifetime? • Was the programme sufficiently and appropriately aligned (in principle) with the evolving wider national science policy context and objectives? 	<ul style="list-style-type: none"> • Desk research • Interviews with SFI and other agencies • Interviews with Hosts and industry
Appropriateness of programme in relation to other related interventions in the national research system	<ul style="list-style-type: none"> • What other interventions in the national research system have sought to address the same or similar policy objectives? • To what extent, and in what ways, did the PI programme fit with these other programmes (any gaps / duplication, synergies / complementarities)? 	<ul style="list-style-type: none"> • Desk research • Interviews with SFI and other agencies • Survey of PI grant holders • Interviews with Hosts
Appropriateness of programme in relation to similar initiatives in other countries	<ul style="list-style-type: none"> • What schemes have existed in other (similarly sized) countries that are comparable with the PI programme (i.e. similar targets / objectives)? • How does the PI programme’s fit / appropriateness to its own context and objectives compare with the situation of these other schemes? 	<ul style="list-style-type: none"> • Desk research

Figure 27 Unpacking the ‘effectiveness’ objective

Area	Evaluation question	Indicators	Data sources and analysis
Research and translation	<ul style="list-style-type: none"> • Did the PI programme build internationally competitive scientific research capacity in Life Sciences, ICET and Energy? 	<ul style="list-style-type: none"> • Publications and citations; conference presentations • Funding from other public sources secured, national (e.g. other SFI, PRTL) and international (e.g. EU, Wellcome) • Research activity sustained post-PI grant • New permanent staff positions created • Benchmarking against comparable funding schemes 	<ul style="list-style-type: none"> • Desk research and tracking • Bibliometric analysis • Survey of PI grant holders and teams • Interviews with Hosts • Interviews with SFI and other agencies
	<ul style="list-style-type: none"> • Did the PI programme build capabilities in key basic orientated research areas that would see translation into enterprise and industry? 	<ul style="list-style-type: none"> • Links to industry (including participation in CSET centres) • Licensing agreements, patents • Industry funding secured 	<ul style="list-style-type: none"> • Desk research and tracking • Survey of PI grant holders and team members • Interviews with industry
Human capital	<ul style="list-style-type: none"> • Did the PI programme help to develop and enhance internationally competitive research talent in Ireland? 	<ul style="list-style-type: none"> • PI grant enhanced research capability of funded individuals, e.g. as indicated by publication and conference presentation record, prizes, patents, other funding secured (pre- and post PI-award) • Researcher continued appointment within Ireland post-PI grant • Benchmarking against comparable funding 	<ul style="list-style-type: none"> • Desk research and tracking • Bibliometric analysis • Survey of PI grant holders and team members • Interviews with hosts

Area	Evaluation question	Indicators	Data sources and analysis
		schemes	and industry <ul style="list-style-type: none"> Interviews with SFI and other agencies
	<ul style="list-style-type: none"> Did the PI programme help third level institutions to attract and retain world-class researchers in Ireland? 	<ul style="list-style-type: none"> Number of foreign researchers with appointments within Ireland post-PI grant (long-term) Relative “attractiveness” of Ireland as a destination for research talent (and change over 2000-2011 period): Number of foreign applicants Quality of foreign applicants, e.g. number of peer-reviewed publications / h-index at time of application, HEI ranking of institution of origin Number (and quality) of foreign applicants for PhD /postdocs positions Number and destination of applicants who were successful but did not take up the PI programme grant Benchmarking against comparable funding schemes 	<ul style="list-style-type: none"> Desk research and tracking Bibliometric analysis Survey of PI grant holders and teams Interviews with Hosts
	<ul style="list-style-type: none"> Did the PI programme provide excellence in training and development for students and postdoctoral fellows through state-of-the-art research opportunities with world class researchers and teams? 	<ul style="list-style-type: none"> Number of PhD students and postdocs trained Enhanced research outputs of PhD students and postdocs in PI programme-funded teams Career progression of students and postdocs from PI programme-funded groups, career progression Benchmarking against comparable funding schemes 	<ul style="list-style-type: none"> Desk research and tracking Survey of PI grant holders and team members Interviews with Hosts
Participation in international research community	<ul style="list-style-type: none"> Did the PI programme enhance the candidates’ research and provide capacity and reputation to promote Ireland’s participation in the international research community? 	<ul style="list-style-type: none"> Number of international collaborations and collaborations outputs, e.g. co-authored publications, joint funding, researcher/student exchanges, access to overseas research facilities, institutional partnerships, participation in international research initiatives Participation in international funding programmes, e.g. EU FP Participation in, and extension of, international research networks 	<ul style="list-style-type: none"> Desk research Bibliometric analysis Survey of PI grant holders
		<ul style="list-style-type: none"> Reputation of Irish science research abroad 	<ul style="list-style-type: none"> Survey of PI grant holders
Counterfactual	<ul style="list-style-type: none"> What is likely to have happened in the absence of the PI programme? 	<ul style="list-style-type: none"> Comparative data Opinion 	<ul style="list-style-type: none"> Bibliometrics Surveys and interviews

B.1.6 Development of fieldwork tools

Two main survey questionnaires – one for PI award holders, one for the wider set of PI award team members - were drafted and presented in the interim report at the end of phase 1. These questionnaires were then revised based on the feedback given by SFI, and uploaded to an online survey facility. A summary of the main topics covered by each questionnaire is shown in the figure below. The full questionnaires can be viewed online at the following addresses:

<https://www.surveymonkey.com/s/SFIPI>

<https://www.surveymonkey.com/s/PIteams>.

Figure 28 Main topics covered by PI award holder and team member surveys

Award Holders	Team Members
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<ul style="list-style-type: none"> • Funding sources (pre-/during-/post-award), and the importance of the PI grant to follow-on funding • Location (pre-/post-award), the impact of the PI grant on location decisions / options, and the counterfactual • Key features, and uniqueness of the PI grant 'offer' • Impact of PI grant on research group size, activities and outputs, and whether these were sustained post-grant • The impact of the PI programme on subsequent activities and experiences • The impact of the PI programme on the wider research community in Ireland 	<ul style="list-style-type: none"> • Position within the team and funding source • Impact of the grant on the group and its experiences • Location (pre-/post-award), and the impact of the PI grant on location decisions • Reasons for joining award team, and likely alternatives • Subsequent career progression, and the impact of involvement in the PI award team on direction/speed of career progression • The impact of the PI programme on subsequent activities and experiences
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Interview guides for SFI/other officials, host institutions and industrial representatives were also drafted and approved by SFI before use. The main topics covered in each case are summarised below.

Figure 29 Main topics covered by stakeholder interview guides

SFI / Other Officials	Host Institutions	Industrial Representatives
<ul style="list-style-type: none"> • The role / position of the PI programme within the wider funding landscape, and its alignment/fit with other initiatives • The relevance / appropriateness of the programme's objectives, focus areas and activities within the wider evolving context • Outcomes achieved by the programme, and progress made in relation to PI programme objectives • The need for a similar programme / to address similar issues in the future 	<ul style="list-style-type: none"> • Impact of the PI programme on the institution's / departments' research, research capacity, training of students, collaboration network and international standing • Counterfactual • Main impact of the programme on the institution • Strengths and weaknesses of the programme • How the programme compares / aligns with other major funding programmes supporting research • The relevance / appropriateness of the programme's objectives within the wider evolving context • Progress made in relation to PI programme objectives • The need for a similar programme / to address similar issues in the future 	<ul style="list-style-type: none"> • Origins of collaboration with PI(s), and what this involved • Benefits / impact / sustainability of collaboration • The relevance / appropriateness of the programme's objectives within the wider evolving context • Progress made in relation to PI programme objectives • The need for a similar programme / to address similar issues in the future

B.1.7 Interim report and meeting

An Interim Report was provided to SFI on 3rd June. This detailed activity during the first phase of the study (as discussed above), and set out full plans and details for the second phase. It served as the basis for discussion at a meeting between Technopolis and SFI on 9th June.

B.2 Phase 2 – Fieldwork and analysis phase

B.2.1 Tracking PI award holders

The PI database provided by SFI gave basic information on individual PIs, including: their name, gender and nationality; their location (organisation and country) at the time of application (in most cases); and their host institution for the period of the award; as well as their email address at this time. On the basis of web-research the study team attempted to verify and update these details, identifying and recording for each of the 281 award holders their current title, post, department, organisation, country and email address. Updated details were identified for all PIs, except in 5 cases where the individual had retired or is deceased.

This initial 'tracking' exercise already revealed some interesting and useful information. For instance, it suggested that 260 of the PIs receiving awards during the 2000-2011 period were still working in Ireland – indeed 250 appeared to still be working for the institution hosting them during their award, suggesting that the programme has had a positive impact on the retention of key individuals. Most PIs also appeared to have remained in academia, though at least 3 individuals appeared to now be working mainly in the private sector. These findings would be verified through the questionnaire survey addressed to PIs.

B.2.2 Identifying and tracking PI award team members

The PI programme was not just about capacity building and training of PIs, but also the development of, and opportunities offered to, a much larger number of researchers and students. The impact of the PI programme on these wider teams (and not just PIs) is an area of interest for SFI, but also an area where little is currently known. As such, it was agreed that, despite the difficulties involved, the study team would dedicate additional resources to identifying, tracing and consulting with this group of participants / beneficiaries. This would involve the study team making a first attempt to identify most of the relevant team members, followed by a request to PIs to extend these lists and provide information on current locations and contact details (where known), followed by further efforts by the study team to identify missing contact details that would then allow a large number of team members to be contacted and invited to participate in a questionnaire survey.

PI award holders were required to provide details of current (and in some years also graduating / departing) team members in their annual reports. On 30th May, SFI therefore provided the study team with one annual report (often from the 2nd or 3rd year of the award, when teams would be well established) for each of the PI awards in scope. The study team then extracted the relevant table(s) of team members from the pdf/word documents and compiled this information into an excel database. In total, 389 annual reports were reviewed, from which 3,533 team members were identified. This is unlikely to be a complete list of all involved, as those leaving before, or joining after the reporting year would not be included. However, SFI predicted that around 80-90% of team members are likely to be included within the reports reviewed. Also, not all of the team members listed will necessarily have been funded by SFI – they may just be associated with the award, or working in the lab of the award holder. However, that is not to say that they are not benefiting indirectly from the PI award. The request to PIs and subsequent survey of team members sought to better clarify the funding situation of team members, and get a better sense of who was funded through the programme.

Because of changes in reporting requirements over the years, and gaps in the information provided by PIs, the details available on each person varied (see figure below).

Figure 30 Data available on individual team members

Fields	Number of entries
Team members identified from annual reports	3,533
Information available on each team member:	
<i>Their name</i>	3,533
<i>Their position within the team</i>	3,376
<i>Their gender</i>	3,533
<i>Their prior affiliation</i>	3,091
<i>Their nationality</i>	3,526
<i>Their highest degree at the time</i>	3,170
<i>Their date they graduated / departed from the team</i>	52
<i>Their subsequent occupation / affiliation after leaving the team</i>	269
<i>Their email address</i>	0

Importantly, contact information is not provided in the report data – and only in a minority of cases are leavers identified, and their destination affiliation given. Considerable additional work was therefore needed to track and locate these individuals, as well as to identify other team members not detailed in reports. As such, the decision was taken to limit the scope of this tracking activity to just Postdoctoral researchers and Postgraduate (Masters and PhD) students. This reduced the total pool of identified team members in scope to 2,590, covering 379 awards. No relevant team members were identified in the reports of the other 10 awards.

On 13th June the study team wrote to all PIs to introduce the study and to ask for their assistance in identifying and tracking the members of their award team. To each mail we attached an individualised template, setting out for each of their awards, our current list of team members (identified from their annual reports). Where no team members had been identified, this was explained, and a blank table was provided. Each PI was asked to review the lists provided, to verify and (if necessary) add to this list, and then (wherever possible) indicate each individual's current affiliation and email address, before returning the amended document to the study team. A reminder email was sent at the end of June to encourage those that had not yet returned their template to do so.

Templates continue to be returned, but at the time of writing 115 PIs (41% of all PIs) had returned a verified and updated list of team members, which between them covered 156 PI awards (40% of all awards). Together these returned templates listed 1,155 relevant team members (postdocs, Masters students and PhD students). The following figure summarises the response rates.

Figure 31 PI award team member tracking exercise – response rates

PIs	
PIs in Database	281
Do not contact (retired, deceased, other)	6
Templates	
Template request sent to	275
Undeliverable requests (i.e. invalid email)	3
Template request delivered to	272
Templates returned by	117
% template return rate (templates returned / templates delivered)	43%
Relevant (postdoc, PhD and Masters) team members identified	1,155

For those awards where a template was returned, the number of individual team members identified increased from 992 (identified from annual reports) to 1,155 (once verified and updated by PIs). Applying this rate of correction to the full list of team members identified from annual reports, would suggest that there may have been around 3,015 Masters, PhD and Postdoctoral team members (split approximately 13%, 46%, 41% between these three groups) involved across all PI award teams.

In around half of cases an email address was provided for the identified team member, while in many of the remaining cases some information had been provided on the current occupation / location of the individual concerned. From this information on current locations, the study team undertook further efforts to identify relevant email addresses where these were missing, taking to 804 the total number of team members with contact details that could then be contacted to request participation in the study (see below).

B.2.3 Survey of PI award holders

PIs were sent a second request on 13th June, inviting them to participate in a short online questionnaire about their experiences as a PI award holder. A reminder email was sent to non-respondents at the end of June to encourage additional responses. Responses continue to come in, but at the time of writing 183 PIs (65% of the total) had provided a response, covering between them over 250 PI grant awards (65% of the total). The following figure summarises the response rates.

Figure 32 PI award holder questionnaire survey – response rates

PIs	
PIs in database	281
Do not contact (retired, deceased, other)	6
Undeliverable requests (i.e. invalid email)	3
PI Survey	
Survey requests sent to	273
Opt outs	12
Survey request delivered to	263
Surveys completed	183
% response rate (surveys returned / requests delivered)	70%

Not all respondents answered (or indeed were asked) all questions in the survey, and so the response rates vary across the questionnaire. The number of responses to individual questions is noted against the presentation of individual results in this report.

B.2.4 Survey of PI award team members

Identified team members were sent requests, inviting them to participate in a short online questionnaire about their experiences. An initial tranche of individuals were emailed on 18th June, with further requests sent out as PIs returned templates with additional contacts identified. All 804 team members identified, where email addresses had been found, were invited to participate in the questionnaire. At the time of writing 334 team members (42% of the total) had provided a response, covering between them 131 PI grant awards (34% of the total). The following figure summarises response rates.

Figure 33 PI award team members questionnaire survey – response rates

Team member survey	
Number of valid team members identified from templates	1,155
Number without email address	351
Survey requests sent to	804
Opt outs	40
Survey request delivered to	764
Surveys completed	334
% response rate (surveys returned / requests delivered)	44%

Again, not all respondents answered (or indeed were asked) all questions, and so the varying response rates are indicated in this report against survey results.

B.2.5 Interviews with stakeholders

Representatives from the four other stakeholder groups were approached by email to request a telephone interview with a member of the study team. A broad outline of issues for discussion was provided in advance, based on the specific topic guide developed for that group. The table below summarises the number of interviews undertaken within each group.

Stakeholder group	Contacts identified	Interviews undertaken
SFI / PI programme officials	3	3
Host institutions	14	6
Industrial representatives	8 (companies)	2 (companies)
Other Irish agencies	2	2
Total	27	13

The original proposal suggested we would try to consult with around 15 individuals through interview in total. It has not been possible to quite meet this target in time for this report (due to the availability of a number of contacts).

B.2.6 Case studies

Based on responses to the PI survey questionnaire (and whether they agreed to a further conversation), we selected 20 individuals to approach for further discussion. We conducted in-depth interviews with a selection of ten high-calibre researchers to explore how the PI programme has affected 1) their personal careers and 2) the structure/direction of their research community in Ireland. Discussions covered how the programme has influenced their decision to remain, or move to Ireland, what alternatives they would have considered in the absence of this funding stream, and what opportunities/challenges they had to sustain their research programme beyond the PI programme grant. Furthermore, they were asked if (and how) the PI programme funding has affected the size and connectedness of their research community in Ireland as a whole, and influenced the direction of research. These personal stories were developed into short case studies to provide a personal perspective and additional texture to the evaluation.

B.2.7 Bibliometrics

A set of bibliometric analyses were undertaken to explore the extent to which the PI programme funding has: (i) enhanced grant holders' scientific development; and (ii) supported the participation of PI programme grant holders in the wider international (and national) research communities. In both cases, we considered the impact of grant-holder nationality, and excluded from the analysis the small number of PIs that are no-longer based in Ireland. An additional exercise compared the bibliometrics of some of those who were successful in their application to the PI programme, with some of those that were 'just' unsuccessful – in essence to explore the counterfactual in terms of research output.

A short introduction to bibliometric analysis

Technopolis uses Scopus as its working platform for bibliometric analysis because it includes 32m records post-1995, and 21m from earlier, plus 20,874 peer-reviewed journals, 30,000 books, and 5.5m conference papers. It is also updated daily.

Bibliometrics is based on the scientific output of researchers. We distinguish two main types:

- **Publication counts** - This is the most basic of bibliometric methods and measures research output. It provides a good indicator for productivity and measure of scientific production. However, it does not tell anything about the quality of the research and is

therefore an inadequate indicator of scientific progress. This is because most publications provide only a small contribution to scientific knowledge, whereas a few seminal papers provide significant contributions.

- Citation counts - This addresses questions of quality, influence, and transfer of knowledge. It is assumed that the most cited publications contain eminent research findings, which contribute most to science. However, there are many factors challenging this assumption: citation cartels, self-citations, review articles, or negative references in particular. In addition, publication habits differ between scientific fields, and there is an English-language bias. Nevertheless, citation analysis is commonly used as a proxy for the contribution to scientific progress.

Among the indicators based on citation counts is the so-called Hirsch- or h-index. The index ('h') is calculated for an author where they have published h papers, each of which have been cited at least h times. As such, the index is associated with both the productivity and impact of a scientist. Obviously a critical aspect is its bias towards older, established scientists, which tend to have a longer publication history and thus a larger probability to achieve a higher h-index than a more junior scientist.

As with the underlying different propensity to publish and to cite by discipline, average h-indices also differ among disciplines, as they do by the age of researchers. For example, an h-index of 18 may be typical for an established professor in physics, while in economics the average may be 7. Young researchers tend to have a lower publication record and thus, a lower h-index. Thus the h-index (as initially conceived) has a strong correlation to the age and publication history (publication length) of a researcher and depends largely on publication and citation habits per field/discipline.

Analysis of PI award holders' outputs

For the study, a representative sample of grant holders was taken from three periods of the PI programme (from awards made in 2003/4, 2006/7 and 2009/10). The sample size for each period varied to reflect the total number of (first time) awardees in each case. Those who had already held a PI grant were excluded, as were those now outside of Ireland. The samples also included PIs from both of the two main programme focus areas (ICT and Life Sciences).

The study team then sought to identify each PI within Scopus, checking also for prior affiliations in case of recent changes. As a result of this process, 7 individuals were unidentifiable, taking the total sample size from 113 to 106, as shown below.

Figure 34 Number of researchers in each sample

	Sample 1: 2003/2004	Sample 2: 2006/2007	Sample 3: 2009/2010
PI Grants awarded	52	78	71
Total PIs funded (first award)	50	36	42
Number of PIs selected for sample	44	32	37
Number of PIs identified within Scopus	41	30	35

Source: Technopolis

Data extraction and analysis

Once researchers were identified, the study team extracted their Scopus IDs and downloaded their total number of publications and their h-index. As shown below, 11,695 publications (all years, all publication types) were found for the 106 PIs in the three samples, with 110 publications per PI on average. The average number of publications for those in the earliest sample is significantly higher (+25%) than the two later groups of PIs. This group also has a slightly higher h-index. This difference may partly reflect age / seniority differences (at the time and / or now) between researchers first funded in 2003/4, and those in later years.

Figure 35 Researchers' aggregated outputs, per sample

Sample group:	1	2	3	All
Number of researchers	41	30	35	106
Total number of publications of researchers	5,115	2,933	3,647	11,695
Average number of publ. per researcher	125	98	104	110
Average h-index for all publications	26	23	22	

Data: Scopus; Calculation: Technopolis. Note: the publications contain the entire publication history of the grant holders, regardless of type of publication.

This data alone does not allow us to make any inferences about the PI programme. For this, more detailed publication records were also downloaded, covering the years of the PI scheme. The search was limited to articles and reviews since they are the ones typically used for citation analysis. For the purposes of citation analysis, yearly citations per article (excluding the self-citations of all authors) were also downloaded. Figure 36 provides an overview and description of the indicators then used for the analysis presented in this report.

Figure 36 Overview of bibliometric indicators

Indicator	Description
Publications Y	Total historical publication count Publication count over set periods: the two years covered by the sample, plus the previous and subsequent two years.
Citations (PubY+2) excl. self citations	Total number of citations, in the year of publication and in the two subsequent years (short citation window), excluding self-citations from all authors
Citations (PubY+8) excl. self citations	Total number of citations, in the year of publication and in the seven subsequent years (long citation window), excluding self-citations from all authors
CPP (PubY+2)	Citations per publication. Based on the number of citations (PubY+2) and the number of publications.
% non-externally cited publications (PubY+2)	The proportion of publications not being cited within the year of publication and in the two subsequent years (short citation window)
% non-externally cited publications (PubY+7)	The proportion of publications not being cited within the year of publication and in the seven subsequent years (long citation window)

Source: Technopolis

Counterfactual analysis

The study team also used bibliometrics to explore the counterfactual. It was agreed with SFI that we would take a sample of those applicants to the PI programme who just missed out on an award in the 2009 and 2010 application rounds (Group A, n=19), and compare their publications/citations with applicants that were awarded a PI grant in these rounds (Group B, n=19). While we ensured that those in the non-funded sample did not receive a PI award in another round, we do not know what (if any) funding they may have gone on to receive from other sources. For these two groups, their publication history, change in publication rates and citations were compared.

International comparison

Departing from samples of award holders, we also used bibliometrics to undertake an international comparison for the two main fields of the PI grant: ICT (for which we focused on computer sciences) and life sciences (focusing on the largest sub-fields within this broad area). Various indicators are compared with countries of a similar size to Ireland: Denmark (population of 5.6m), Slovakia (5.4m), Finland (5.4m), Norway (4.9m), and Croatia (4.6m).

B.2.8 International comparisons

The study was asked to consider briefly the performance of the PI programme in relation to similar programmes in nations of comparative size. SFI wished to understand whether other countries, with similar contexts, had deployed a similar model or initiative to the PI programme, what the objectives and role of these comparable schemes were, and whether they were considered to have been successful in relation to their missions. The intention was that this might help to understand whether the PI programme was an appropriate programme to run, and provide some positive validation for its deployment in Ireland at the time.

The study team reviewed a large number of schemes from around the world, and ultimately concluded that the SFI PI programme was unique in terms of its objectives, combining a strong focus on human capacity with retention of top talent in Ireland and alignment of Ireland's academic research direction with industry interests. Nevertheless, we identified a small selection of 12 programmes and initiatives that were most similar to the SFI PI

programme. We focused on those that targeted established researchers (as in the SFI PI programme), rather than the numerous schemes aimed at supporting up-and-coming young research talent (but that also have some similarities to the PI programme objectives).

Each scheme was reviewed, and the key features and characteristics of each are summarised and presented in this report. A selection of these programmes, for which evaluations were publicly available, were then assessed in more detail, in order to better understand their objectives, budget, activities and (assessed) achievements. Notable similarities and differences to the PI programme were also drawn out.

B.2.9 Analysis and reporting

Having completed the various elements of fieldwork we then proceeded to analyse all of the information and to use it to answer the full set of study questions and objectives. The results of this assessment were presented in a draft final report, which was delivered to SFI on 18th July. Having been reviewed and discussed internally, feedback was then provided to the study team, such that the report could be revised and finalised. This final version of the report addresses all of the issues as outlined in the original terms of reference for the study.

Appendix C Individuals consulted

C.1 SFI / PI programme officials interviewed

Name	Post	Organisation
Aisling McEvoy	SPM, Pre-Award team (formerly SPM for PI programme)	SFI
Lisa Higgins	Head of Pre-Award Team	SFI
Ruth Freeman	Director of Strategy and Communications	SFI

C.2 Representatives of Host Institutions interviewed

Name	Post	Organisation	PIs
Prof. Clive Williams	Dean of Faculty for Eng, Science and Mathematics	Trinity College Dublin	105
Prof. Anita Maguire	VP for Research and Innovation	University College Cork	53
Dr. Kieran Drain	CEO	Tyndall National Institute	28
Prof. Lokesh Joshi	VP for Research	National University of Ireland - Galway	26
Prof. Edmond Magner	Dean of Faculty of Science and Engineering	University of Limerick	20
Prof. Bernard Mahon	VP for Research	National University of Ireland - Maynooth	19
Dr Tim McCormac	Head of Research	Dandalk Institute of Technology	1

C.3 Industrial representatives interviewed

Name	Organisation
Leonard Hobbs	Intel
Jim Somers	Eblana Photonics
Mazhar Bari	Solarprint

*Interview booked, but could not take place before deadline for this report

C.4 Representatives of other agencies / departments interviewed

Name	Post	Organisation
Aidan Hodson	Principal Officer, SFI EU & International Policies and Programmes, Innovation and Investment Division	Department of Jobs, Enterprise and Innovation, Ireland
John Dooley	Head of Department, Science Technology and Innovation Policy	Forfás

C.5 PI award holders interviewed

Name	Organisation
Dr Thomas Ritter	National University Ireland Galway
Professor Dermot Diamond	Dublin City University
Professor Louise Kenny	University College Cork
Professor Mike Lyons	CRANN, Trinity College Dublin
Professor Paul Moynagh	National Institute Maynooth
Professor Douwe van Sinderen	University College Cork
Professor Ian Robertson	Trinity College Dublin
Professor Chris Dainty	National University Ireland Galway
Dr Paul Hurley	Tyndall National Institute
Professor James Gleeson	University of Limerick

Appendix D Overview of relevant policy objectives

Figure 38 provides a simple representation of a “hierarchy of objectives” for the SFI PI programme. This attempts to summarise and link the relevant high-level challenges and policy objectives under which the PI programme was developed and operated, and to which the programme was expected to contribute. It is discussed in Section 3.1.2.

The diagram is intended to illustrate how the objectives of the PI programme (to the right-hand side) align with and support some of the wider objectives of the National Development Plan and STI strategy (left-hand side), via the objectives of the intermediate organisation (SFI). These wider challenges and policy objectives set the scene and context for the development of a specific logic model for the PI programme, which is presented in Section 2.1.

The contents of the hierarchy of objectives are drawn from the documents listed below, and are focused predominantly on the earlier versions of these (where they exist) to ensure the rationale and objectives of the PI programme are considered in terms of policies in place when it was established.

Figure 37 Key documents used in the development of the hierarchy of objectives

Title (key documents)	Responsible dept/ agency
Ireland National Development Plan 2000-2006	DJEI (and its predecessors)
Strategy for Science, Technology and Innovation 2006-2013	DJEI (and its predecessors)
SFI Value for Money 2008	Indecon for SFI
SFI Vision 2004-2008	SFI
Other documents consulted:	
<ul style="list-style-type: none"> • National Development Plan: Productive sector Operational Programme 2000–2006 • Industrial Development (Science Foundation Ireland) Act 2003 • National Development Plan 2007-2013 • Building Ireland’s Knowledge Economy – the Irish Action Plan for Promoting Investment in R&D to 2010 (2004) • Powering the Smart Economy, SFI Strategy 2009-2013 	

Figure 38 Hierarchy of Objectives for the PI programme



Appendix E Bibliometrics analysis

Given that high quality and high impact publications are a cornerstone of the PI programme, and a key indicator of the impact of funding on the quantity / quality of research undertaken, the study has explored these outputs in more detail through a bibliometric exercise.

A representative sample of 106 grant holders was taken from three periods of the PI programme (from awards made in 2003/4, 2006/7 and 2009/10). The sample size for each period varied to reflect the total number of (first time) awardees in each case. Those who had already held a PI grant were excluded, as were those now outside of Ireland. The samples also included PIs from both of the two main programme focus areas (ICT and Life Sciences).

E.1 Pre- and post- award publication record

For each of three samples of PIs, the following table shows average publications per PI (counting only articles and reviews), as well as average citations per publication (including citations in the year of publication and in two subsequent years). Results are shown for three periods, which vary by sample, in order to cover a pre-award, 'on-award', and post-award period in each case. The length of individual PI grants differs between individuals, but in most cases the grant funding covers both the second and third period shown.

For all three samples, the average publication rates increase from the period immediately prior to the PI award to the period in which the award was made (by 20%, 13% and 43% respectively). For the first sample, the average number of publications continues to increase in the third period, while for the other two samples the average drops again slightly, though not to pre-award levels. Given the differing start dates and lengths of grants, and the fact that the publication process can take around a year (including peer review), it is difficult to make a precise correlation between the PI award and publication rates. However, the award of a PI grant does appear (on average) to trigger an increase in the number of papers the PIs publish. The level may then fall back, but it seems to remain higher than before they got the grant – suggesting that the programme funding may have put them on a new trajectory.

In terms of citations per publication (CPP), we can observe for PIs in sample one and two, that their CPP rate increased considerably from the pre-award to on-award period (though fell back again subsequently). By comparison, for PIs in sample three, there is a small decline in the CPP between the two periods. The data does therefore suggest that the PI award may have led to an increase in the quality/influence of publications for many award holders (the total number of citations per person increases over the period) – but that the simultaneous increase in publishing rates has dampened this effect somewhat. However, the variability between samples and over the full three periods means that the evidence does not provide a very conclusive trend.

Figure 39 Average publications and citations per publication, by sample

	Pre-award	On-award	Post-award
Sample 1 – Awards starting 2003-2004	2001-2002	2003-2004	2005-2006
Average publications per PI	5.5	6.6	7.7
Average citations per PI (PubY, Y+1, Y+2)	27	61	40
Citations per publication (PubY, Y+1, Y+2)	5.1	9.5	5.1
Sample 2 - Awards starting 2006-2007	2005-2006	2006-2007	2008-2009
Average publications per PI	6.9	7.8	7.5
Average citations per PI (PubY, Y+1, Y+2)	67	86	80
Citations per publication (PubY, Y+1, Y+2)	9.7	11.2	10.5
Sample 3 - Awards starting 2009-2010	2008-2009	2009-2010	2011-2012
Average publications per PI	8.8	12.6	11.4
Average citations per PI (PubY, Y+1, Y+2)	63	85	
Citations per publication (PubY, Y+1, Y+2)	6.8	6.5	

Data: Scopus, Calculations: Technopolis

An alternative indicator of quality / influence is the proportion of publications that go uncited in a given period. The proportion of uncited publications for the same three samples of PIs and publication/citation periods is shown below. This does not reveal a very clear pattern either, other than the fact that for all three samples the proportion of uncited papers in the

post-award period is lower than in the pre-award period. This provides some further evidence of an increase in quality/influence of PI work, which may be attributable to the PI award.

Figure 40 Average share of non-cited publications, by sample

	Pre-award	On-award	Post-award
Sample 1 - 2003-2004	2001-2002	2003-2004	2005-2006
Average % of un-cited publications	18%	21%	15%
Sample 2 - 2006-2007	2004-2005	2006-2007	2008-2009
Average % of un-cited publications	10%	7%	8%
Sample 3 - 2009-2010	2007-2008	2009-2010	2011-2012
Average % of un-cited publications	17%	19%	14%

Data: Scopus, Calculations: Technopolis

E.2 Long-term publication impact

Above we have considered 3-year citation windows, but obviously citation rates continue to develop over time. For our sample 1 (awards in 2003/4) there has been a longer time period for citations to accrue, and we can therefore look at a longer citation window for this group.

Below, we present citations for sample 1's 2003-4 publications (271), both for a short (2003-6), and longer citation period (2003-11). This suggests that increasing the length of the citation window increases the average citation rate per publication for this group considerably, from 9 to 22 citations per publication on average (an increase of 139%). The proportion of uncited publications also more than halves to just 8% of the 271 total publications when the citation window is extended.

The long citation window has size effects on both the frequently cited publications and those that were less cited in the first few years. Indeed, for this sample, the increase is relatively larger for those with an initially low citation count (1-9), compared with the higher cited (10-200 citations) publications.

Figure 41 Citation rates of 'sample 1' publications, from 2003-2004

	2003 - 2006	2003-2011
Total external citations	2,504	10,824
Average citations by publication	9.2	22
Number of non-cited publications	58	22
% of un-cited publications	21%	8%

Data: Scopus, Calculations: Technopolis. Note: citations exclude self-citations

E.3 Counterfactual analysis – funded and unfunded applicants

The study team also used bibliometrics to briefly explore the counterfactual. A sample of 19 unfunded applicants to the 2009/10 rounds of PI award funding was compared to a sample of 19 successful applicants (PIs) from the same time.

Information from Scopus on the entire publication history of these two groups is shown below. The average number of publications per person in the funded group is 27% higher than in the non-funded group, which may reflect higher age / seniority amongst those funded. The average h-index is the same for both groups. This indicator combines both productivity and impact, and suggests that there is little difference between these two groups (at least on average), as we might expect from such borderline (fund / do not fund) applicants.

Figure 42 Comparison of funded vs. non-funded populations, publication history

	A - non-funded researchers	B – funded researchers
Total publication history	1,440	1,943
Average publication per person	80	102
Average h-index	19	19
Minimum h-index	7	8
Maximum h-index	54	44

Data: Scopus, Calculations: Technopolis

As previously we then analysed only articles and reviews for a given publication period. We took a simplified two period approach, with the first broadly relating to a 3-year pre-award period, and the second broadly relating to a post-award period (i.e. during the period of PI grant funding). For both groups, the average number of publications per person increased from the first to the second period. However, the rate of increase for the funded researchers, was slightly higher than the non-funded group.

Figure 43 Publication statistics – only articles and reviews, 2007-14

	A - non-funded researchers	B – funded researchers
Publications 2007 - 2009	212	254
Publications 2010 - 2012	246	316
Avg publications per person 2007 - 2009	11.2	13.4
Avg publications per person 2009 - 2012	12.9	16.6
Increase	16%	24%

Data: Scopus; Calculations: Technopolis

If we compare the share of non-cited publications, the non-funded group does slightly better, despite (or perhaps because of) the lower volume of publications produced by this group during the period.

Figure 44 Comparison of non-cited publications

	Non-cited publications (short 3y citation window)	Non-cited publications (long 7y citation window)
A - non-funded researchers	15%	7%
B - funded researchers	17%	9%

Data: Scopus, Calculations: Technopolis

Overall, therefore, while the Irish PI programme may have helped to increase the publication outputs and thus productivity of the individuals concerned, it appears to have had an unclear influence on the quality of the research (as indicated by citations) within the groups sampled.

E.4 Irish and peer country publication activity in ICT and Biosciences

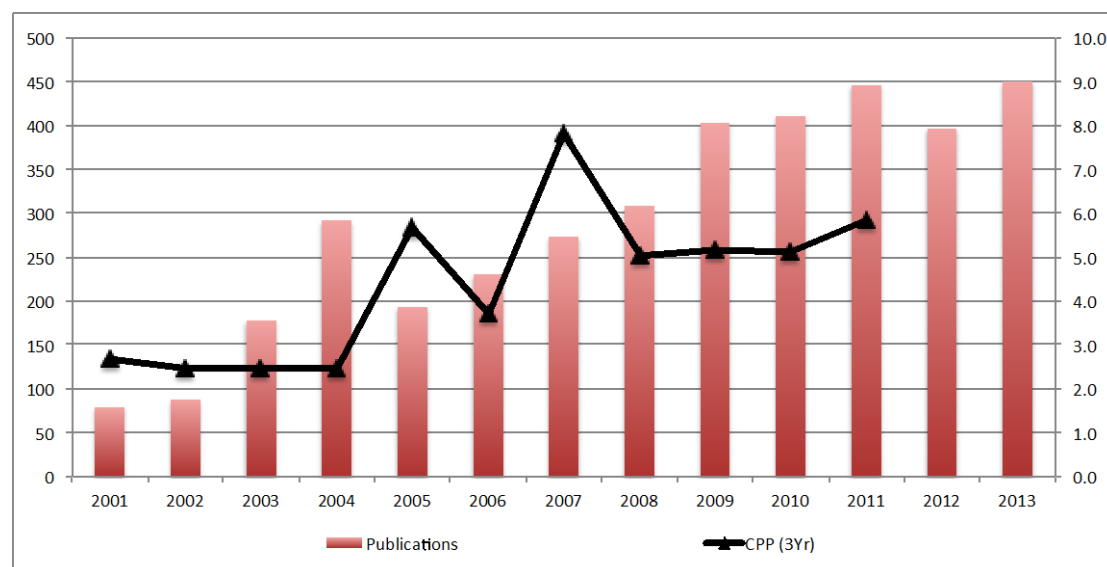
We first considered Irish publications in the PI award initial focus areas (ICT and life sciences), over the period of the PI programme, and in an international context, by comparing against peer countries of a similar size (in terms of total population).

We have used the field of **computer sciences** as an (imperfect) indicator for ICT within this part of the bibliometric analysis. The ICT area within the PI programme actually encompasses elements of a broad range of disciplines (such as physics, chemistry, materials science, engineering and applied mathematics etc.), but it is not possible to cover the full breadth of this coverage within our analysis. The computer science results should therefore be treated with caution, and not be assumed to reflect the PI programme’s wider ICT remit.

Ireland’s contribution to the global publication of articles and reviews in computer sciences is relatively small. There were 3,750 publications with an Ireland-based author in the field from 2001 to 2013, ranking it 36th among producing countries. However, during this period the number of computer science publications per year with an Irish author increased dramatically – from around 80 in 2001 and 2002 to 400+ per year from 2010. In fact, the average annual growth rate in this period was 15.6%, and this is testimony to Irish success in building capacity in the field. In 2002, there were 11 authors with two or three publications (one of whom went on to hold a PI award). In 2003, there were already 52 authors with two or more publications (of which 13 were – or would be – PI award holders).

The average number of citations per publication (CPP) (based on a 3 year citation window) for each of the years 2001 to 2011 is also shown in the figure. This suggests a gradual increase in the citation rate of publications over the period, from 2-3 CPP in the first four years, to 5-6 CPP in the latter four years covered. The 3-year citation windows for 2012 and 2013 publications is not yet complete, and so CPP information is not available.

Figure 45 Evolution of Irish publications and citations per publication in the field of ICT



Data: Scopus, Calculation: Technopolis

The table below compares Irish ICT publication metrics with those of five other ‘peer’ countries of a similar size, in terms of total population. As can be seen, Ireland started from a very low publication base in 2000. However, it experienced a high growth-rate during the following decade, placing its total publications during the 2001-13 period close to that of Norway and Denmark, and well above Slovakia and Hungary. Almost 90% of Irish publications from 2001 were cited over the subsequent decade (including self-citations), which compares well with the other countries. However, 2010 Irish publications obtained much less attention relative to the other countries in the shorter 3-year citation window.

Citations are not only an indication of quality but also a signal of how well researchers are connected in their respective communities. In order to be noticed – or one’s publication to be cited – it helps to have international co-authorship and to have large networks. Peers cite each other more often when they also know each other. Of the countries shown, Ireland has seen the second biggest increase (after Norway) in the proportion of international co-publications between 2001 and 2010. In terms of international co-publications, the US and the UK are the preferred partners of the Irish authors. About 10-12% of the total 3,750 Irish publications have co-authors from these two countries. Germany, France, Spain, Italy and China follow. Gaining US co-authors tends to be an asset for being more widely cited, and we see Irish co-authorship with the US increase significantly from 2003 onwards.

Figure 46 ICT publications (2001-13) for Ireland and peer countries

	IE	DK	FI	NO	SK	HR
Total publications (articles, reviews)	3,745	4,862	6,856	4,453	1,322	1,196
Average annual growth rate (in %)	15.6	12.1	9.5	12.6	10.5	10.5
% of cited documents 2001	87.5	80.0	80.0	82.4	79.3	40.0
% of cited documents 2010	58.2	68.4	62.3	66.8	60.7	51.0
% of int'l co-publications 2001	26.8	38.7	26.0	31.0	44.8	7.5
% of int'l co-publications 2010	49.0	59.4	46.7	53.7	50.4	28.8

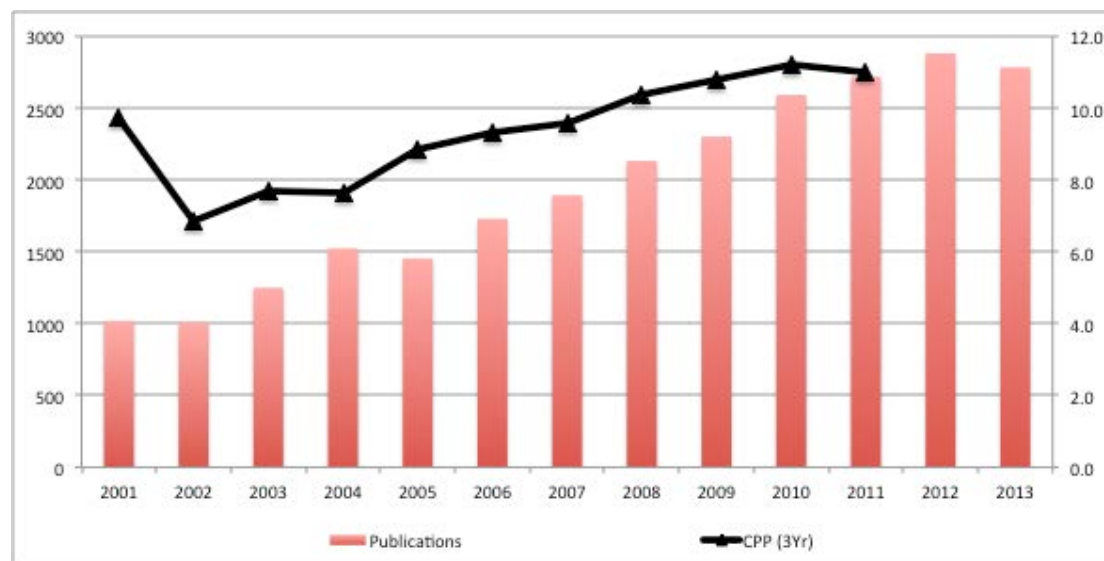
Sources: Scopus; Scimago. Calculations: Technopolis, Scimago

Over the same 2001-2013 period, Irish publications in the broader field of **life sciences** grew by 8.7% per year on average, from 1,000 publications in 2001 to over 2,500 in 2013. This compares very favourably to an average global annual growth rate during the period of 5.2%. It is also a higher growth rate than in the five comparator countries we are using. Again this is testimony to the success of Ireland in building capacity in the area of life sciences.

The average number of citations per publication (based on a 3 year citation window) for each of the years 2001 to 2011 is also shown. This suggests a gradual increase in the citation rate of publications over the period, from around 7 CPP in 2002 to around 11 CPP in 2011. The high CPP rate in 2001 can be attributed to *Nature* paper ‘Initial sequencing and analysis of the

human genome’, which was cited over 3,000 times in the 3-year citation window. Without this publication, the CPP would be 6.5 and in line with the general trend.

Figure 47 Evolution of Irish publications and citations per publication in life sciences



Sources: Scopus; Scimago. Calculations: Technopolis, Scimago

Within the life sciences globally, ‘Biochemistry, Genetics and Molecular Biology’, ‘Agricultural and Biological Sciences’ and ‘Medicine’ are the largest sub-fields. In the following three tables we compare metrics in these fields between Ireland and five comparator countries.

Comparing first publications in biochemistry, genetics and molecular biology between 2010 and 2001, Ireland saw the biggest absolute increase in publications amongst the comparator countries (except Denmark) and the biggest relative increase overall. Its percentage of cited publications also compares well for publications in both years. Its international co-publication rate remains similar to the Nordic examples, and above the Eastern European examples across both years.

Figure 48 Biochemistry, genetics and molecular biology publications

	IE	DK	FI	NO	SK	HR
Nr of publications 2001	420	1,420	1,210	710	362	151
Nr of publications 2010	1,210	2,400	1,600	1,280	457	368
% of cited documents 2001	96.3	97.1	97.6	97.0	90.0	92.9
% of cited documents 2010	90.8	92.5	92.3	92.3	79.1	82.1
% of int'l co-publications 2001	42	43.8	40.5	42.3	38.1	28.8
% of int'l co-publications 2010	57.3	59.5	61.7	61.7	54.1	47.5

Sources: Scimago

A similar pattern can be seen in agricultural and biological science publications. Again, Ireland saw a significant increase in the number of publications per year over the period, and a citation rate similar to the Nordic comparators. Its international co-publication rate though has not seen the increases evident in some of the other countries between the two years.

Figure 49 Agricultural and biological sciences publications

	IE	DK	FI	NO	SK	HR
Nr of publications 2001	450	1135	935	875	273	239
Nr of publications 2010	839	1645	1328	1560	477	471
% of cited documents 2001	95.6	96.9	90.7	96.0	78.8	79.3
% of cited documents 2010	84.9	86.0	84.1	86.7	65.3	59.8
% of int'l co-publications 2001	35.3	37.0	28.6	35.0	25.6	15.3
% of int'l co-publications 2010	51.3	64.3	52.2	60.2	43.7	36.2

Sources: Scimago.

Finally, in the field of medicine, Ireland has seen the largest increase in the number of publications between 2001 and 2010 of the countries shown. Its citation rate compares favourably in both years, and its international co-publication rate has remained similar to most other countries in the table.

Figure 50 Medical publications

	IE	DK	FI	NO	SK	HR
Nr of publications 2001	866	2382	2294	1721	430	514
Nr of publications 2010	2327	4336	2760	3362	713	1256
% of cited documents 2001	83.6	87.5	93.3	89.9	48.8	69.2
% of cited documents 2010	76.3	78.7	87.4	78.2	44.8	49.2
% of int'l co-publications 2001	25.1	26.5	27.0	25.7	16.2	15.0
% of int'l co-publications 2010	43.4	46.5	49.7	46.4	33.1	21.9

Sources: Scimago.

What we can see from the international bibliometric comparison with three Nordic and two eastern European countries of a similar size is that Ireland managed during the ten year period of the PI programme to keep pace with the acknowledged leaders among small countries - though not to outrun them – and to pull ahead of two late developers. This is a considerable achievement given the scale of investment in R&D in the Nordic countries considered, where R&D was 1.5%-4% of their GDP during this period. The PI programme, funding research in life sciences (in particular biotechnology) and ICT, will have contributed considerably to this progress.

Appendix F Case studies of individual PI experiences

Building on the broad assessment of programme achievements provided through survey results, below we introduce a selection of eight PI award holders and their research, highlighting some of the key achievements and impacts made possible by their PI grants, and presenting their personal perspectives on the PI programme.

Dr Thomas Ritter, National University of Ireland Galway

Dr Thomas Ritter is a Senior Lecturer in Medicine, working in Cellular Immunology, Cornea Transplantation, and Gene Therapy. He held two PI awards, with the latest starting in 2013.

Thomas states that the PI grant has enabled him to build a strong and stable team around his research; the continuity between his two grants meaning that it was possible to maintain knowledge and technologies, rather than starting from scratch. It has also been crucial for accessing further funding, most recently a large FP7 grant to conduct clinical trials.

"For me it had a huge impact, including promotion within the University. I came as a lecturer, but was promoted to Senior Lecturer" following the PI grant, Thomas states. In addition, the international standing of being a PI award holder is highly impactful, as international colleagues realise that the work being conducted is of high quality and is internationally competitive. In this respect, Thomas states, the PI award makes it easier to get collaborators involved in projects; it also makes finding and accessing similarly strong partners easier.

Thomas notes that having a large award, rather than the 2-3 smaller grants that would be required to reach a similar scale, minimises the flux of funding cycles and makes it easier to focus on core research. In this respect, being able to focus on the research continuously, with the responsibility and drive to build something great, has been instrumental.

One of the best features of the SFI PI programme for Thomas has been the personal approach in management, being able to build a relationship with the programme manager. Thomas states that the positive pressure of expectation is also a key driver.

Professor Dermot Diamond, Dublin City University

Professor Diamond is director at the National Centre for Sensor Research at DCU, and an SFI PI with the Adaptive Information Cluster, a major initiative on wireless sensor networks.

Dermot believes that SFI has had a very positive impact on the research scene in Ireland. "It has done a very good job over just a decade", states Dermot. "One of the great things is that they haven't been rigid, they keep talking to the research community, and adjusting the programmes". This, Dermot says, is integral to supporting and developing scientific research.

Dermot believes that building capacity in the research base is fundamental, supporting not just PIs, but stating that there is a need to nurture a population of research leaders in Ireland. SFI PI funding acts as a magnet, introducing the potential to focus on developing emerging leaders within the PI teams.

In terms of collaboration, SFI have encouraged a layer of high-performing researchers to work in concert across the university sector; so while universities may continue to compete at an institutional level, researchers collaborate openly and willingly. This, Dermot says, is a population of researchers that have come up through SFI and continue to work together.

One of the key impacts has been building excellence through supporting both basic and adaptive research, each being fundamental pillars of a research base that can sustain quality and reputation. Dermot notes that it is really important to continue supporting both basic and adaptive research; SFI PI awards have been successful in getting industry funding and more applied EU funding; Dermot believes that what really attracts industry is a steady core of fundamental researchers.

Professor Louise Kenny, University College Cork

Louise is a Professor of Obstetrics at University College Cork and a Consultant Obstetrician and Gynaecologist at Cork University Maternity Hospital, focusing in adverse pregnancy outcomes. Her work focuses on the development of screening tests for early detection, and includes a biomarker programme. There are no screening tests at present, and no biomarkers available for use, but Louise's PI award (2009) allowed her to take this work to the next step.

Louise states that being associated with a prestigious PI award put her research on the map, and that the grant accelerated scientific progress. The PI award was an extreme catalyst for commercialisation; within the first 2-3 years one piece of technology had already been protected, filed, and spun out with the support of University College Cork and SFI. This then allowed Louise to work as an SME, "Metabolomic Diagnostics", in an FP7 stratified medicine call to conduct a clinical trial.

"Without a doubt SFI accelerated progress and drew attention [to the research]", Louise stated. SFI was key to drawing attention from the university, who then worked on spinning out the technology; SFI were also key in getting Louise out there for networking, national events, and bringing in Enterprise Ireland. As a result of the latter, Louise won the Enterprise Ireland Life Sciences & Food Commercialisation Award for developing and commercialising the first predictive diagnosis for pre-eclampsia in early pregnancy.

Louise is now the director of an SFI research centre, Infant (Irish Centre for Fetal and Neonatal Translational Research), the first of its kind in Ireland, having bid with the existing research team built through the PI award. "Had it not been for initial investment, it probably wouldn't have happened. It mushroomed from the investment of the first PI award, and continued to grow", Louise stated.

There has been a pronounced international impact too, with a large multi-billion, multi-national company approaching Louise to partner soon after the award was announced. The company was attracted by the biomarker programme and potential future returns, and suggested forming a centre of excellence.

Professor Mike Lyons, CRANN, Trinity College Dublin

Professor Lyons is Professor of Physical Chemistry focusing on electrochemical energy generation, and regards SFI as a game-changer. He states that the PI programme gave people the ability to perform at an international level and increased the presence and visibility of internationally-competitive research where scientific excellence is maintained.

Mike states that his PI award meant that he could tackle a large problem in a focused way, and could develop a team and a strategy. The number of publications increased, and the international profile of his research has been raised, gaining a reputation for being leaders in this research area. Mike states that his PI award has also allowed him to build towards an ERC application, having been able to build concentration and align complementarities.

One of the most striking personal impacts is that the PI award has "given [Mike] a new lease of scientific life", as he is able to pursue something he is genuinely interested in to a degree of depth not previously possible. This coincided with a resurgence in electrochemical energy generation research, in which he originally did his PhD. He is now able to solve problems originally set out in his doctoral thesis in the 70s, making substantial progress in the first three project years. Mike has developed nickel oxide and iron oxide materials that facilitate the splitting of water into hydrogen and oxygen, achieving lower cost and higher efficiency, with a lower energy input. As the funding continues, Mike is looking at doing the same with sea water, a more plentiful resource. This research has now made the economics of water splitting more realistic.

From the perspective of career trajectories, Mike believes that the PI programme has had very positive effects, for him and for students - the prestige of the award, the increased quality of research and training, and international exposure all enhancing job opportunities.

Mike's SFI funding is ongoing; and he hopes to further develop his research as part of the new Investigators Programme, which focuses more on commercial exploitation. He believes that this will help to focus the work, with a view to creating devices and commercial opportunity. However, he would caution that there should continue to be room for fundamental research.

Professor Paul Moynagh, National University of Ireland, Maynooth

Professor Moynagh is a two-time PI award holder, with the first grant awarded in 2007/8, and a second awarded based on continuing the same work area.

For Paul, these PI awards have had a very big effect on both research and career. Prior to being awarded his first PI award, the majority of Paul's research funding was project-based; being relatively small both fiscally and in duration, with limited scope to recruit. This meant that even within an overarching research theme in the lab, work was more fragmented, with individuals working on different, distinct projects.

While it was possible to make meaningful contributions working this way, Paul wanted to make an impact in a focused area. The PI awards have allowed that to happen, providing the stability and funding necessary to build an integrated team; publication frequency has increased, as has publishing in higher-ranked journals, where previously there wouldn't have been critical mass in the lab. This in turn has led to gaining a more international reputation, being regarded as leading areas of the field.

The continuity of Paul's PI awards have meant that it is now possible to also work on translating earlier fundamental scientific work, creating potential for further publications as well as spinouts. Paul is passionate about transforming basic research into something meaningful in terms of therapeutics and diagnostics, and the longer-term funding of a PI award makes it easier to collaborate with industry, which is often more difficult when working project-by-project.

Expectation from SFI is high in terms of what returns would or should be seen following awards, which is seen as a good thing by Paul, and matches his ambitions. "The achievement is not getting the money", Paul states, "that's just day 1 - what you have to do is produce something worthwhile from that money". This ambition and the expectations of SFI are major drivers to doing research at the highest level.

In summary, Paul believes that SFI has changed the landscape of Irish research, in terms of both scale and quality, achieving so much in just over a decade. "[The funding] allows us to lead fields, to do research that is recognised internationally as being top level. Suddenly we're leading, where we were following. The value of return you get for PI awards is very good."

Professor Douwe van Sinderen, University College Cork

Douwe, an Associate Professor in the School of Microbiology, University College Cork, has been active in the Irish research system since 1994 and has held three PI awards. Following his first award, which started in 2003, there was a slight gap of under one year before being awarded his second. The third award followed immediately after (in 2014).

"The programme has been absolutely crucial", Douwe states. "Before the PI scheme was introduced, the opportunities for fundamental research funding were very limited in Ireland and it was difficult to secure funding for pre-competitive research". There is a 'black and white' contrast; before SFI, research and funding was at a completely different scale, and with a very low base. "In 1994, Ireland was seen [in EU terms] as Category 1 status - it was clear that the scientific basis was very low, and so were expectations".

Now, the standing of Irish scientists and Irish science has improved, and in a very short space of time. Douwe believes that attracting people in has been key to quickly raising this knowledge base. The investment from SFI means that Ireland is now a global leader in several areas (including in Douwe's area of work), with many of these being directly relevant to the Irish economy, supporting jobs and growth.

"It was a catalyst, of crucial importance", Douwe continues, "building teams and scale". Douwe explains that one key element of building effective teams through the PI award is the possibility of recruiting senior postdoc positions through the PI programme, in contrast to most other funding regimes that are targeted towards individuals who have just finished their PhD. Because the PI award allows the recruitment of more senior Post—Docs, it means more capacity for managerial responsibilities exists within the research team, in addition to mentoring for younger members (while also providing opportunities for such senior post-docs to obtain such managerial / mentoring responsibilities and experience).

Another key advantage of the SFI PI grant, from Douwe's perspective, was its scale and duration, which allowed researchers to focus on their work instead of struggling from one grant to the next with a risk of falling out of the system. In the event of failing to secure a grant, it is difficult to ensure continuity and to stay current, Douwe notes, and this problem is even more acute in scientific research than in humanities, where there is no need for a lab or large teams in order to continue producing scientifically relevant publications.

In terms of scale, Douwe notes that an SFI PI award allows a researcher to build the core of their research team, and that critical mass is fundamentally important in order to launch additional funding. Speaking personally, Douwe states:

"If it wasn't for this scheme I would be in a completely different place scientifically, and maybe not even able to continue in that stream of research. It's very hard to get funding without a fundamental base - when you have that you can build a profile, people come to you based on the science you present. They know you have a good background and quality."

Douwe states that there is a distinct, observable increase in his publication output in the years where a PI grant was active, speaking to the effects on productivity of that continuity. At the same time, he notes, it is almost automatic that a researcher won't be awarded a PI grant without having impactful publications, so these go hand-in-hand, meaning quality is built on.

Having a pre-competitive base of funding that is broad enough to support the building of critical mass has made it possible for Douwe to attract and leverage industry funding of an equivalent scale to the SFI input. This in turn, Douwe states, doubles critical mass and further attracts others funding through EU or personal fellowship schemes.

Professor Ian Robertson, Trinity College Dublin

Ian is a Professor of Psychology, and has been active in the Irish research system since 1999, becoming the first psychologist to come into an essentially entirely wet-lab science department. Ian's PI award ended in 2007. He reports that that it allowed him to "establish and essentially get an fMRI imaging programme running, and to develop a quantise genomics strand of research that resulted in a very large GSK-funded industry programme".

The SFI PI programme contributed to the development of expertise and publications, out of which has come a number of other investments and developments. "This grant was critical in building bigger infrastructure and integrating multi-disciplinary expertise that led to bigger things". There hadn't been any facilities for brain imaging in the department, so capital investment from PRTLTI to acquire dedicated scanning equipment, plus the PI award that allowed us to make use of this equipment, enabled the building of credibility that was essential to getting the industry input now seen.

From a low base - there was no history of cognitive neuroscience in Ireland - SFI was very much seeding a new area of research. Ian estimates that there were perhaps two or three very good people working in isolation 15 years ago - so, patchy expertise, but no critical mass. The investment - from PRTLTI creating the building, to the PI award funding work - has borne an area where top young international talent is attracted to work in this field in Ireland. The grant created a new area by bringing together human research in terms of psychology with existing strengths in genetics, and then together with brain imaging. "I don't think it necessarily would have happened otherwise", said Ian, "there is a whole group of young investigators that would not have had space in this system, that would have gone abroad". Some of these names are making fundamental contributions in their areas, and Ian is excited about the future.

Ian goes on to say that the willingness to follow up an area of research where there hadn't been any experience in Ireland was crucial, and he believes that maintaining the capacity for opportunistic investments is important for SFI going forward "the greatest shortage is of new ideas". There is now a situation where major advances are being made in techniques that will be of use to basic and applied research, and are attracting further high-profile funding and industry attention. As part of wider investment, the PI award, Ian says, was a critical investment in solidifying that nexus.

Professor Chris Dainty, National University Ireland Galway

Chris is Professor Emeritus at NUIG, having been a Professor in applied physics at the university for the last decade. He held two SFI PI awards (2002-2007 and 2007-2012) during this time, having moved to Galway specifically for the first.

Chris states that while one of the most attractive elements was the prospect of five years funding that would be beneficial for planning and flexibility, "the agenda was broader than just sitting in a lab and working, [we] had to show that good work could be done, and draw attention to Ireland's potential". Part of that work was initiating a seminar series of approximately 18 seminars per year over 8 years, which hosted every top academic in the field in the world.

The approach taken was very deliberately to shine a light on Galway and Ireland, including purposefully appointing an industry outreach co-ordinator in the third year of the first award. This, Chris notes, emphasised that he was willing to put money into not just research, but also reaching out to industry. This also highlights the flexibility allowed with the funding, which was an important feature.

Chris states that over the course of these awards, Galway - and Ireland - were "put on the map" in the field of optics and photonics, rising from a very low base with little positive reputation. "I did the best work I've ever done under these grants; the group I set up was better than in any other place I've been", Chris states.

Post-award, there is a continuation in developing and maintaining this expertise in Galway; through Chris and – now that he has retired – through his successor. Chris states that "the field is evolving, and there is a strong group in place. We put Galway on the map, and made it known that good quality work can be done here".

Dr Paul Hurley, Tyndall National Institute

Paul was awarded his first PI award in 2005, and second in 2010, which runs to August 2015.

Prior to the first award, Paul had been working in a very small team consisting of himself and one PhD student, and had been required to do a lot of disconnected projects to secure and maintain funding. "I had to cover my own salary and there was lots of pressure to bring money in". While the projects were enjoyable and beneficial in terms of building varied experience, he says, the work was often very short term and there was a lack of continuity. There was often also little publishable output, and so little to show from the work from an academic perspective, because much of the funding was coming from industry.

"When the PI award came in, we could turn projects down if they were not complementary; we were able to focus in an area, add complementary projects", Paul says. "It allowed us to focus our energy, which was transformational." As a result of this focus, Paul was able to grow the team, publishing important papers, receiving invitations to speak at major conferences and receiving an international award from Intel, as well as developing research collaborations with colleagues in Stanford and Dallas. "This all came about because of the platform SFI provided. Without that platform, the significant increase in the quality and impact of the research, the invited presentations and the collaborations with Stanford and Dallas wouldn't have happened - I can say that with absolute certainty", adds Paul.

Paul also states that without the PI award, he may have moved on to academic positions abroad. "I would have had to keep doing little bits on various projects to keep my head above water, and I have been approached for a number of professorships." Now though Paul says "I'm a lot happier. The SFI award was significant enough to really allow me to focus our research activity, it was extremely important, and I can now spend a more manageable proportion of time on administration and identifying funding opportunities".

Overall the SFI PI grant has been wholly positive for Paul: "It allowed me to grow from me plus one other person to a team of 11 people. Without that grant, I don't think we could've grown at all." He continues, "the biggest impact has been being able to focus our research on what we're good at - you only get impact if you focus". "Focusing meant we had time to publish, could collaborate with the main international research groups in our area, and could build our reputation."

Professor James Gleeson, University of Limerick

James returned to Ireland having completed his PhD in Caltech on a Fullbright Scholarship, and was then awarded a PI grant. "It was the primary reason I stayed in Ireland" James says.

"I wanted to build my career in the US. Ireland had no history of credible fundamental science. But my timing was fortunate, having arrived in 2000, and receiving my PI award in 2002". Prior to this, James had picked up small amounts of funding, conducting a Post-Doc at University College Cork and then receiving a lectureship, which put him in a position to apply for his own further funding. "It was the right thing at the right time". The PI programme developed a high reputation among Irish researchers, and there was a certain status to holding an award. Early PIs came to Ireland from abroad, James says. "To have a sense that you were in the same league with them was very important".

The PI programme's orientation toward fundamental research was also very beneficial. "Maths doesn't normally fit under the large European projects - it's usually more blue sky, a less applied part of the sciences" James notes. "There was also funding available through Enterprise Ireland, but this was for research closer to industry.

For James, the ability through the PI award to fund good PhD students was also highly important. "Very few were staying in Ireland - the accepted path in mathematics was to go to the US". Through SFI, though, James has been able to build a group and fund a number of promising PhD students, seeing a drop-off in the number of people heading to overseas. "In the 1990s, there was no option of doing a PhD in Ireland", James adds, detailing that there was neither quality nor funding in place. "It is impossible to develop reputation for scientific excellence if you can't recruit students and collaborators on which the reputation of the country scientifically depends".

According to James, the main strength of the PI programme was its focus on the individual project in its own right, as opposed to its affiliation with national priority or policy directions, with James noting that "people could come with good ideas and develop a group around that.

James believes that it is crucial to continue funding people with bright ideas at the level of basic research if the Irish research system is to continue thriving in the next 20 years. Bodies such as the Irish Research Council can complement SFI as it continues to evolve, funding young people early in their academic careers, much as SFI did for James. "It is important that everyone is aware of the need for diversity in science funding", James adds.

Appendix G International Comparators

The study was asked to consider briefly the performance of the PI programme in relation to similar programmes in nations of comparable size. SFI wished to understand whether other countries, with similar contexts, had deployed a similar model or initiative to the PI programme, what the objectives and role of these comparable schemes were, and whether they were considered to have been successful in relation to their missions. The intention was that this might help to understand whether the PI programme was an appropriate programme to run, and provide some validation for its deployment in Ireland at the time.

The study team reviewed a large number of schemes from around the world, and ultimately concluded that the SFI PI programme appeared to be unique in terms of its objectives, combining a strong focus on human capacity with retention of top talent in Ireland and alignment of Ireland's academic research direction with industry interests. Nevertheless, we identified a small selection of 12 programmes and initiatives that were most similar to the SFI PI programme, and covered a subset of its objectives. We focused on those that targeted established researchers (as in the SFI PI programme), rather than the numerous schemes aimed at supporting up-and-coming young research talent (but that also have some similarities to the PI programme objectives). Each scheme was reviewed, and the key features and characteristics of each are summarised and presented in the figure below.

The **objectives** (1-5) in the following figure, relate to the objectives of the PI programme:

3. Retain excellent researchers in country
4. Attract excellent researchers to country (from abroad)
5. Capacity building, skilled workforce
6. Participation in international research forum
7. Alignment of university research with industry

As can be seen, many of the selected schemes sought to attract excellent scientists from abroad (9), while a smaller number sought to retain excellent researchers in country (6) – including 5 that sought to do both. Half of the selected initiatives had a clear objective to increase capacity or expand the country's skilled workforce, while the same number sought to increase participation in international research. Most schemes applied to all scientific fields, but a small number were more selective, and in just two cases the schemes explicitly sought to align research with industry needs.

All of the selected schemes selected are ongoing, and have so far been running for between 6 and 22 years. Annual budgets (approx.) vary between €1.2m and €210m (if we exclude the European ERC scheme), and average €46m across the schemes – the PI programme (at €55m per year) is slightly above this average. In fact, only two of the national initiatives selected were larger than the PI programme in terms of their average annual spend. Furthermore, if we take account of the relevant country size (population), the PI programme annual spend (€12m per 1m population) is the largest of those shown in the table, and much greater than the average for these schemes (€2m per 1m people).

Programme	Overview	1	2	3	4	5	Pop.	Dates	Programme focus areas	Programme budget
SFI PI programme	Substantial grants for established individuals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.6 m	2000-2011	ICET and life sciences, energy	€609M (average €55M/ year)
Institució Catalana de Recerca i Estudis Avançats (ICREA)	Permanent tenure-track positions at Catalunyan HEIs for researchers with excellent track-record	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.5 m	2001 - current	All research domains, but most in S&T (> 70%)	€20.6M in 2010
Canada Research Chairs Programme (CRCP)	Research chairs for established researchers at Canadian HEIs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	35 m	2000 - current	Natural sciences, engineering, health, social sciences, humanities	Initial budget (2000-04): C\$ 900M / €710M. Since 2005, the annual allocation C300 M / €210M
Canada Excellence Research Chairs (CERC) Programme	World-renowned researchers and teams from abroad, to relocate to Canadian HEI, in priority areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	35 m	Established in 2008, first awards made in 2010	Environmental sciences + technologies; natural resources and energy; life sciences; ICT	Initial budget: C\$190 million / €150M - up to €21M per year - for 19 chairs. An additional C\$53.5 million over 5 years announced in 2011 (for 10 chairs)
South African Research Chairs Initiative (SARChI)	Research chairs for established researchers at South African HEI	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	51 m	2006 - current	All disciplines, allocated by national priorities	Actual spend 2005-2011: R660 M/€66 M (€13M / year) or R1.1B / €110M (€19M / year)
DNRF, Niels Bohr Professorships	Top research talent, spend time at / relocate to Danish HEIs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.6 m	In changing format, since 2005	All scientific fields	2005-2011: DKK 163M/€20M for 9 awards. 2011 allocation: DKK 167M / €22M over 5 years, for 6 awards (average €0.75M per grant per year)
Danish National Research Foundation, CoE scheme	Centres of research excellence, with focus on inter- disciplinary, cutting-edge high-risk research	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.6 m	1992 - current	All fields, but most are in natural/life sciences	5.4 billion DKK / approx. €725M, (approx.€36M/ year)
Odysseus Programme, Flanders (FWO)	Salary and research cost grants for top talent from abroad to work at HEIs in Flanders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.3 m	2006 - current	All science disciplines	Approx. €12 M per year
Methusalem Programme, Research Foundation Flanders (FWO)	Long-term funding for top researchers already working at HEIs in Flanders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.3 m	2006 - current	All science disciplines	Approx. €20 M per year
Innovational Research Incentives Scheme, Veni Vidi Vici, Dutch Research Council (NWO)	Grants for promising researchers, to retain scientific excellence in academia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	17 m	2000 - current	All science disciplines, but with additional allocation to physical sciences	€150 M per year for the entire Veni, Vidi and Vici programme (since 2009)
Finland Distinguished Professor Programme (FiDiPro)	Temporary research in Finland by distinguished foreign (or expatriate) scientists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.4 m	2006 - current	All science disciplines	2006: 24 grants for a total of €17.5M. 2008: 42 grants for a total of €32.5M (likely includes 2006 grants). 2012: 18 new grants for a total of €15.9M
ERC Advanced Grants	Grants for exceptional established research leaders of any nationality and age to pursue ground-breaking, high-risk projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	n/a	2008 - current	Any field of science, engineering and scholarship	€680M in 2012; €660M in 2013; 1587 grants since 2008 (250-300/year)
Research Chairs and Senior Research Fellowships, RAEng, UK	Public-private funded Research Chairs in engineering	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	63 m	2002/03 - current	All engineering disciplines	5- 10 new Chairs & Fellowships annually. 63 since 2002, 40 active in 2012. Budget 2012: £1M/ €1.2 M (<5% UK public spend on engineering research)

A selection of these programme, for which evaluations were publicly available, were then assessed in more detail, in order to better understand their objectives, budget, activities and (assessed) achievements. Notable similarities and differences to the PI programme were also drawn out. An overview of the findings on each programme is provided below.

The Canada Research Chairs Program

The Canada Research Chairs Program (CRCP) was launched in 2000, with the aim of creating 2,000 university Chairs. By 2005, all Chairs had been filled. A fairly constant number of Chairs (150) are vacant at any time due to turnover. The SFI PI programme and CRCP share a focus on attracting and retaining excellent researchers, and on building research capacity.

Objectives: The CRCP's four main objectives (2010) are: to attract and retain excellent researchers in Canadian universities; to improve universities' capacity for generating and applying new knowledge; to strengthen the training of highly qualified personnel (HQP); and to optimize the use of research resources through strategic planning.

Programme details: Each Canadian university is entitled to a fixed number of Chairs. The universities then nominate individuals for two levels of Canada Research Chairs: Tier 1 for experienced researchers, worth CAN \$200,000 (€154,000) per year for a period of seven years, and Tier 2 for young researchers showing great potential, at CAN \$100,000 (€77,000) per year for a period of five years. Tier 1 appointments can be repeatedly renewed, whereas Tier 2 appointments can only be renewed once. Funding may cover chairholders' salaries, student and staff salaries, as well as direct research costs. The university negotiates a package that includes compensation, teaching release, and research support. Hence, a central feature of the program is that the government retains some control over the nomination process but universities administer the grants. Chairs are split equally between tier levels, and are allocated proportionally between the natural sciences/engineering (45%), health (35%), and social sciences/humanities (20%).

Eligibility: Chair appointments funded through the CRCP are open to Canadian researchers, whether they are working in Canada or elsewhere, as well as researchers from other countries.

Programme budget: The Government of Canada allocated an initial CAN \$900 million to the programme for the 2000-2004 time period; subsequently CAN \$300 million were allocated per year (2005-2010), of which around CAN \$250 were expended. Notably, the CRCP was partnered with the Canada Foundation for Innovation (CFI), with a CAN \$250 million (€192M) allocation for infrastructure support - generally valued at CAN \$125,000 (€100,000) per chair, to cover up to 40% of the total project cost.

Programme evaluation: The CRCP has been evaluated at the 3, 5 and 10-year mark. While triggering some adjustments to the programme, they were all broadly positive. The *tenth-year evaluation* of the CRCP, conducted in late 2010, found that the programme had been well implemented, created a research environment that was conducive to the long-term retention and attraction of top researchers, and continued to be relevant and effective. CRCP chairholders produced a greater number of peer-reviewed papers, were cited more frequently, and more often published in high-impact journals than comparable groups of leading researchers. The programme fulfilled its objective to contribute to the training of highly qualified personnel, with large numbers of students and postdoctoral scholars trained by CRCP chairholders. Overall, evaluation informants at both the programme and university levels agreed that in 2010, Canada was much better positioned with regard to research, nationally and internationally, compared to the situation in 2000, at the time the programme was launched.

Notable similarities / differences to the SFI PI programme: CRCP assigns Chairs across Canadian HEIs, for which the individual institutions nominate candidates. Once the appointment is made, universities administer the grant. Universities also need to provide a strategic research plan alongside their Chair nominations to ensure that the appointment supports building of strategic clusters within the system. CRCP awards are fixed, and hence capped at a lower level than PI programme awards; however, universities can apply for an infrastructure grant alongside the CRCP application (around €100,000 per Chair).

The Canada Excellence Research Chairs programme

In 2008, the Canada Excellence Research Chairs (CERC) programme was launched to attract world-renowned researchers to Canada. The aim is to build a critical mass of expertise in priority research areas of the federal government's science and technology strategy.

Awards provide generous funding for researchers and their teams (up to CAN \$10M/ €7M over 7 years), which have to be 100% matched by the host institution. 19 CERC appointments were made in 2010.

Programme evaluation: The programme has not yet been evaluated. However, online discussion fora have highlighted issues around the 'cost' of these researchers, especially through the matching requirement. The latter is perceived by some as an unjustifiable draw of funding away from other parts of the university and hence disruptive to the long-term strategic plans of the institution in place prior to the appointments.

Notable similarities / differences to the SFI PI programme: The CERC programme requires 100% in matching funds from host institutions. The upper level of funding provided by the funding bodies was comparable (<€1M / year), but budget available to CERC professors is then doubled by the match.

Institució Catalana de Recerca i Estudis Avançats (Catalan Institution for Research and Advanced Studies), ICREA

ICREA was established in 2001 as a virtual institute: research professors are recruited and employed by ICREA but are hosted by, and conduct their research within Catalunya's universities and research institutes. ICREA recruits 13 to 21 new ICREA recruits each year, selected from between 130 to 500 applicants. By 2013, the initiative had recruited 245 ICREA Research Professors into the Catalan research system.

Objectives: ICREA was created to recruit high quality international researchers and embed them within the Catalan research system, which at the time showed a low level of internationalisation. The intention was to allow Catalunya's HEIs to compete with other research systems.

Programme details: The award covers researcher salary, "in line with those paid at Catalan universities"; there is however flexibility in salary levels as ICREA functions outside the Spanish civil servant system. Awardees become permanent research professors, without teaching responsibilities. Research funds are not provided; hence, once located within their host institutions, awardees must compete for funding on the same terms as all other Catalan researchers.

Eligibility: The programme is open to experienced researchers (min. 4 years from PhD) who do not currently have a permanent position in Catalunya (i.e., they could be at a university in other parts of Spain). The emphasis during selection is on scientific excellence and leadership potential.

Programme budget: The programme budget for 2010 was €21.6M.

Programme evaluation: A ten year evaluation of ICREA was conducted in 2012. It determined that all ICREAs had significant international experience gained outside of Spain, and the opportunity of a permanent position provided by ICREA was seen as a main factor in their decision to relocate. ICREA Professors outperformed comparator groups of researchers at all levels i.e. in Catalunya, Spain, the European Research Area and worldwide with regards to publication outputs. ICREAs also attracted significant levels of research funding (€34.6 million in 2009 for example), with over 50% of funding from non-Catalan or Spanish sources such as the European Union, industry and international foundations. Awardees had an exceptionally high success rate in winning the prestigious ERC grants, making up over half of all ERC grant recipients in Catalunya and 30% in Spain (31 out of 104) in 2012, while its share of national R&D investment (public and private) was only 21%.

The evaluation also found that ICREA had a strong impact on the establishment of new research lines and research groups in Catalunya. By 2010, 150 new groups had been created, comprising of between 650 and 750 researchers and PhDs students.

The evaluation found that the cumulative beneficial effects of ICREAs in the Catalan research system had contributed to an emerging mind-set that was much more favourable to a research system based on excellence and openness. ICREAs tended to have the most impact when they were clustered into small research institutes (standalone centres or distinct institutes within universities), where they made up a large proportion of senior research staff and had more influence over research strategy, management and content. However, evaluation informants indicated that ICREA had not yet led to sustainable behavioural or systemic change in the Catalan research system – if ICREA funding were stopped, many of the benefits achieved to date would cease. Most ICREAs employed at the time of the evaluation, for example, could not have been quickly and easily employed by their hosts.

The evaluation concluded that ICREA was an effective mechanism meeting a well-defined need and the evaluation recommended that it should continue in its current form towards its target of 300-400 research professors.

Notable similarities / differences to the SFI PI programme: While both, ICREA and SFI PIP, aim(ed) to build out scientific excellence and research capacity, the primary rationale behind ICREA was to circumvent the rigidity of the Spanish civil service hiring process. ICREA offers permanent, research-only, tenure-track positions from the outset. It does not aim to retain existing talent – in fact, researchers who hold a position at an institution in Catalunya are not eligible to apply (as they have already ‘mastered’ the Spanish HEI hiring process). A separate funding scheme was launched to even out inequalities arising: the ICREA Academia programme offers top-up funding to researchers who already hold positions in Catalunya.

The Danish National Research Foundation, Centres of Excellence Scheme

The vision of the Danish National Research Foundation (DNRF) is to support frontier research that is potentially groundbreaking and may change the state of the art within its field. To achieve this objective, the DNRF funds outstanding researchers with (often high-risk) proposals that could lead to scientific breakthroughs. The Centres of Excellence (CoE) scheme is the main funding instrument of the DNRF.

Objectives: The objective of the CoE programme is to strengthen Danish research by providing the best possible working conditions and organisational set-up for selected top researchers.

Programme details: Until 2009, CoEs were established for a five-year period with the possibility of an additional five years; since 2011, the first period has been extended to 6 years (but the 10 year cap remains). Funding from the DNRF is primarily used for salaries for temporarily hired staff (PhD students and postdocs), for equipment, conferences and travel, and administrative support. The grant includes an overhead contribution to the host institution(s). Host institutions are requested to co-fund the CoEs, which has accounted for 20%-28% of total CoE costs over the lifetime of the programme (mainly by providing salaries for permanent staff). From the outset, the host institution has to detail how centre activities will be embedded within the university. CoEs can be established within and across all research areas, but the majority address the natural sciences and the life sciences. By 2014, a total of 88 Centres of Excellence had been established.

Eligibility: Outstanding scientists of any nationality.

Programme budget: The programme budget was approx. €725M between 1992 and 2013, equating to an annual average of €36M. The average annual funding per CoE is €1M.

Programme evaluation: A 2013 panel review of the DNRF concluded that the CoEs had strongly contributed to raising the quality of research in Denmark and the international profile of Danish research. The publication record of CoEs was on a par with the highest-performing universities in Europe, and often better (but below top US universities). An international review panel judged 4 (out of 16) CoE to have achieved world-leader status. The CoE scheme contributed strongly to the training of students and staff, with 8% of all PhD students and 16% of all postdocs in Denmark (2011 and 2012, respectively) working at a CoE. A large proportion of these were recruited from abroad, with a third of postdocs remaining at Danish universities post-CoE award.

The DNRF took **additional initiatives** specifically targeted at increasing the internationalisation of Danish research. Several initiatives were merged into the Niels Bohr Professorship in 2011, offering attractive funding options for outstanding international researchers in Denmark (average of €750,000 per year). While the evaluation commended the Niels Bohr Professorships as a successful additional instrument to recruit excellent researchers from abroad that should be continued, it did not recommend extending the scheme - judging the international visibility of the CoEs and the flexibility of the DNRF's funds which allow the CoEs to seize opportunities of hiring researchers from abroad as the best instruments for internationalising Danish research.

Notable similarities / differences to the SFI PI programme: While the DNRF CoE programme funds research centres, rather than individuals, much emphasis is put on the qualifications of the proposed centre leader when assessing applications. Centres may differ in size and mode of organisation, depending on their subject and scope. Some centres become rather large during the grant period, employing more than 60 people divided into several research teams, while others have fewer than 15 members. As such, some of the resulting "research units" may be very similar to SFI PI-funded groups.

Both programmes, CoE and PI, have a strong objective in research training and internationalisation of research groups. However, the CoE programme does not have a specific aim to attract top researchers to Denmark – and since the salary of centre leads continues to be paid by the host institution, applicants already need to have a position at a Danish university. In order to attract foreign talent, DNRF offers a separate funding track - the Niels Bohr Professorship scheme.

South African Research Chairs Initiative (SARChI)

The South African Research Chairs Initiative (SARChI) was established in 2006/07, with the intention to appoint 210 new research Chairs by 2010, significantly expanding South Africa's research capacity. The scheme was modelled on Canada's Research Chair programme.

Objectives: The programme was launched to: increase the number of world class researchers in South Africa; retain and/or attract qualified research scientists and thereby help reverse systemic decline in research outputs; stimulate strategic research across the knowledge spectrum and thereby increase the level of excellence in research areas of national and international importance; improve and accelerate the training of highly qualified personnel through research; and provide a research career pathways for highly skilled, high quality young and mid-career researchers that addresses historical racial, gender and age imbalances in the country.

Programme details: The scheme provides a base grant of up to R2.5M / €250,000 per year to cover salaries of Chair holders, postdocs and students, research operating costs, small equipment, and institutional overheads (Tier 1). A Tier 2 level of awards was introduced at a later date, aimed at supporting up-and-coming researchers generally under the age of 40 with up to R1.5M / €150,000 per year. Chairs are tenable for five years, renewable for two further five year periods (total: 15 years). Chairs are awarded in all knowledge domains including science, engineering and technology and the social sciences and humanities.

Eligibility: Candidates from abroad who will spend at least 50% of their time at a South African university. Preference is given to Southern African nationals working abroad.

Budget: At the inception of SARChI, the goal was to have 210 operational Chairs by 2010, through a commitment of R1.61 billion over six years. An additional R2.88 billion were foreseen to sustain the appointed Chairs and renew the initiative for the subsequent five years (2011–2015). However, the programme led to only 89 fully operational Chairs by March 2012. In 2012, an additional 60 Chairs were awarded to South African universities. The current budget allocation is unclear.

Programme review: A five-year review of the first phase of SARChI scheme, 2006 - early 2012, was published in late 2012. The review found that the programme had been successful in attracting and retaining talented researchers, increasing numbers of graduate students (masters, doctoral and postdoctoral) and enhancing research outputs such as publications. The SARChI had also resulted in the development of significantly improved research capacity at host

institutions and created and reinforced nodes of excellence at the major research universities as well as at a number of newer and/or disadvantaged institutions. The review recommended to build on this base in the following years, and group Chairs together into critical mass clusters of excellence.

Notable similarities / differences to the SFI PI programme: As with the Canadian Research Chair Programme, the SARChI allocated a fixed number of chair appointments to individual institutions across the HEI system. The programme focused on research talent with existing strong (personal) links to South Africa, but did not exclude 'new' researchers.

Odysseus Programme, Research Foundation Flanders (FWO)

Launched in 2006 to attract top research talent to Flemish Universities, the Odysseus Programme was modelled on the SFI PI programme and the EU Marie Curie International Reintegration Grants.

Objectives: The Odysseus-initiative aims to recruit Belgian researchers with international careers to Flemish Universities. The programme specifically targets a) top researchers and b) researchers with high potential to become top researchers. The programme aims to build out research capacity at the faculty level, but does not specifically refer to students and postdocs.

Programme details: The programme provides 5-year long financing of €400,000-1.5M / year (€2M - €7M in total) to start research projects. This covers salary costs for supporting staff, equipment and bench fees. The award holder's salary is covered by the host institution. 80% of the appointments are directly assigned to Flemish institutions (via a performance-related formula) who select their awardees independently; whereas 20% is determined by open competition (where selection is carried out by FWO). By 2008, 25 appointments had been awarded: 16 to non-Belgians, and 9 to Belgian nationals. 11 appointments were made to researchers that were in Belgium at the time of application.

Eligibility criteria: Both Belgians and non-Belgians are eligible.

Budget: The annual budget was € 12M for 2006-2010; €60M in total. At the time of evaluation (2008), €46 M had been spent.

Evaluation findings: An evaluation was conducted in 2008 on the 2006-2008 period. It found that a particular hurdle to recruitment was the low salary offered at Flemish universities. The programme was also relatively unknown outside of Belgium, limiting the number of potential candidates. The evaluation did not look at the scientific output of awardees.

Notable similarities / differences to the SFI PI programme: Unlike the SFI PI grant, the Odysseus programme does not cover awardees' salary costs. Allocation of awards to HEIs is determined to 80% by a pre-set formula (based on previous research performance). Odysseys and SFI PI grants were comparably generous, but Odysseus can offer even higher grant levels (up to €7M over 5 years, salary excluded).

Innovational Research Incentives (Veni Vidi Vici) scheme, Dutch Research Council (NWO), Netherlands

The Innovational Research Incentives Scheme comprises three grants geared to different stages in a researcher's scientific career – Veni Vidi Vici. The "Vici" component of this programme funds senior researchers that have the capacity to independently develop a research field and function as supervisors to younger researchers.

Objectives: The Veni Vidi Vici Programme's objectives are to re-juvenate the academic talent pipeline, and retain promising researchers in academia by offering researchers attractive academic career prospects.

Programme details: The programme provides funding to build up a research group, leading to a 'hoogleraarschap' position (full professor). Proposals are submitted to NWO by the researchers. Approximately 25 Vici grants are allocated per year, for up to €1.5 M over 5 years (€1.25M 2002-2008). From 2002-2009, the host institutions had to match NWO funding by 33%. This requirement was dropped from 2009.

Eligibility criteria: Vici-candidates are eligible if they obtained a PhD somewhere between eight and fifteen years ago and have been granted a professorship less than three years ago. They must be in the top 10-20% of his/her research community with a good international reputation, have an innovative research proposal and show leadership capacity. The scheme is open to researchers of any nationality.

Budget: €150 M per year for the entire Veni, Vidi and Vici programme (since 2009).

Evaluation findings: An evaluation of the Veni Vidi Vici scheme was conducted in 2007 (for the 2000-2006 time period). Between 2002-2006, 139 Vici awards were allocated. The evaluation found that Vici-researchers conducted more innovative/frontier research, had elevated status in the research community, and published more frequently in high-impact journals than the national average (also prior to award). There were concerns about the requirement of universities to submit an integration plan for Vici researchers at the proposal stage – some researchers indicated that this had significantly slowed the application process. It also limited their negotiation position for a long-term appointment at the host institution after the Vici grant had come to an end. The evaluation also examined the matching requirement (33% from the universities), noting several negative effects – for example, some institutions discouraged researchers from applying to ensure they only received a ‘manageable’ number of applicants, and it limited researcher mobility between Dutch institutions. The pros and cons of abolishing the matching requirement were discussed in detail. (The requirement was dropped in 2009.)

A 2013 study by the Netherland Bureau for Economic Policy Analysis found that the receipt of a Veni Vidi Vici-grant enhanced the probability of a successful career in science. Grant recipients were more likely to remain in academia, to become a full professor and to receive follow-up grants. The grant did not have a positive impact on the level of salary, and recipients were less likely to be employed on a permanent contract compared to unsuccessful applicants.

Notable similarities / differences to the SFI PI programme: The Vici component of the International Research Incentives scheme does not specifically aim to attract foreign research talent.

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