PA Consulting Group

Ten Years On: Confirming Impacts from Research Investment

A case study focusing on the direct commercial and economic impacts from exchequer investment into centres and initiatives supported by the Programme for Research in Third Level Institutions (PRTLI) 2000-2006

An independent report to the Higher Education Authority (HEA) by PA Consulting

August 2011

Foreword

Demonstrating the impacts from public investment in research, particularly in quantitative terms, is a challenge faced by many funders and research performers worldwide. The fact that much of the impact is in terms of public good, whether educational, societal or economic, makes it particularly difficult to directly link cause and effect. Additional complexity arises when one considers the multiple factors that play into economic success and, in the Irish context; further challenges are presented by the fact that we are an open economy.

However, in spite of these challenges, in the early summer of 2010, after a competitive tendering process, the Higher Education Authority (HEA) commissioned an independent assessment of commercial and economic impacts arising from those centres/initiatives established or expanded by the Programme for Research in Third Level Institutions (PRTLI) in the period 2000-2006. Other centres established by the PRTLI or in the process of being established and other funders since that time, did not form part of the study as it would be too soon to assess impact from those investments. This approach has been endorsed by the fact that in this study the vast majority of impact has been found in the last three years.

By 2010, centres/initiatives established or expanded by the PRTLI had evolved and were being supported by other private and public funders - indeed the report shows that over the timeframe examined the majority of public funding was channelled to these centres through Science Foundation Ireland, the Health Research Board, Enterprise Ireland, the Environment Protection Agency and the Irish Research Council for the Humanities and Social Sciences and the Irish Research Council for Science, Engineering and Technology. As is set out in the study it was not possible to separate out the impacts from each of these streams of investment so the report presents a snapshot of the impacts from the entirety of that public investment up to 2010.

In understanding the report, the reader needs to be aware that whilst the many impacts of the investment are summarised, this report presents a detailed quantitative picture only vis-*à*-vis particular impacts. A decision was taken within the study to focus purely on measuring the impact that could be directly validated by beneficiaries. Important and all as it is, the main quantitative component of this study – direct commercial impact - represents only one component of the broader economic impact and dividend. To illustrate this point, the economic dividend arising from attraction and retention of foreign direct investment due in part to our ever increasing reputation for research and enhanced skills base has not been quantified. Nor indeed has the economic impact from the multiplier effect of this investment in terms of indirect and induced expenditure been quantified. It is of course broadly acknowledged by the companies themselves and by government agencies that the presence of a quality public performing R&D system, matched with quality human capital, are key factors in attracting companies to Ireland. Other economic impacts not quantified in this study are –

- the employment generated through construction in the significant infrastructure projects;
- income ‘dividends’ realised by individuals due to the increasing supply of PhDs;

- additional international student income generated due to the improvement in global institutional reputation arising from enhanced research capability;
- visitor impacts arising from the holding of high profile conferences and events based on new facilities and international research reputation;
- multiplier effects of the investment in higher education in terms of indirect and induced expenditure

So to be clear this study focused on the area – direct commercial impact for companies - where benefit could be quantified and verified by those who have directly benefited. On this basis the outcome from the study is indeed very encouraging particularly when one considers the value placed on the return on investment by companies to date and the value placed on the potential for the next five years.

As such, the study presents a minimum valuation of impact at this stage.

In presenting this work to the public, the HEA wishes to thank PA Consulting for its contribution and for contributing to the broader understanding of impacts from investment in research. The methodology of assessing direct commercial impact on the basis of the determinations from the private sector is, as far as we are aware a novel approach in the Irish context, and we are encouraged by the results to date when one considers that many of the international studies conduct assessments of this nature up to 15 years post investment. The HEA also wishes to thank members of the independent steering committee for the review, Martin Cronin, Mark Dynarski and David Hegarty.

Finally it is the case that these impacts are but one component of economic dividend and societal impact. This clearly means that further work is needed to capture and quantify all economic impacts and the systems need to be established to do so. A comprehensive study of the impacts of the research investment in health and well being, the improvements to our environment, the enrichment of our heritage and culture and our better quality of life is also required. These latter impacts are equally, if not more important for the economy and society, and cannot be overlooked or discounted.

Mr. John Hennessy
HEA Chairman
August 2011

Ireland's EU Structural Funds Programmes 2007 - 2013

Co-funded by the Irish Government and the European Union

EUROPEAN REGIONAL DEVELOPMENT FUND

Centres and initiatives in this study have been funded through the Programme for Research in Third Level Institutions (PRTLI) and supported through a number of other Irish Exchequer sources. The PRTLI is co-funded under the European Regional Development Fund (ERDF).

Executive Summary

Introduction

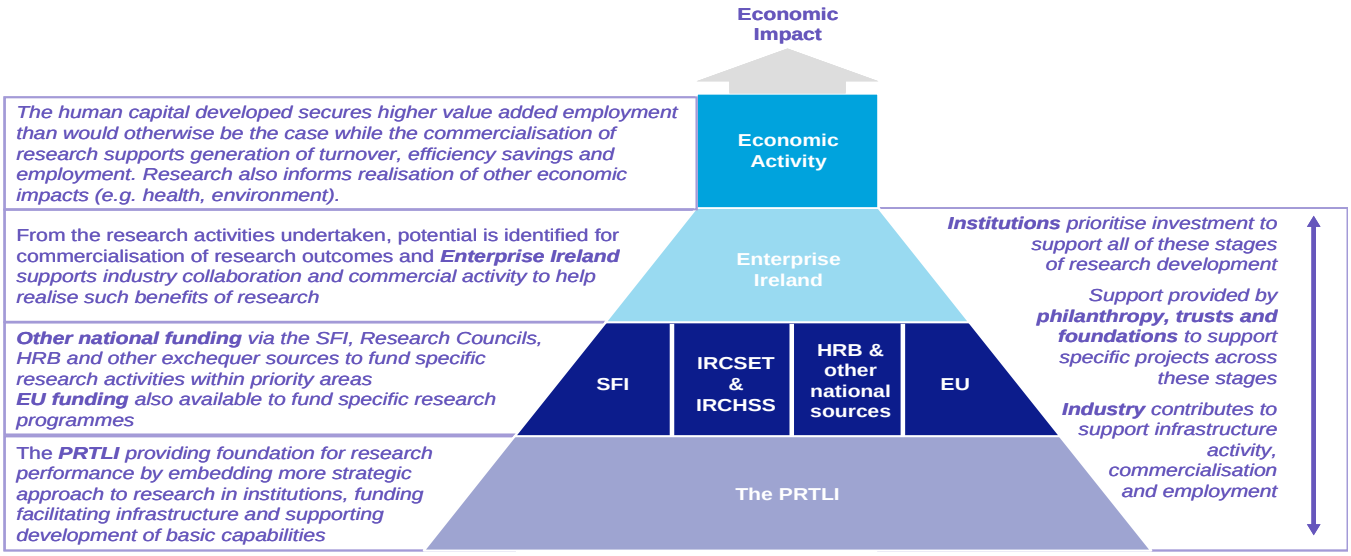
This report, commissioned by the Higher Education Authority (HEA), presents PA Consulting's independent assessment of the commercial and economic impacts arising from exchequer investment in the centres and initiatives initially funded via the Programme for Research in Third Level Institutions (PRTLI) over its first three investment cycles. The programme was established in 1998 to strengthen national research capabilities through investment in physical infrastructure and human capital, channelled through 45 specific specialist research centres and initiatives within and across institutions. It worked with other research support interventions (most notably via Science Foundation Ireland, the Health Research Board , Research Councils and Enterprise Ireland programmes) to deliver research outcomes from these centres and initiatives and this study has set out to validate impacts which have arisen as a result.

PRTLI is part of an overall solution to address a research deficit…

The situation with regard to research infrastructure and investment prior to establishment of the PRTLI was markedly different to that at present. Despite a range of positive wider socio-economic indicators between 1991 and 1999, there was less evidence of progress with regard to research, development and innovation performance. Expenditure on R&D and numbers of researchers in Ireland lagged behind international peers, while a Circa Group study in 1996 identified undercapitalisation of higher education research as a major problem. Weaknesses were also identified in the organisation and management of research activities within the institutions with limited strategic focus overall.

The decision to establish the PRTLI represents a key milestone in development of Ireland's research capability and one which allowed substantial additional funding to be leveraged. A particular benefit of the programme was the injection of €178mn from Atlantic Philanthropies over the first three Cycles, accounting for around 30% of total programme investment over this period (€605mn). The PRTLI was not intended to fund specific research activities or defined research projects, but rather to put in place the conditions that would allow the right type of activities and projects to subsequently proceed. The success of the centres and initiatives supported by the PRTLI in generating commercial and economic impacts was therefore interdependent on many other supports and interventions. All of these interventions work together to generate a funding and support model for higher education research in Ireland as illustrated in the following diagram.

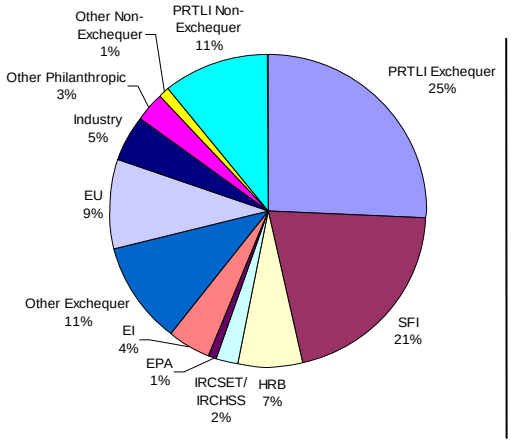
The Support Model for Higher Education Research in Ireland



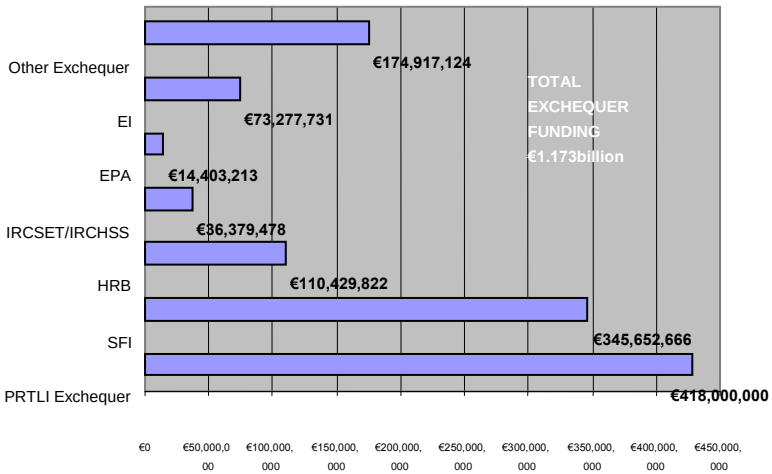
It provided a platform for other funding inputs to support research activities…

In assessing the commercial and economic impacts that emerged from the centres and initiatives supported by the PRTLI investment, it is essential that all other subsequent funding inputs to sustain their research activities are taken into account. Our analysis revealed a multi-faceted funding profile underpinning the work of these centres and initiatives as shown in the diagram opposite. Overall funding of the centres and initiatives since initiation of the PRTLI support was recorded at €1.661bn, with Exchequer inputs in this regard amounting to €1.173bn.

Overall Funding Profile



Exchequer Funding Inputs



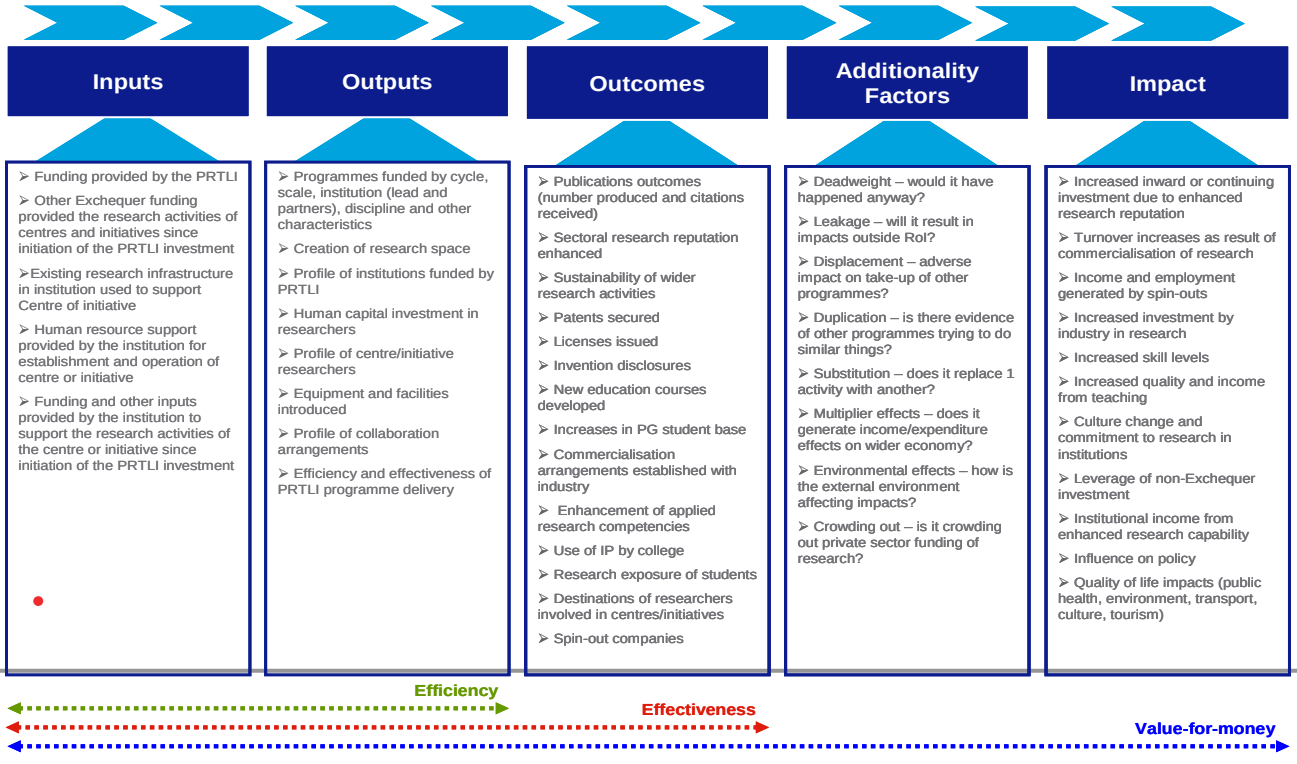
Commercial impacts from research are critical within a broader landscape…

Measuring the impact of investment in knowledge creation, research and innovation is complex. It is in itself the subject of considerable research and there remains a lack of consensus on best practice approaches to deal with issues including:

- the long-term nature of the realisation of impacts from initial infrastructure development;
- dealing with the unpredictable nature of 'breakthrough' moments in research (making it difficult to predict the value of continuing to invest or timing of returns);
- the interdependency with and complexity of other funding streams (as is the case in the Irish support model above) to support research activity, and;
- isolating and attributing commercial benefits and increased employment to the PRTLI when they depend on so many other business and wider market variables.

This study deployed a comprehensive methodology that set out to map the intricate relationships between the inputs, outputs, outcomes and impacts of the PRTLI supported centres and initiatives, and we have been able to produce and validate robust evidence of the commercial and economic dividends that have resulted. Given the lack of a pre-defined monitoring framework or commercial objectives and metrics, there was a need to define a methodology which could offer insight and value while recognising constraints on available data. In this regard we considered the wider stakeholder interest in the study from parties including the HEA itself, the Department of Finance, the Department of Education and Skills, the Department for Jobs, Enterprise and Innovation, Forfás and IDA Ireland. We determined that the assessment would be of the greatest practical use to such stakeholders if it could demonstrate clearly the extent to which initial funding stimulated private sector commercial activity. This approach was consistent with other impact studies internationally (particularly in the US and UK) and the validation of such impacts in companies thus became a key focus of our methodology, with other economic impacts also tracked as far as possible. We focused on establishing a clear logical relationship between the PRTLI and other exchequer funding inputs the outputs, outcomes and impacts which emerged from the centres and initiatives since programme support was initiated. The assessment has been built around an evaluation framework that establishes this relationship chain.

Economic Impact Assessment Framework for the PRTLI



There has been progress in delivering commercial and wider economic impacts…

The PRTLI investment over its first three cycles provided a foundation from which significant research activity was progressed with the support of other exchequer funded interventions and further philanthropic, EU and industry investment. The funding inputs detailed stimulated a chain of outputs, outcomes and impacts via centres and initiatives as follows:

- **45 centres and initiatives** were supported across **five thematic research areas.** These were the direct outputs of the investment in the development of infrastructure, equipment, collaboration and increased numbers of PhDs.
- There are marked increases in the research outcomes from the work of these 45 centres and initiatives. Indicators such as **publications, citations, inventive disclosures and PhDs graduated have risen significantly** in the period since the initial PRTLI investment.
- There is a significant human capital impact with a **threefold increase in the human capital research base** and support for **1,661 research jobs** through their ongoing activities. The expertise is becoming dispersed within industry and the public sector at senior levels.
- There are **wider impacts in shaping policy and realising minor public health and environmental improvements** but there must be focus on targeting such impacts and monitoring achievement by relevant centres.
- Commercial impacts have been established in tracking and attributing investment, savings, turnover and employment to the products of particular research activities. This has resulted in **50 companies** where impact has been validated, a commercial impact of **€753.7mn**, and an employment impact of **1,255 jobs**.
- There has been a ramp up in the level of commercial impacts realised in recent years, and this is also reflected in the **significant potential future commercial impact identified by industry**. This amounts to €1.108bn, and although realisation of this impact will be dependent on many variables, it underlines the fact that the study has been undertaken as a snapshot at a point only part of the way along the journey to realise the full benefits of the research investment.
- **Not all of the centres or initiatives had the potential for generating commercial impacts** and this must be recognised in considering any return on investment. The 16 centres and initiatives within the social sciences and humanities and environment and marine thematic areas fall into this bracket and considering success in terms of human capital, reputational, policy-related and wider economic impacts is more appropriate. However **from the €952mn recorded as flowing through the other 29 centres in biosciences and biomedical**; **platform technologies and materials; and ICT and advanced communications; a return in terms of commercial impact could be expected** (although it should also be acknowledged that this was not a specific objective of the initial PRTLI funding). This is borne out by the fact that 99.9% of all impacts validated emerged from the work of these 29 centres and initiatives.
- **These commercial impacts do not represent the overall economic impact in terms of these centres.** The focus of the study was only on identifying impact which could be directly validated by industry. While important impacts have been measured from multi-national companies investing or continuing to invest in Ireland as a result of research and development activities progressed by the centres or initiatives, it was also found that there are **significant wider**, but unquantifiable, **Foreign Direct Investment benefits as a result of the strong research system put in place**. This will provide associated knock on and ripple effects in the economy, while other impacts, such as those related to the construction of projects and human capital and institutional reputational benefits, are similarly not included in this figure. There will also inevitably be commercial impacts which exist which could not be confirmed by industry as part of this study, although this is countered somewhat by the fact that impacts realised by multi-national companies will result in some leakage.

Nonetheless it is reasonable to take the impact calculation as a **minimum estimate**. It is also a figure which compares well with the limited international comparative analysis which has been undertaken in this space.

Commercial Impacts arising from the PRTLI Supported Centres and Initiatives

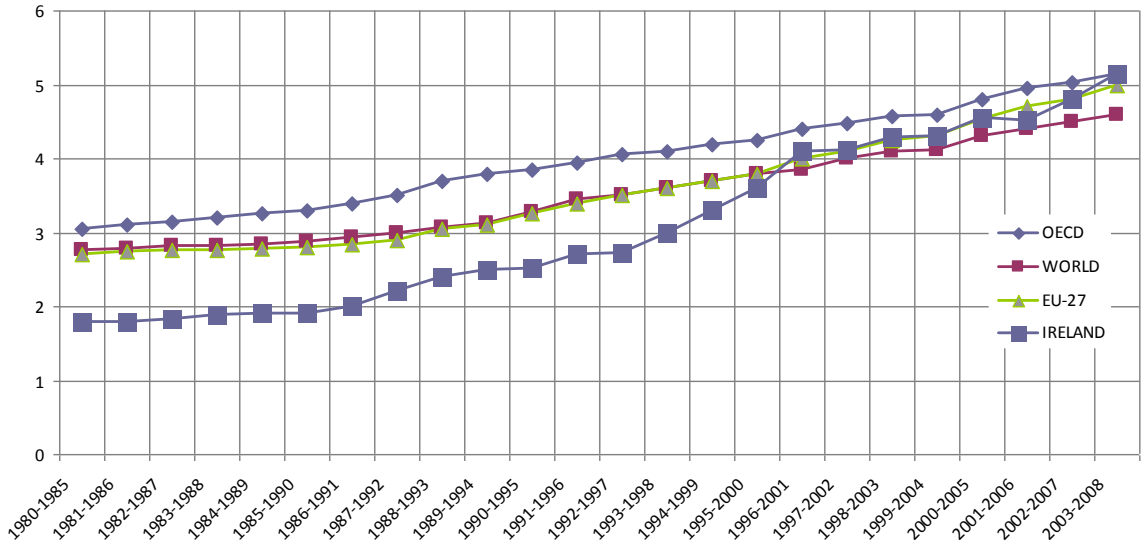
Type of Enterprise	Spin-Outs	Established Companies	Total
No of company impacts identified	44	113	157
Number of company impacts in terms of commercial turnover, investment or savings identified	24	26	50
Estimated commercial impact in terms of commercial turnover, investment or savings identified	€99.6million	€654.1million	€753.7million
Estimated employment impact resulting from the research undertaken by PRTLI supported centres and initiatives	192 jobs	1,063 jobs	1,255 jobs
Number of companies where future impact in terms of commercial turnover, investment or savings is projected	12	19	31
Estimated future impact (next 5 years) resulting from the research undertaken by PRTLI supported centres and initiatives	€96.3million	€1.012billion	€1.108billion

Source: PA Consulting Impact Validation Exercise

The next stage of development requires a renewed approach…

From the time when the PRTLI was established in 1998 and was followed by other substantial research support interventions, we can see a notable closing of the gap with international averages. The improved performance has now allowed Ireland to achieve a position where it sits above the EU and world averages and is on a par with that of the OECD in terms of research performance indicators (including, for example in the Thomson Reuters research impact index shown below). Although Ireland's innovation system has made significant progress in developing world-class research and development facilities and expertise, it is still not as mature as other leading systems (e.g. Finland, Sweden, Germany, etc). Although Ireland is now 'at the table' as a significant player in international research, further investment will be required in order to bring it onto the same stage.

Thomsons Reuters Research Impact Indicators 1980-2008



Source: Thomson Reuters InCites March 2010

We have found that the establishment of the PRTLI and subsequent investment programmes through SFI, the HRB, IRCHSS, IRCSET, the EU, etc. have resulted in the rapid growth, expansion and improvement of research in Ireland. Ireland is now at a point where we need to reflect on our approach to research and development, how and where we invest and how we manage and organise the policy agenda strategically. Case studies of innovation leaders have shown that establishing infrastructure and developing specialisms represents only the first part of the journey in putting in place an effective innovation system. We are at a different point in terms of the stage of maturity of our research base and in the development of the economy. These conditions mean that there is an urgent need to ensure value for money across all future investment areas and to maximise return on investment. From the assessment conducted, it is our judgement that continued investment in specialist research activity offers the potential to ensure that an economic return is made. However this will only be the case if the targeted commercial and economic impacts are made clear at the point of funding and monitored and pursued at every stage of the research process. By doing this and taking a very strategic approach to the support of research, focused on building on success and key areas of strength, a platform exists for significant future economic success.

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1 Introduction

1.1 Introduction

This report summarises the findings of an assessment of commercial and economic impacts arising from the exchequer funding inputs in centres and initiatives supported by the Programme for Research in Third Level Institutions (PRTLI) over its first three cycles from 2000 to 2006. The report is the product of comprehensive research and consultation undertaken between June and December 2010. The report has been developed in line with guidance provided by a Steering Group and the Higher Education Authority (HEA).

1.2 Requirements from the assessment

Given the length of time since establishment of the PRTLI, the progress made in development of research capability and the changing economic context, it was decided that now was an appropriate point to consider the economic impacts that have emerged from initial investment in the programme. In inviting tenders for this work the HEA stipulated that the assessment was to involve a review of the economic dividend arising from the PRTLI investment to date, as well as an assessment of the contribution of the programme to academe and society. A number of specific requirements were also defined by the HEA to frame the undertaking of the exercise:

- Review the PRTLI initiated centres/initiatives to examine the amount of funding they have attained from PRTLI and other sources.
- Consider whether the PRTLI centres/initiatives have performed and developed as would be expected based on the level of investment received, regardless of source, also taking cognisance of their maturity. This includes a review of individual centres/initiatives to determine if they are having economic impact using a multilayered approach to include less quantifiable economic impact such as effects on the environment, public health and quality of life.
- Determine the impact of PRTLI on the basis of a 'roll-up' of the above and its contribution to the 'Innovation and Ideas Economy'.
- Determine the measures in place to ensure utilisation and sustainability of Centres/initiatives.

It was further noted that the evaluation should identify areas or platforms where PRTLI initiatives are having a collective economic impact in particular areas or disciplines. In terms of impact assessment, it was to provide evidence of productivity, economic growth and wealth creation, enhanced skills base, increased employment, the employability of PhD graduates, increased innovation capability, increased global competitiveness, attraction of other external funding, indicators of commercialisation and IP and invention disclosures.

In recognition of the complexity involved in meeting these requirements, the HEA embarked on a competitive dialogue process to consider and develop a methodology that could facilitate success. This process involved a pre-qualification stage, a dialogue session, the issuing of an individualised Invitation to Tender and the evaluation of responses. PA Consulting was commissioned to undertake this work in June 2010 on the basis of a methodology which is set out in Chapter 3. The full terms of reference on which this proposed methodology was based are shown within the Invitation to Tender document provided as Appendix J.

1.3 Report structure

The remainder of this report is structured as follows:

Chapter 2 – Provides an overview of the PRTLI, its purpose, structure and scope, and its role within the wider innovation system in Ireland.

Chapter 3 – Sets out the rationale for our approach to assessing commercial and economic impacts, the assessment framework adopted, methodology deployed and the evidence base from which the findings in this report are derived.

Chapter 4 – Considers the base case at the time prior to the launch of the PRTLI, summarising the socio-economic characteristics, research and innovation performance and HE research infrastructure and capability.

Chapter 5 – Assesses performance in terms of inputs, outputs and outcomes that from the centres and initiatives that were supported by the PRTLI under Cycles 1 to 3. This makes clear the logical relationships between these inputs, outputs and outcomes and provides a platform for examining how they then link to commercial and economic impacts.

Chapter 6 – Examines the commercial impacts that have been validated as having been directly derived from research undertaken within centres and initiatives supported by the PRTLI under Cycles 1 to 3.

Chapter 7 – Identifies other economic impacts that can be linked to centres and initiatives supported by the PRTLI under Cycles 1 to 3 including those related to human capital development; enhanced research capability; and policy, health, environmental and cultural benefits.

Chapter 8 – Considers research capability in Ireland in its present context, providing an overview of how this has changed since the base case prior to the launch of the programme.

Chapter 9 – Draws conclusions on the commercial and economic impacts arising from the Exchequer investment in centres and initiatives supported by the PRTLI and discusses the lessons learned from the assessment.

2 The Programme for Research in Third Level Institutions (PRTLI)

2.1 Background to the PRTLI

The PRTLI was established in 1998 to strengthen national research capabilities through investment in physical infrastructure and human capital. This followed the success of the Programme for Science and Technology which had been rolled out by the government in response to the Tierney report[1]. The overarching vision for the programme was to propel Ireland towards establishing an international profile as a premier location for carrying out world class research and development. The specific objectives which were set for the programme[2] were to:

- Enable a strategic and planned approach by third-level institutions to the long-term development of their research capabilities, consistent with their existing and developing research strengths and capabilities and national goals;
- Promote the development of high quality research capabilities in third-level institutions, so as to enhance the quality and relevance of graduate outputs and skills;
- Within the framework of these objectives, to provide support for outstandingly talented individual researchers and teams within institutions and the encouragement of cooperation between researchers both within the institutions and between institutions, with a particular focus on promoting inter-institutional cooperation within Ireland, the EU and internationally.

Although overall government motivation for investment via the PRTLI was the achievement of sustainable, long-term economic benefit, the programme itself was focused on developing basic research capability and did not seek to secure immediate commercial benefits from funding. The Calls for Proposals under each of the first three cycles of funding stated that "the emphasis is, in effect, on assisting the institutions to enhance and develop their research capabilities and not on proposals which can reasonably be expected to lead to commercial applications and exploitation in the short term."[3]

PRTLI funding has been invested across disciplines, geographies and institutions. Under the programme, funding has been deployed across the sciences (including biosciences and biomedical, environment and marine, platform technologies and materials), technologies (ICT and Advanced

[1] 'Making Knowledge Work for Us', Science, Technology and Innovation Advisory Committee, March 1996.

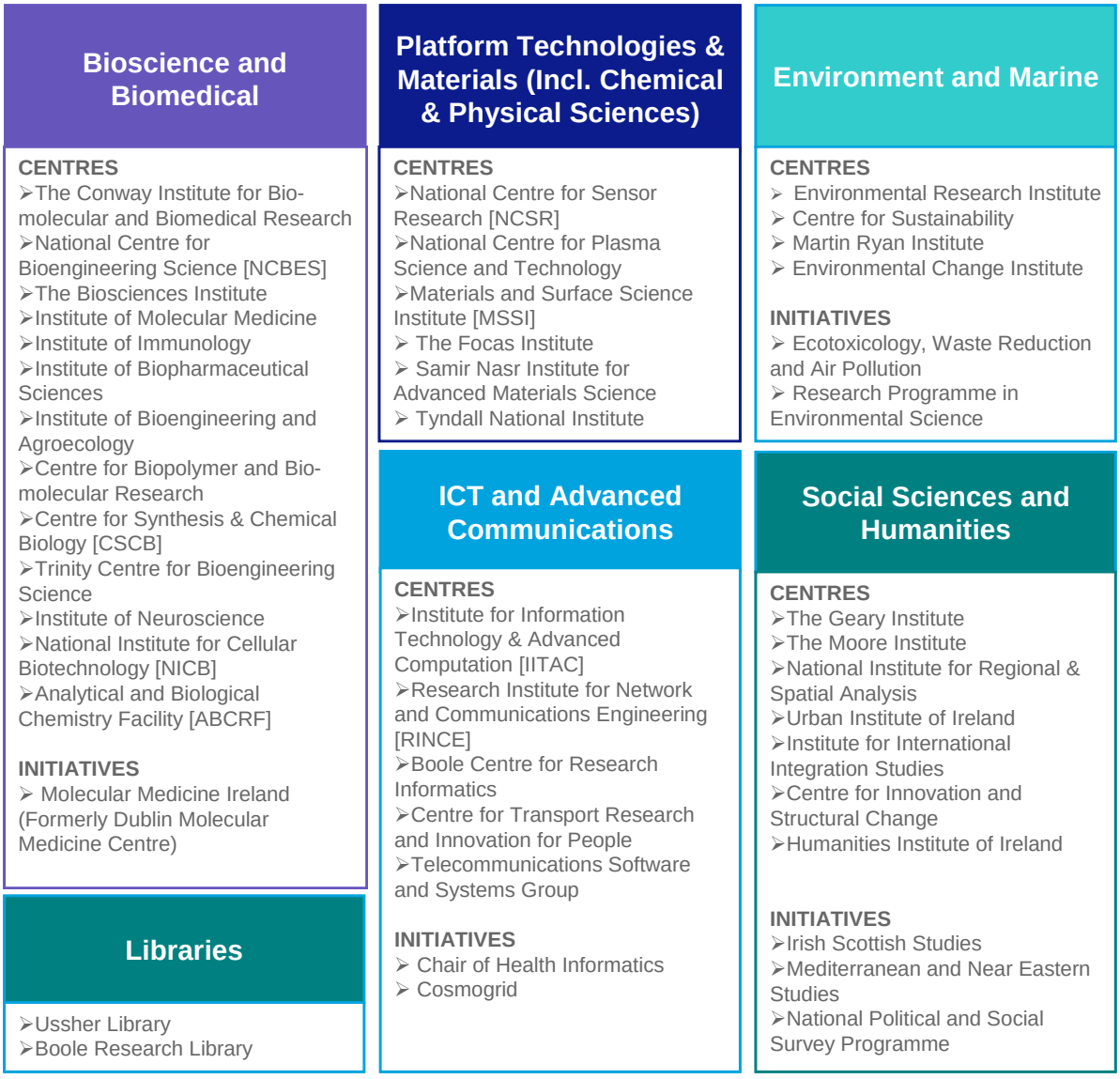
[2] 'Programme for Research in Third-Level Institutions: Call for Proposals'. Higher Education Authority, Cycle 1, November 1998

[3] 'Programme for Research in Third-Level Institutions: Call for Proposals'. Higher Education Authority, Cycle 1 (issued November 1998), Cycle 2 (issued December 1999), Cycle 3 (issued December 2000)

Communications) and social sciences and humanities as well as providing strategic investment in a number of university library facilities.

Since its launch in 1998, five cycles of funding have been launched, with PRTLI Cycle 5 announced in 2010. This economic impact assessment has been asked to focus upon the first ***three cycles of assistance over the programming period 2000-2006***. The projects that were funded over cycles 1-3 across the five core disciplines are shown in Figure 2.1.

Figure 2.1: Centres and Initiatives Funded by the PRTLI Cycles 1-3



As shown in Figure 2.1, funding typically flows through centres of excellence or initiatives within wider higher education institutions. Awards are made following a formal evaluation process by an international panel of distinguished researchers and scholars on the basis of excellence in strategic planning and focus; inter-institutional collaboration; research quality; and impact of research on teaching and learning.

The PRTLI funding is provided for both capital and current expenditure. Capital expenditure includes investment in buildings and equipment and current expenditure includes investment in research programmes and people. Figure 2.2 provides an overview of overall investment in the PRTLI over the first three funding cycles.

Figure 2.2: Overview of the PRTLI Funding in Cycles 1-3

Cycle	Year of Award	Funding Period	Building and Equipment (€Mn)	Research Programmes & People (€Mn)	Total (€Mn)
1	1999	2000-2003	177.5	28.6	206.1
2	2000	2001-2004	48.8	29.7	78.5
3	2001	2002–2006	178	142.4	320.4
TOTAL FUNDING OVER FIRST 3 CYCLES			**404.3**	**200.7**	**605**

Source: HEA Programme Data

The total investment over the first three cycles of the PRTLI amounted to €605mn. The deployment of funding on this scale was greatly assisted by the contribution of Atlantic Philanthropies. The organisation co-funded the first three funding cycles, investing €178mn in total, with an additional €9mn from other non-exchequer sources. This means that overall Exchequer funding in Cycles 1 to 3 of the PRTLI was €418mn.

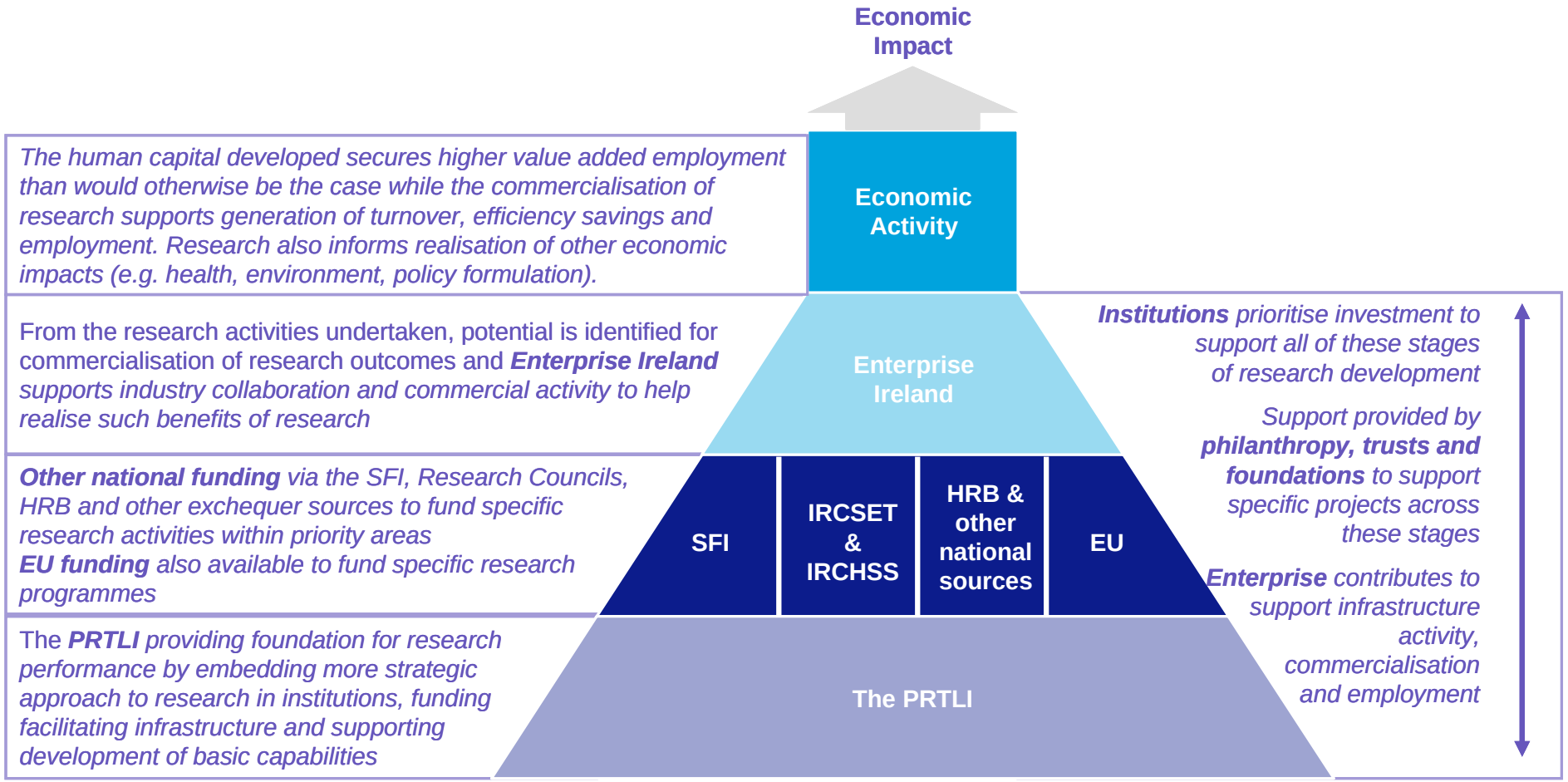
2.2 The role of the PRTLI in the wider innovation system

The role of PRTLI was specifically focused on building research infrastructure and basic research capability in institutions, allowing a more strategic approach to be put in place. It was not intended to fund specific research activities or defined research projects. Rather the aim was to put in place the conditions that would allow the right type of activities and projects to subsequently proceed.

The success of the centres and initiatives supported by the PRTLI in generating commercial and economic impacts was therefore interdependent on many other supports and interventions. The launch of the programme was closely followed a series of other developments. These included the founding of SFI, IRCSET and IRCHSS to fund research activities and the formation of technology transfer offices and provision of commercialisation support by EI to facilitate closer working between higher education and enterprise.

There are also many other interventions which contribute to the outcomes and impacts produced by centres or initiatives. All of these interventions work together to generate a funding and support model for higher education research which is currently delivering commercial and economic impacts and these will continue into the future. In Figure 2.3 we illustrate how the model is intended to work in practice. This provides the context for understanding how the inputs, outputs, outcomes and impacts of the centres and initiatives supported by the PRTLI under Cycles 1 to 3 can be assessed.

Figure 2.3: The Support Model for Higher Education Research in Ireland



3 Methodology and evidence base

3.1 Assessing economic and commercial impacts

Given the nature of the PRTLI as a foundational and facilitating research investment mechanism which was interdependent with other interventions in delivering impacts, significant consideration was given to selecting the most appropriate methodology to meet the requirements of the assessment. An economic impact assessment traces spending through an economy and measures the cumulative effects of that spending. There are different measures that can be used in assessing economic impacts, with key examples including employment levels, value added, aggregate wages and salaries, wealth and business output.

In defining our own approach we consulted the body of work that has been undertaken on the economic impact of research investment. This reinforces the challenge and complexity involved in such a process, with studies deploying varying methodologies and producing significantly different results. Indeed a literature review by SPRU in 2006[4] on such material concluded that "any attempt to assess and quantify the economic and social benefits from publicly funded research is beset with problems". A report by the Advisory Committee on Measuring Innovation in the 21st Century economy in the US noted that "measurement of innovation, in this country and elsewhere, remains rudimentary" Nonetheless techniques have been developed that assist in assessing impacts from research investment including:

- The study undertaken by Mansfield in 1991, with follow-up research published in 1999, calculated a 28% rate of return on research investment by using an approach of **surveying companies** to determine how investment patterns has changed as a result of the commercialisation of HE research. A similar approach was also adopted in studies by Toole (1999), Beise and Stahl (1999), Huffman and Evenson (1993) and Cockburn and Henderson (2000).
- In PA Consulting's own study of the economic impact of Research Councils UK[5] there was a strong focus on **case study assessment** which showed how investment in HE research led to outputs, outcomes and impacts. This sample based approach acknowledged the difficulties in attempting an overall quantitative analysis of research investment but nonetheless was able to demonstrate commercial, human capital, policy and quality of life benefits. In the US a key principle of measuring innovation at national policy level is a recognition of qualitative evidence, with a recent

[4] 'The Benefits of Publicly Funded Research', Ben R. Martin and Puay Tang, SPRU, July 2006

[5] 'Study on the Economic Impact of the Research Councils', Research Councils UK, PA Consulting, SQW Consulting. October 2007

federal Advisory Committee stating that “because of the collaborative nature of the innovative process, there needs to be tolerance of qualitative and subjective measures.”[6]

- Work by the OECD adopted an approach of **comparative econometric analysis**, considering how research investment trends related to particular economic indicators. For example, work undertaken by the OECD in 2001 which compared data from 1980-1998 across 16 countries found that a 1% increase in public R&D expenditure increases Total Factor Productivity by 0.17%, as against 0.13% for an increase in business R&D spend. A later OECD study in 2004 also concluded that no evidence existed for crowding out of private investment by public investment in R&D.

As fiscal pressures grow, there has been increasing scrutiny on all aspects of expenditure and the returns that can be demonstrated. In the UK, the STI published a policy framework document[7] that set down guidelines for the measurement of impact. This acknowledged difficulties in the process including the time taken from an increase in R&D spend to an increase in welfare and the global nature of science and innovation constraining the ability to attribute domestic economic impacts to domestic research investment. It recommended establishment of a monitoring framework at the outset of funding which facilitates collection of data to allow ongoing tracking of impacts in the midst of such a complex environment.

The lack of focus on commercialisation of research at the outset and no collection of ongoing data to feed into an understanding of emerging economic impact are key issues which impede the ability to assess the impact of the PRTLI supported centres and initiatives. They exacerbate the already significant challenge of measuring the economic impact of investment in knowledge creation, research and innovation which is complex and multi-faceted, with key features including the:

- long-term nature of the realisation of impacts from initial infrastructure development
- relationship between impacts and unpredictable ’breakthrough’ moments in research (making it difficult to predict the value of continuing to invest in a particular area of research)
- interdependency with and complexity of other funding streams to support research activity all combine to deliver impact
- difficulty in attributing commercial benefits and increased employment to the PRTLI supported centres and initiatives when they depend on so many other business and wider market variables.

Ideally the subject requires an in-depth multi-annual longitudinal study which measures how funding inputs relate to research outcomes and ultimate impacts. Although this would require significant investment, it allows external factors to be considered as they emerge and promotes consistency and control in evaluating indicators across different centres and initiatives. Without such an approach, producing an overall objective calculation of the economic impact that singles out the specific investment/return dimension is very challenging.

Nonetheless the current economic and fiscal environment means that an understanding of the effectiveness of investment in the programme is critical. Given these constraints and the lack of a pre-defined monitoring framework which tracked the links between funding inputs and research outcomes and impacts at the outset, there was a need to define a different methodology which could offer insight and value. In this regard we considered the wider stakeholder interest in the study from parties including the HEA itself, the Department of Finance, the Department for Education and Skills, the Department for Jobs, Enterprise and Innovation, Forfás, IDA Ireland and other key funders of the research undertaken by centres and initiatives including SFI, HRB and EI. We determined that the

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[6] ‘Innovation Measures: Tracking the State of Innovation in the US Economy’, A Report by the Advisory Committee on Measuring Innovation in the 21st Century, January 2008

[7] ‘Measuring Economic Impacts of Investment in the Research Base and Innovation: a New Framework for Measurement’, Department of Trade and Industry

assessment would be of the greatest practical use to such stakeholders if it could demonstrate clearly the extent to which initial funding stimulated private sector commercial activity. This approach was consistent with other impact studies as noted above and the validation of such impacts in companies thus became a key focus of our methodology, with other economic impacts also tracked as far as possible. The importance of using case studies to demonstrate how such impacts are realised was also drawn from the other studies considered, as was the need to place analysis in a comparative context by considering international indicators. Despite the constraints, we believe that the methodology developed offers significant additional insight which builds on previous research undertaken, focusing on commercial beneficiaries from the development of research specialisms. It has essentially involved answering three key questions:

- Can a link be established between the initial investment via the PRTLI in research centres and initiatives, the development of research performance and specific research activities undertaken and commercial and economic impacts as a direct result of these research activities?
- Can we validate and quantify the generation of commercial and economic impacts by companies as a result of research within the PRTLI supported centres and initiatives by direct engagement to confirm jobs created and safeguarded; finance invested; efficiency savings achieved; and turnover increases realised?
- Can we illustrate how initial funding inputs via the PRTLI have linked to support from other interventions to deliver research outcomes and generate commercial and economic impacts by citing examples and case studies?

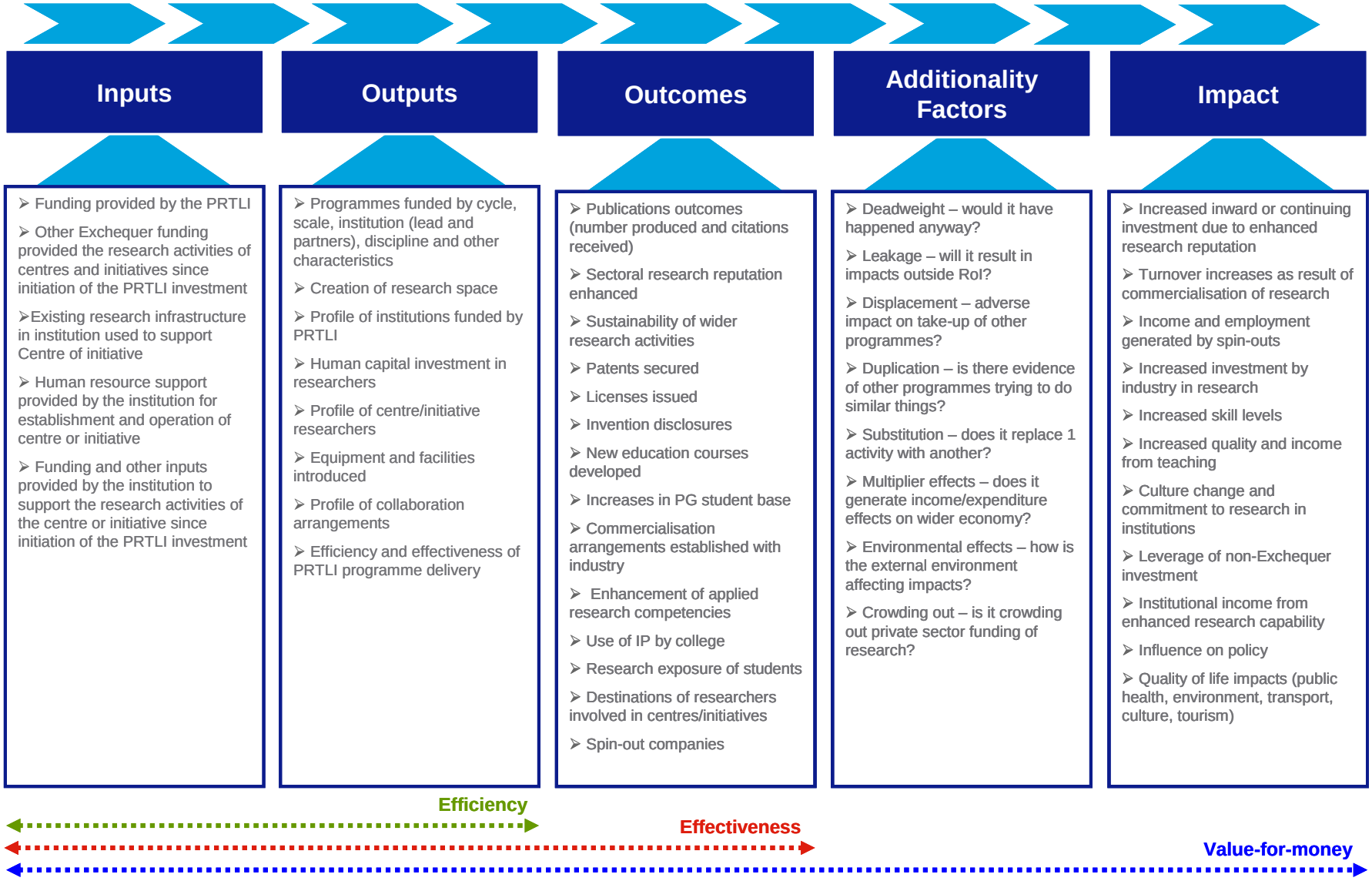
We have answered these questions by developing an overarching framework that set out how the PRTLI worked with other funding inputs to generate outputs, outcomes and impacts.

3.2 The assessment framework

In establishing the commercial and economic impacts which arose from the PRTLI supported centres and initiatives, the interdependency with other interventions in the delivery of outcomes and the multi-annual development cycle in realisation of these outcomes presents significant challenge. It means that it is absolutely critical that there is a clear logical relationship between the PRTLI inputs and outputs and the outcomes and impacts from the programme.

The assessment has been built around an evaluation framework that establishes this relationship chain. The chain begins with the **inputs** in terms of the PRTLI funding, the other Exchequer investment which funded the subsequent research activities of the centres and initiatives and any other sources of support (e.g. such as that provided by institution itself). This results in a series of **outputs** which consist of the direct product of this funding (e.g. the centres and initiatives funded, research space created, equipment and facilities put in place, researchers supported, etc). These should then lead to a set of **outcomes** from the supported centres and initiatives principally in terms of the immediate benefits generated (e.g. patents secured, citations received, collaboration facilitated). It would then be hoped that such outcomes result in **commercial and economic impacts** such as private sector investment or jobs created due to commercialisation of research or inward investment stimulated from development of international reputation in a particular specialist area. Basing the analysis on this framework, **additionality** factors are taken into account, making sure that there is evidence that the impacts identified would not have occurred in the absence of the initial PRTLI support and the other Exchequer funding injections. An impact assessment framework, set out in Figure 3.1, is based on establishing such logical relationships and frames the analysis in the remainder of this report.

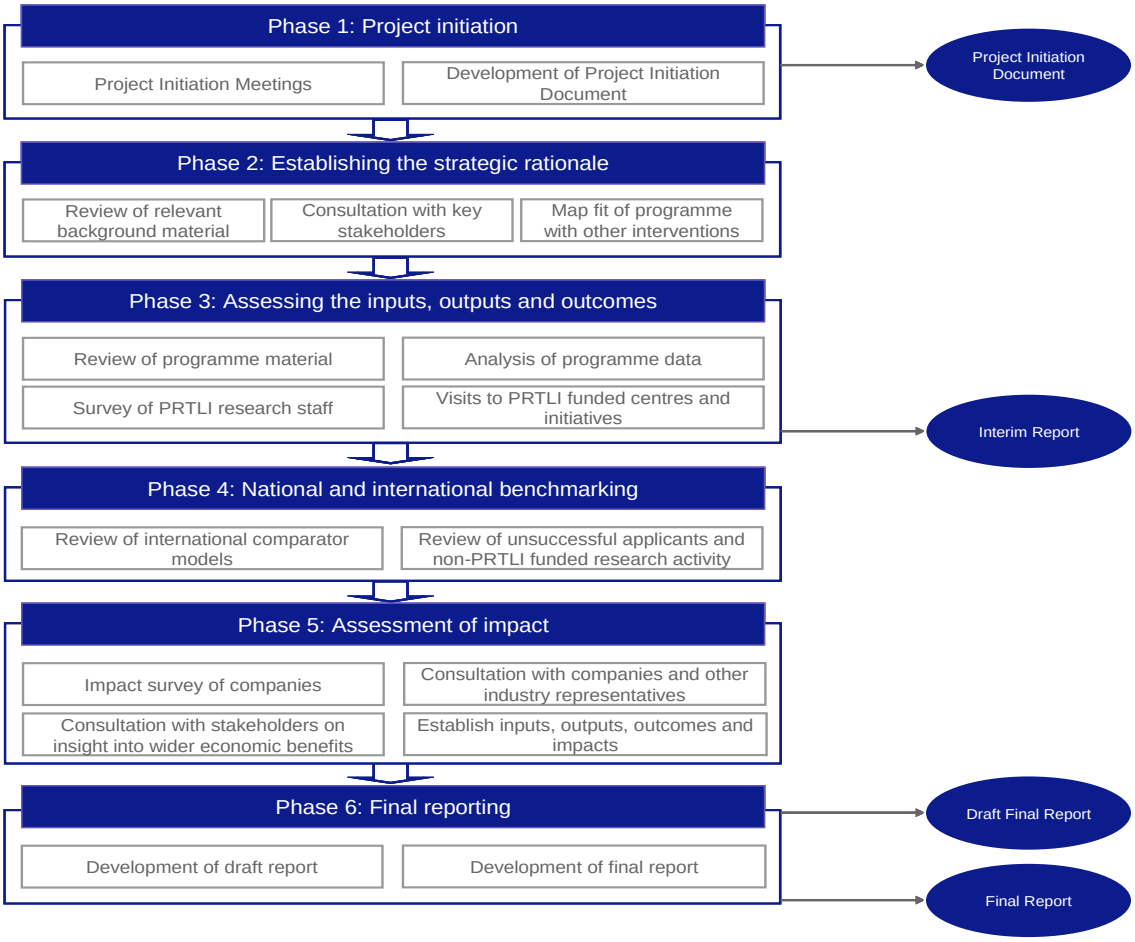
Figure 3.1: Assessment Framework for PRTLI Supported Centres and Initiatives



3.3 The methodology deployed and evidence base

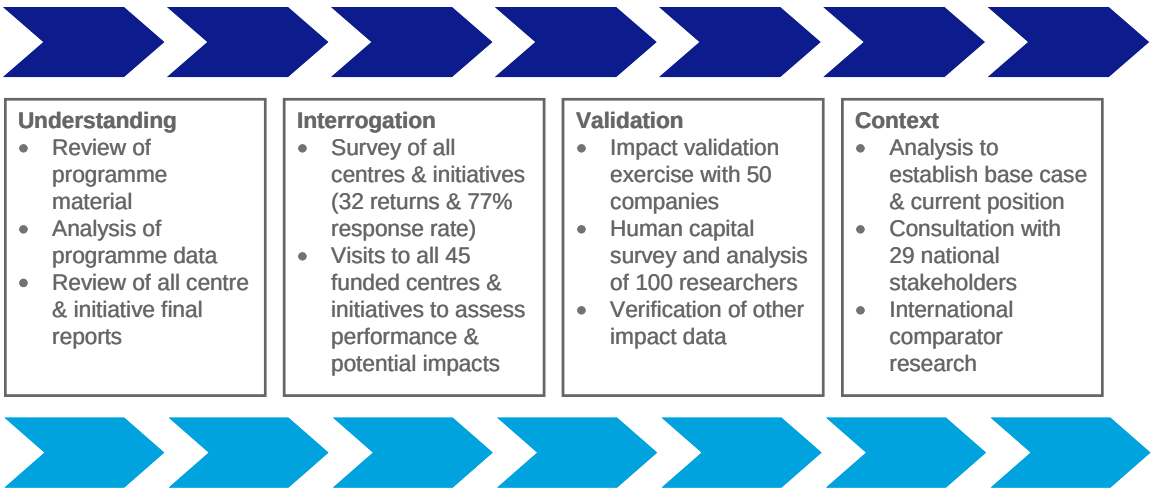
In responding to the requirements stipulated by the HEA, and building on the assessment framework constructed, a comprehensive six-phase methodology was deployed in the undertaking of this assessment, as shown in Figure 3.2.

Figure 3.2 Overview of Methodology



Deploying the methodology and undertaking these tasks has generated a significant evidence base from which the analysis in the remainder of the report has been drawn, as shown in Figure 3.3.

Figure 3.3: Evidence Base for Assessment



4 Establishing the base case

4.1 Socio-economic characteristics pre-PRTLI

The starting point for considering impacts arising from the centres and initiatives supported by the PRTLI must be the establishment of the 'base case' prior to the launch of the programme. At the time when the PRTLI was introduced in 1998, Ireland was already in the midst of a sustained period of economic growth. GDP had grown by 59.8% throughout the decade, with the growth rate reaching 10.7% in 1999. The unemployment rate had fallen from 14.7% to just 5.7% between 1991 and 1999 and positive trends were apparent across most socio-economic indicators.

The significant changes that were taking place in the economy were also reflected in the industrial base. An increase in the labour force participation rate combined with a rapidly growing population drove an expansion of employment across most areas of the economy. Employment increased across all industrial categories between 1993 and 1998 with the exception of agriculture, forestry and fishing. Key growth areas included building and construction and other production industries, with a strong base of manufacturing activity also underpinning this growth. This was in contrast to the trend in most other developed economies where activity in productive industries was declining in the midst of rapid expansion of service sector employment. The ability to attract significant inward investment in manufacturing activity over a sustained period of time was an important contributory factor in this regard. However issues were acknowledged in the quality of such employment and its cost competitiveness moving forward, particularly when compared with emerging economies in Asia and Eastern Europe.

A Review of Industrial Policy and Performance was undertaken by the Department of Enterprise, Trade and Employment in 2003[8] and concluded that "the factors that underpinned the advances of the past decade — such as a large-scale labour surplus and a relatively low-cost environment — are increasingly less applicable. We have a good deal of ground to make up if we are to match the record of the best-performing economies in key areas such as innovation". This laid the foundation for the subsequent development of the 'Ahead of the Curve' report produced by the Enterprise Strategy Group in 2004. This noted that the growth in manufacturing employment had largely been driven by foreign owned enterprises, but that "even though they are in high-value sectors, a significant proportion…are, by global standards, still positioned at a relatively low point in the value chain. The R&D and marketing activities and those activities that require a direct relationship with the customer – in other words, the activities that underpin the competitive strength of the parent organisations – are not for the most part located in their Irish operations."[9]

[8] 'Review of Industrial Performance and Policy', Department of Enterprise, Trade and Employment, 2003

[9] 'Ahead of the Curve: Ireland's Place in the Global Economy'. Enterprise Strategy Group, July 2004

Thus as the PRTLI was becoming established, a central thrust of national policy was development of innovation capability and a move up the value chain. While Ireland's economic performance was strong, its global 'brand' had developed as a low-tax, low-cost manufacturing location, where multinational corporations invested significant sums in low value-add basic manufacturing activities. There was concern about the long-term sustainability of this position and recognition that change was essential, with significant improvements required in performance in R&D and innovation.

4.2 Research, development and innovation performance pre-PRTLI

Despite the strong economic performance, the level of investment in research and development activity in Ireland was significantly lagging behind comparator countries during the 1990s. Figure 4.1 highlights gross expenditure in R&D (GERD) in the period leading up to PRTLI, comparing levels with other selected European nations.

Figure 4.1: Gross Expenditure on R&D as % of GDP

	1987	1989	1991	1993	1995	1997	1999
Denmark	1.35	1.48	1.59	1.72	1.82	1.92	2.18
Germany	2.74	2.73	2.47	2.28	2.19	2.24	2.4
Sweden	2.81	2.75	2.68	3.11	3.26	3.48	3.61
The UK	2.15	2.11	2.03	2.02	1.91	1.77	1.82
Ireland	0.82	0.79	0.92	1.16	1.26	1.27	1.18

Source: OECD

The lag was also apparent in R&D spend in higher education alone (HERD) in the period leading up to the establishment of PRTLI, as shown in Figure 4.2. In line with gross expenditure trends, this showed consistently low levels of investment in comparison with other states. There were some signs that Ireland was beginning to close the investment gap towards the end of the period, helped by an increase in the budget allocated to the HEA to support university research from £21.4mn in 1990 to £41.4mn in 1996[10].

Figure 4.2: Higher Education Expenditure on R&D as % of GDP

	1987	1989	1992	1994	1996	1998
Denmark	0.34	0.38	0.38	0.40	0.40	0.41
Germany	0.42	0.41	0.43	0.43	0.42	0.41
Sweden	0.87	0.91	0.79	0.87	0.79	0.83
The UK	0.33	0.32	0.36	0.39	0.38	0.37
Ireland	0.18	0.18	0.24	0.26	0.27	0.27

Source: OECD

The base of human capital working in research in higher education was also below equivalent levels in comparator countries during this period. However it is interesting that the relative position of Ireland appeared to have worsened during the 1990s, as shown in Figure 4.3.

[10] 'State Investment in Science and Technology 1996', Department of Enterprise and Employment, 1996.

Figure 4.3: Researchers in Higher Education Relative to Labour Force (per 1,000 FTEs)

	1990	1992	1994	1996	1998
Ireland	1.5	1.4	1.3	1.4	1.5
Denmark	1.4	1.5	1.6	2.1	2.2
France	1.7	1.9	2.1	2.1	2.1
Germany	1.3	1.6	1.6	1.7	1.6
Netherlands	1.2	1.8	1.8	1.6	1.6
Spain	1.2	1.4	1.8	1.9	1.9

Source: Forfas Survey of Research and Development in the Higher Education Sector 1992, 1994, 1996, 1998

4.3 Research infrastructure and capability pre-PRTLI

In this context of a comparative gap in expenditure on R&D and associated performance indicators, Circa Group was commissioned by the HEA to conduct a comparative study on international approaches to the organisation, management and funding of university research in Ireland[11]. Published in 1996, this report drew a number of conclusions including:

- The inadequacy of core funding for research in Irish Universities at that time and the knock-on impact that this has in them accessing other external sources of funding support
- That Irish Universities were lagging behind European peer institutions in the adoption of more formal procedures and organisational arrangements for research
- Ineffectiveness by the sector as a whole (although success by individual researchers was acknowledged) in influencing national or international research policies

The findings of the Circa Group report were strongly endorsed during our consultations with stakeholders from third level institutions. Prior to the launch of the PRTLI, these institutions were heavily focused on teaching, with very limited capacity or expertise to support research and development activities. At that time (pre-1998), it was acknowledged that they did not have the facilities, culture or expertise to compete with international comparators in terms of R&D.

The lack of adequate research space and the absence of sufficient incentive for academics to engage in research and development were both cited as key factors which constrained the research performance in the 1990s. Indeed the Circa Group report identified serious issues around the research infrastructure deficit, stating that "For major institutions, attempting to retain a position at the forefront of science…the position is absurd. Undercapitalisation of HE research is a major problem" This assessment of research infrastructure pre-PRTLI was endorsed in the review published by the HEA and Forfas in 2007. This concluded that "higher-education research infrastructure in Ireland in 1998 and prior to the PRTLI, was characterised by chronic public under-investment and a consequent heavy reliance on support from the rest of Europe."[12]

The Circa Group report also recorded research performance indicators at university level which can offer some context as we examine the inputs, outputs and outcomes of the PRTLI supported centres and initiatives. External research income across all universities in 1992/93 amounted to £45.1million (consisting of £17.7million from the Exchequer, £8.6mn from industry, £17.0mn from the EU and £1.8mn from other sources). During this academic year, 6,287 publications had been generated and 316 PhD graduates. Over the 5 year period leading up to 1992/93, 23 patents had been secured and

[11] 'A Comparative International Assessment of the Organisation, Management and Funding of University Research in Ireland and Europe'. Circa Group Europe, December 1996.

[12] 'Research Infrastructure in Ireland: Building for Tomorrow'. HEA and Forfas, 2007

723 jobs had been created as a result of research activity. In 1994, allocations of capital expenditure to institutions totalled £2mn.

The lack of space, equipment and facilities for research across the higher education sector, together with the modest research outcomes noted above, reflected Ireland's lack of competitiveness as an international R&D location. The relatively poor research performance of higher education institutions was reflected in their global reputation and this also had implications for the perceived quality of human capital which again would be an important aspect of the process. The case for change across higher education was therefore clear. In this regard, the Circa Group report proposed a series of recommendations on the development of research capability across higher education:

- The establishment of a research council for the Humanities and Social Sciences (IRCHSS)
- Promotion and facilitation of a 'centres of excellence' approach for the allocation of expensive research facilities nationally, based on identified and institutional and professional strengths and particular fields of application of the individual colleges.
- A more focused approach to developing areas of research strength in individual institutions.
- The establishment of technology transfer or innovation centres to build closer links between third level research and enterprise.
- The introduction of a new funding structure for university research, with support for the research floor from the block grant and project and programmatic support from competitive schemes.
- That the allocation of additional funding for research have the objective to enhance coordination and complimentarity in research between universities, linked to institutional strengths.

Alongside the undertaking of this major study on higher education research, a review by the Science, Technology and Innovation Advisory Committee (STIAC) led by Tierney[13] set an objective of increasing funding for research from £1.5mn to £6mn per year, with a proposal to provide a special fund for research equipment in the third level sector. Acknowledging the very low base of research and development activity in higher education and the emerging needs of the economy, Government introduced a number of interventions to progress the STIAC recommendations. It announced that an additional £4mn would be made available in the budget, with over 50% of this (£2.3mn) going to third level colleges to support research and provide extra funding for post-graduate students. This enabled funding of basic research projects to increase to £2mn per year, from £1mn in 1994. Funding was also made available for five post-doctoral fellowships, an area where no previous support was available.

However there was also an acknowledgement that significantly greater investment would be required if Ireland's research performance was to become more internationally competitive. Assisted by the availability of significant additional funding (via the Atlantic Philanthropies investment) the decision was taken to establish the Programme for Research in Third Level Institutions.

[13] 'Science, Technology and Innovation Advisory Council Report', Forfas, March 2006.

5 Assessing inputs, outputs and outcomes in the supported centres and initiatives

5.1 The inputs in the PRTLI supported centres and initiatives

The PRTLI funding inputs over its first three cycles were intended to kick-start a process of establishing (or in some cases building on existing) research centres or initiatives. In tandem with the PRTLI assistance, recipient institutions were required to prioritise their own resources in the development of these centres and initiatives. As we set out in Chapter 2, other sources of exchequer funding were then accessed to support ongoing research operations. All of these inputs must be taken into account if a comprehensive assessment of the commercial and economic impacts is to be generated. In this section we consider the direct PRTLI and other exchequer inputs that facilitated the generation of outputs and outcomes discussed later in the chapter.

5.1.1 Funding inputs from the PRTLI

The PRTLI brought together a significant base of both government and philanthropic funding to build research capacity and embed a research culture across the higher education sector. A total of €605mn was approved under the PRTLI over the three funding cycles between 2000 and 2006 (of which €178mn was provided by Atlantic Philanthropies and €9mn from other non-exchequer sources).

The PRTLI funding was awarded to all 7 universities (which were allocated 83% of the funding), 6 of the Institutes of Technology (4%) and 2 other specialist institutions (13%) - the Dublin Institute for Advanced Studies (DIAS) and the Royal College of Surgeons Ireland (RCSI). University College Cork (UCC) received the highest overall level of investment over the three funding cycles, securing 20% of total PRTLI investment during Cycles 1-3, with both Trinity College Dublin (TCD) and University College Dublin (UCD) attracting slightly lower levels of support.

The allocations were made to the institutions on the basis of investment proposals to establish or build upon specialist research centres or initiatives. In total, 71 investment proposals were approved over the first three cycles. A number of these investments related to incremental development of the same centres or initiatives (i.e. Cycle 1 investment built upon with subsequent investment in Cycles 2 and 3). The PRTLI investment thus supported a total of 45 distinct centres or initiatives (identified in Figure 2.1 earlier in the report). These centres or initiatives present the most viable means of assessing how outputs, outcomes and impacts emerged from the initial PRTLI assistance. The programme built basic research capability and a specialist research identity via this mechanism which then provided a platform from which activities could be planned, managed and delivered, reputation could be

developed, collaboration pursued and industry engagement facilitated. However, such progress could only be achieved with support from additional interventions and these must also be taken into account when considering the performance the centres or initiatives.

The funding for the centres and initiatives from the PRTLI was spread across five areas as shown in Figure 5.1. Biosciences and biomaterials accounted for the most significant portion of investment (53% of the total deployed under the first three funding cycles).

Figure 5.1: PRTLI Cycles 1-3 Investment by Area of Focus

	Capital	Current	% of Total
Bioscience and Biomedical	202,947,000	114,734,000	53%
Environment and Marine	68,705,000	27,047,000	16%
Social Sciences and Humanities	73,152,000	16,600,000	15%
Platform Technologies & Materials	29,919,000	26,883,000	9%
ICT and Advanced Communications	27,958,000	16,565,000	7%
Total	**402,681,000**	**201,829,000**	**100%**

Source: HEA Programme Data

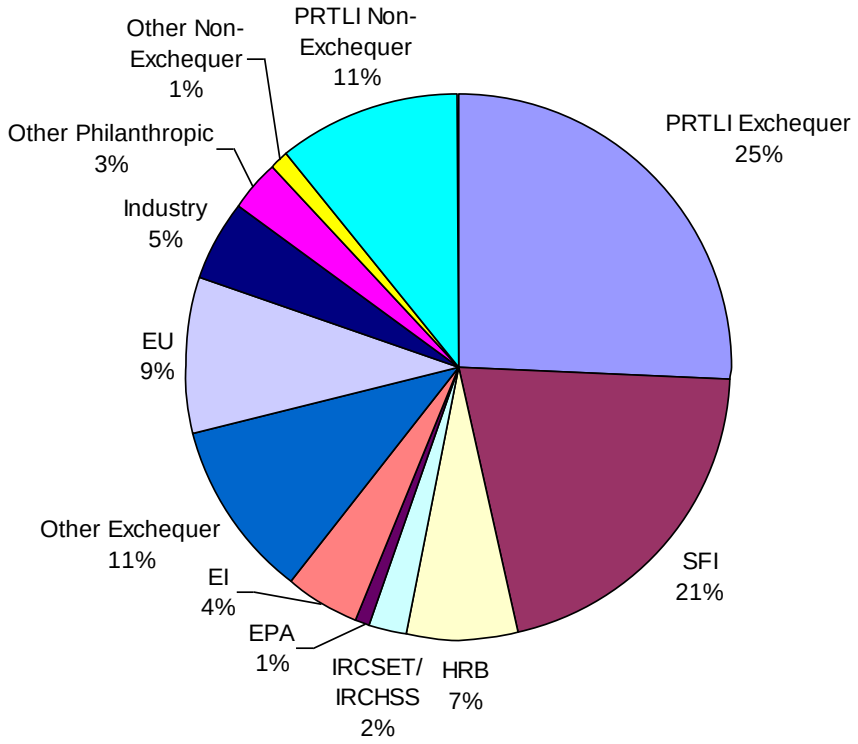
The allocation of PRTLI funding also required significant commitment from the institutions in terms of approach and financial, human and infrastructural resources. Demonstrating the willingness to prioritise such resources in support of key areas of research strength was a key aspect of the PRTLI application process. The analysis of such institutional inputs is difficult to quantify but included:

- **Capital funding** to meet the full costs of buildings or equipment.
- **Current funding** to fund the maintenance of equipment or to support the administration and management of the centre or initiative.
- The **allocation of Principal Investigators, research and administrative staff** to centres and initiatives which were employed by the institution.
- The **provision of additional facilities and equipment** to complement and support PRTLI investment.
- **Funding for PhD scholarships** to deliver research activities within the centres and initiatives.

5.1.2 Other Exchequer funding inputs

The rationale for assessing the commercial and economic impacts that emerged from the initial PRTLI investment by focusing on centres and initiatives is based on the premise that their research outcomes would not have been realised without the developments in infrastructure and basic research capability facilitated by the programme. However the assessment must also take account of the fact that such impacts would not have been realised without the support of many other interventions. Understanding the Exchequer funding inputs in this regard is critical in order to evaluate the return on the public investment made. To begin this analysis, an overview of the overall funding structure of the centres and initiatives is presented in Figure 5.2. This profiles the respective contributions of both Exchequer and Non-Exchequer sources to generate the total funding 'pool' which was found to have supported the work of centres and initiatives since the PRTLI injection. This total funding pool amounted to €1.661bn.

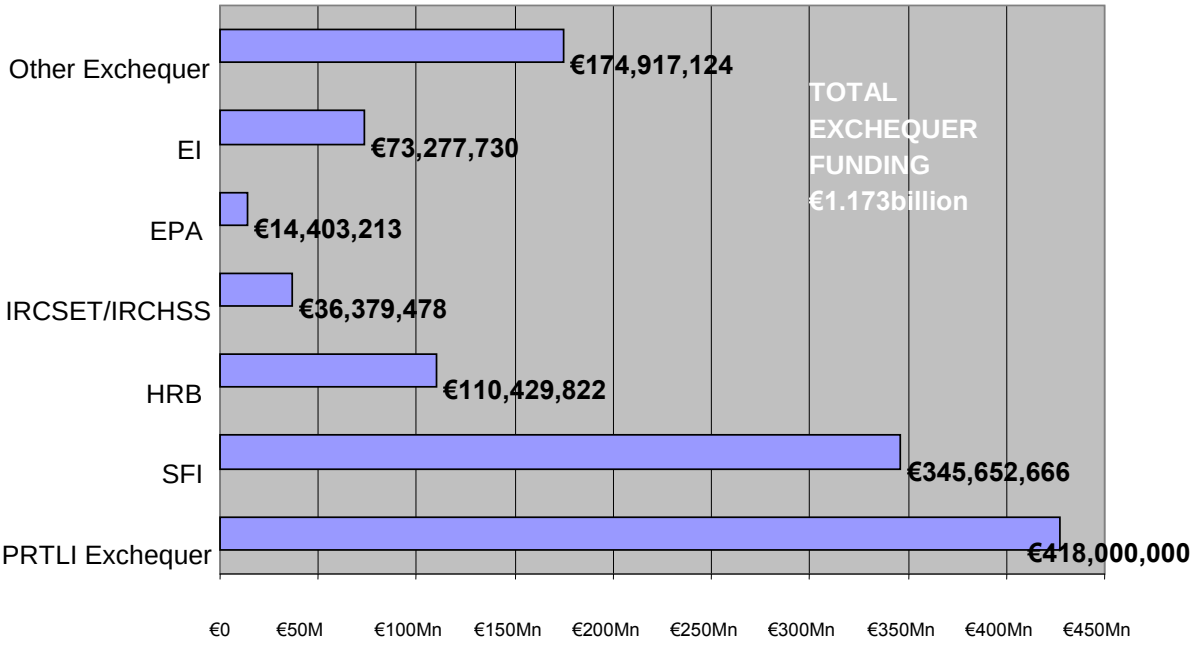
Figure 5.2: Funding Structure for Supported Centres and Initiatives since Initiation of PRTLI Investment



Source: PRTLI Funding from HEA Programme Data; Other Funding Data from Survey of PRTLI Supported Centres/Initiatives

The analysis presented in Figure 5.2 shows that non-exchequer sources contributed 28.8% of the overall funding of the centres and initiatives (€1.661bn). These injections of finance from enterprise, philanthropic and international sources into the Irish higher education system will be considered further when the impacts of PRTLI and other exchequer funding are assessed later in this report. Establishing the exchequer funding inputs into the development and operation of the centres and initiatives is however important at this stage and these total ***€1.173bn*** as shown in Figure 5.3.

Figure 5.3: Exchequer Inputs into Supported Centres and Initiatives since Initiation of PRTLI Investment

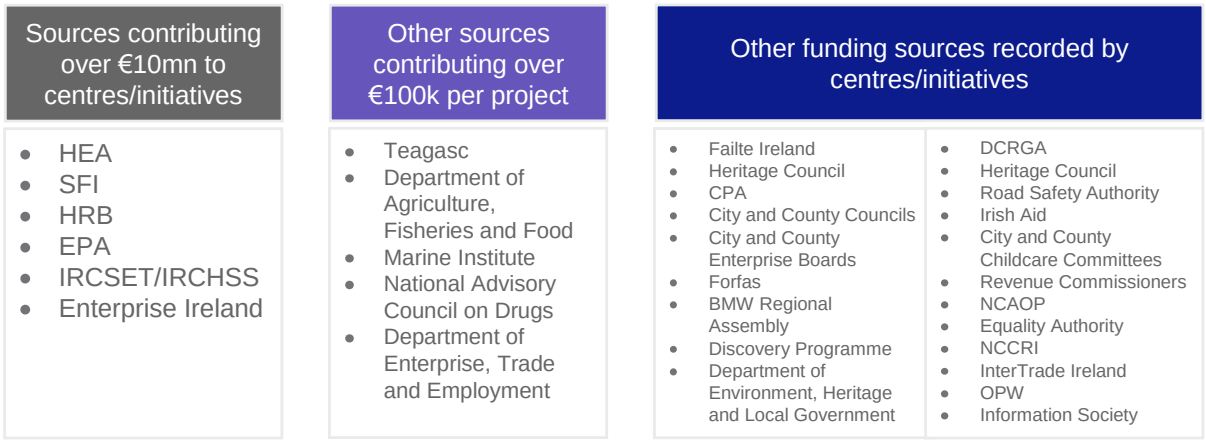


Source: Funding from HEA Programme Data; Other Funding Data from Survey of PRTLI Supported Centres/Initiatives

Consideration of resources such as those provided by SFI, the HRB, IRCHSS and IRCSET as inputs alongside PRTLI investment is essential to fully assess the impacts which resulted from work of the centres and initiatives. The programme facilitated the development of infrastructure and basic research capability which then provided a platform for the delivery of high quality research but without support interventions for the latter the eventual outcomes and impacts could not have been realised. The attraction of funding from these sources is, to some degree, a reflection of the success of the PRTLI investment. Unless capability had been effectively developed in this way the ability to attract funding for specific research activities on the basis of excellence would have been constrained. Likewise any EI funding attracted by a centre or initiative is an indication that it has produced research with commercialisation potential which could lead to the generation of commercial and economic impacts. Therefore although such funding involves additional exchequer finance and must be considered as a funding input, it should also be recognised that it shows that the centres and initiatives winning SFI, HRB, IRCHSS, IRCSET and EI funding were developing in the way envisaged and producing the desired research outcomes.

Other exchequer funding in the analysis in Figures 5.2 and 5.3 includes a range of different sources not listed separately and also public funding where disaggregation could not be provided by centres or initiatives. Typically the other sources involved government departments or agencies commissioning research which was of relevance to their specific area of remit. It included other sources of HEA assistance, such as via the North South Programme for Collaborative Research or the Strategic Investment Fund. In Figure 5.4 we identify the multitude of funding sources that supported the activities of centres and initiatives following the PRTLI investment, categorised in terms of the overall contribution recorded.

Figure 5.4: Exchequer Funding Sources for Centres and Initiatives



Source: Funding from HEA Programme Data; Other Funding Data from Survey of PRTLI Supported Centres/Initiatives

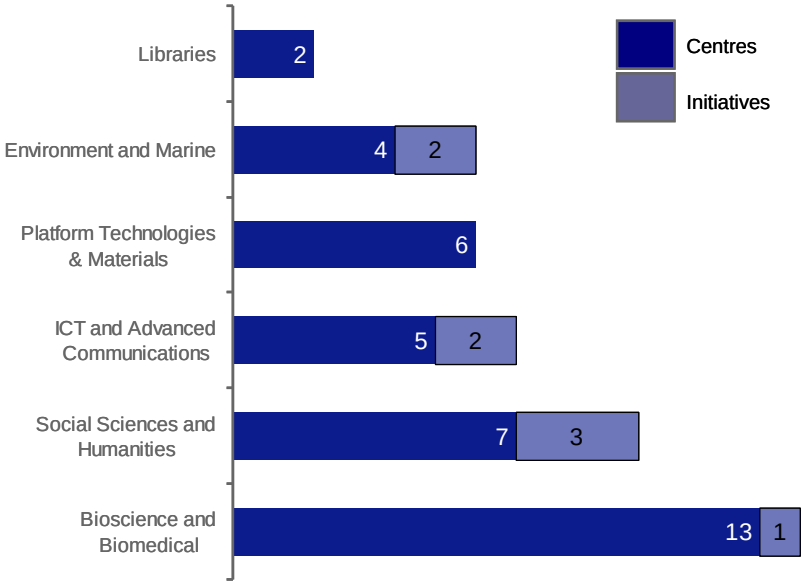
The many sources of exchequer research funding create a complex funding environment. The consultation undertaken revealed concern that the multiple interventions potentially constrain the efficiency and effectiveness of delivering on overall national research strategy. The need for a more coordinated approach was acknowledged by Government, enterprise and academic stakeholders.

5.2 The outputs of PRTLI supported centres and initiatives

With the funding inputs to centres and initiatives established, the analysis moves to the immediate, direct outputs delivered as a result of PRTLI investment. As we note in Chapter 4, the approach to research pre-PRTLI was quite individualised with a lack of facilities available to support collaborative working. The PRTLI provided significant capital investment to address this capital deficit, channelled

through 45 specific research centres or initiatives in Cycles 1 to 3 that reflected areas of institutional research strength or opportunity. The breakdown of supported centres and initiatives by focus of activity is shown in Figure 5.5. A summary of the focus of operations for each centre or initiative is also provided as Appendix F.

Figure 5.5: PRTLI Supported Centres and Initiatives by Focus of Research



Source: HEA Programme Data

Typically the PRTLI outputs involved building up a critical mass of infrastructure within these centres and initiatives that could facilitate the development of basic research capability (with current expenditure allocated to support initial activities in this regard). Four different types of capital investment were eligible as follows:

- Laboratories and associated facilities (including laboratory equipment) exclusively or largely for postgraduate research students and researchers in order to provide for new research programmes or to replace existing substandard facilities;
- Non-laboratory workspace exclusively or largely for humanities and social science postgraduate research students and researchers in order to provide for new research programmes or to replace existing substandard facilities;
- Library developments which will make a significant contribution to the research capabilities of both the institution and of the sector as a whole including the provision of storage space for library holdings, and/or student study space and/or high-tech learning resources, and/or improved reader services;
- Land or property purchases required for the above developments.

In supporting these types of interventions, the PRTLI aimed to create dedicated research space for specialist areas of expertise, equipped with state-of-the art equipment and facilities. A range of examples of the research infrastructure established in centres is provided in Figure 5.6.

Figure 5.6: Examples of Research Infrastructure Established via the PRTLI Assistance

Centre	Institution	Research Infrastructure Established from PRTLI Assistance
Institute of Neuroscience	TCD	The Lloyd Institute is situated near the Pearse Street entrance to Trinity college and is home to the Institute of Neuroscience. Currently, the Institute occupies 4 floors and houses both a 3T and 7T functional brain

		imaging machines (fMRI).
Ussher Library	TCD	The Ussher Library opened its doors in 2002, and is home to nearly 4.5 million items acquired from as far back as the 16th century and acquires on average 100,000 items into its collection annually. The facility itself is 9,586m^2 and links with two other pre-existing libraries, the Berkeley and Lecky libraries, that combined represent an additional 2,033 m^2 in space.
Moore Institute	NUIG	The Moore Institute for Research in the Humanities and Social Studies, was initially funded under cycle 2 of PRTLI in 2000. Besides creating a seminar room and office accommodation, the funding provided a building to house 10 postdoctoral and 18 postgraduate students.
Institute of Molecular Medicine (IMM)	TCD	Situated on the St. James' Hospital campus, the IMM was the first university research lab to be located on a hospital site in Ireland. It is now a 4,500m^2 state-of-the-art facility dedicated to the research into the molecular basis of human disease.
Boole Library	UCC	The Library consists of 15,000 m^2 of space which is designed to provide access to collections and services in support of learning, teaching and research. The renovated and extended building spans five floors and offers a range of reading and access environments, including both open access and consultation only access to collections. The Library houses an estimated 700,000 titles (of which approximately 200,000 are e-books), 3,151 periodicals in print, 60,000 e-journals and 70+ databases.
The Focas Institute	DIT	Prior to the Facility for Optical Characterisation and Spectroscopy, within the sciences, there was 500 m^2 of dedicated research and postgraduate accommodation with dated equipment and no dedicated technical or administrative support. After securing funding under cycle 1 of PRTLI, the facility amounts to 2,400 m^2 of floor space housing €1.9 million worth of equipment. It primarily houses postgraduate, postdoctoral and Research Centre Directors and staff.
National Centre for Sensor Research (NCSR)[14]	DCU	Located at the main entrance of Dublin City University, the NCSR is based in 3,200 sq. m. custom-designed buildings (within the Research and Engineering Building which it also shares with RINCE and NCPST) with clean-rooms, synthetic and biohazard facilities, application-specific project laboratories and support units. Within this infrastructure, NCSR maintains significant high-end instrumentation that facilitates a multidisciplinary approach to sensor development and commercialisation.

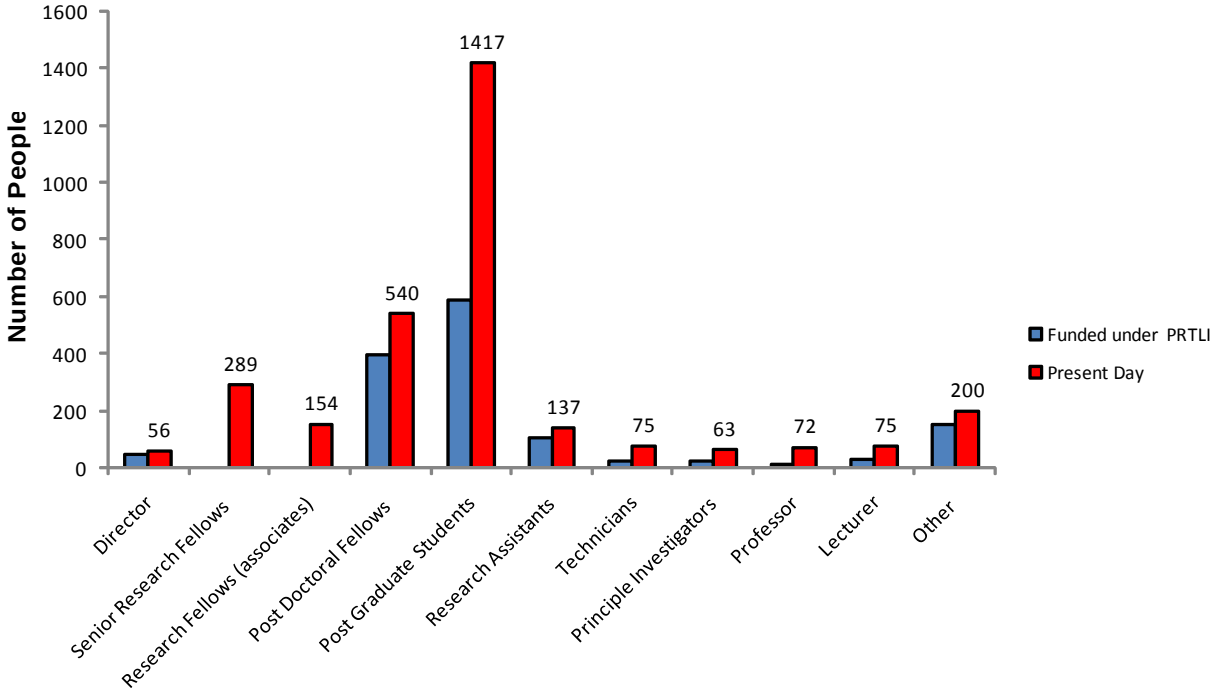
Source: Drawn from Centre Visits and Survey of PRTLI Supported Centres and Initiatives

Human capital resources formed the other core PRTLI output. While the infrastructure put in place facilitated the development of research capability, it was recognised that this could not be realised without the deployment of human capital. The PRTLI supported the costs of Principal Investigators, post-doctoral students, PhD students, research assistants and technicians within centres and initiatives.

In addition to directly funding these posts, the supported centres and initiatives brought together other academic staff that although attached to (and paid through) other schools and departments, devoted significant time to development and delivery of the research remit. Centre management and administrative resources and technical and business development support staff were also put in place to support the work of the centres and initiatives. In Figure 5.7, we present the levels of staff directly funded by Cycles 1-3 of the PRTLI across the centres and initiatives. This is then compared with the levels of staff that were employed to work within the same centres and initiatives at the time of the survey (August 2010), providing an indication of sustainability after initial programme assistance.

[14] See Case Study E1 in Appendix E

Figure 5.7: Staffing levels of the centres compared with staffing levels funded under PRTLI[15]



Source: Survey of PRTLI Supported Centres/Initiatives and Final Reports from the HEA

For all types of staff accounted for in the survey of PRTLI supported centres/initiatives, there has been an increase in staffing levels by a factor of 1.3 or greater. The most striking feature in the analysis is the increase in PhD students that are currently working within the centres, from 586 at the time of the final reports to 1,417, around 2.5 times original levels. This is in line with the significant increases in funding drawn from a wide range of other sources both during and after Cycles 1 to 3 of the PRTLI highlights an increased focus by the universities into growing their research capabilities. It underlines the interdependency of the programme with other research support interventions to create the critical mass which delivered research outcomes and impacts.

A further important output of the PRTLI investment was the establishment of collaborative partnerships. The level and nature of cooperation varied from case to case, but in general can be categorised into three distinct types:

- **Inter-departmental collaboration**. The PRTLI stimulated collaboration by departments that had no history of working together but where the centres or initiatives facilitated cooperation in new fields that required a more inter-disciplinary approach. For example, the Centre for Bioengineering in TCD involves bringing together scientists, engineers and clinicians to respond to cross-cutting issues that affect all three disciplines. The centre allows engineers to work with clinicians to design solutions to real patient problems with biologists providing insight into how particular materials and applications would respond to a particular environment.
- **Inter-institutional cooperation,** where particular areas of expertise are seen as complimentary and they work together to bring benefits for both parties. For example, in the Cosmogrid project led by the Dublin Institute of Advanced Studies (DIAS), computational resources; network services; grid resources and data management services were made available on a equitable basis to five

[15] Staffing levels are taken from final reports on completion of Cycles 1,2 and 3 funding periods in 2003, 2004 and 2006. The cycle(s) under which all centres/initiatives were funded is further detailed in Section 5.5.

other institutions, (DCU, NUIG, TCD, UCC and UCD) plus other partners; the Armagh Observatory, HEAnet and Met Éireann.

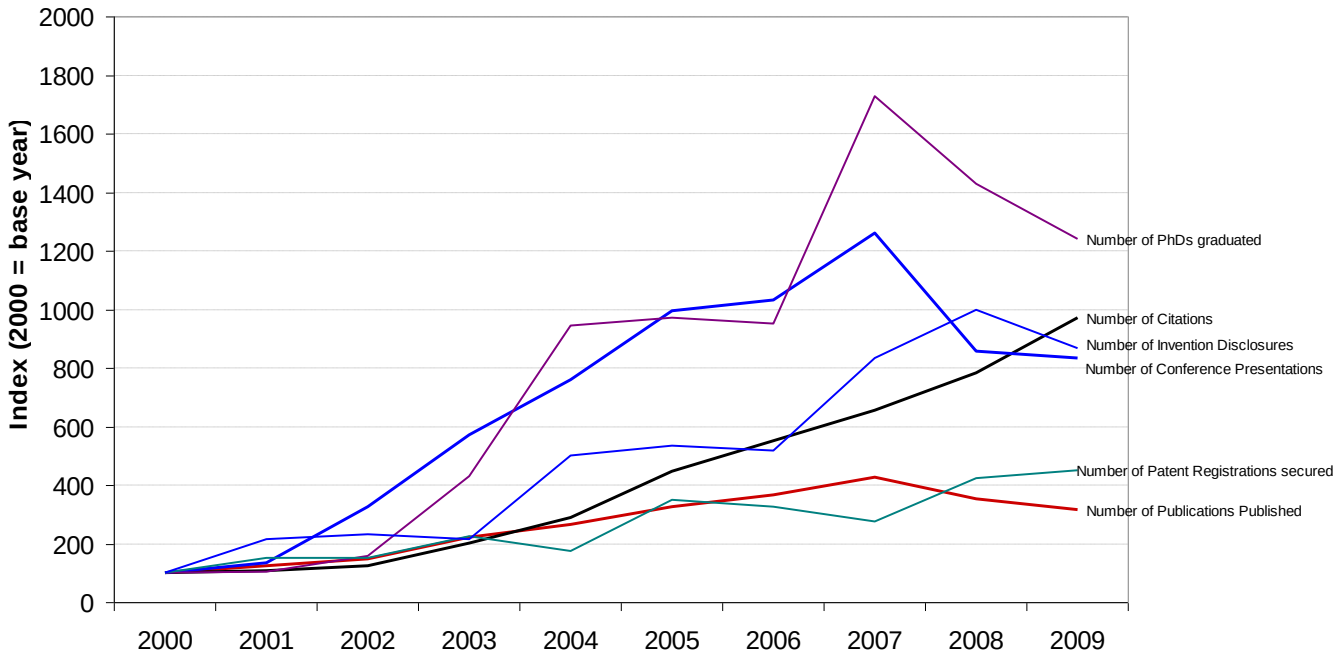
- **National cooperation structures:** The investment by the PRTLI has also led to the establishment of overarching collaborative structures to facilitate joint-working and delivery of focused research outcomes. The Dublin Molecular Medicine Centre (DMMC) was established as a separate body, independent of member universities, to support cooperation between TCD and UCD. Later RCSI joined DMMC and the collaboration was subsequently extended to take on a national remit that included all medical schools on across the country (TCD, UCD, RCSI, NUIG and UCC), with the initiative was re-branded as Molecular Medicine Ireland[16].

5.3 The outcomes in PRTLI supported centres and initiatives

Having analysed the immediate outputs from the PRTLI investment, the next stage in building the assessment framework involves looking at the research outcomes resulting from the programme outputs. This essentially means identifying whether there has been any discernible change in the research performance of centres and initiatives since the initial investment. This will demonstrate whether the PRTLI did provide a foundation from which research capability was built up within institutions by accessing other support interventions.

We begin the analysis by looking at a series of research outcome indicators over the period since the PRTLI was established. Setting 2000 as the base year (as this represents the first year of the PRTLI funding period), we consider how outcome levels have changed each year, using an index-based system to track the trends. This allows us to take into account the data from centres and initiatives that were only able to provide this for more recent years (avoiding skewing the analysis due to the unavailability of data in early years). This analysis is presented in Figure 5.8.

Figure 5.8: Change in Research Outcomes across PRTLI Supported Centres and Initiatives



Source: Survey of PRTLI Supported Centres/Initiatives

[16] See Case Study E2 in Appendix E

The analysis reveals a significant improvement in research performance between 2000 and 2009. Specifically, the centres and initiatives supported by the PRTLI:

- trebled the level of publications produced per annum, with the level of citations generated increasing almost ten-fold
- hosted 7 times the number of conferences, with conference presentations made by academic staff expanding to 8 times the level in 2000.
- produced an annual PhD graduate base of over 12 times the level in 2000.
- expanded the annual level of patent submissions by a factor of 5, patent registrations by a factor of 4.5 and inventions disclosures by a factor of 8.

While the overall change is impressive, there is a notable dip in research performance across some indicators in 2008 and 2009. This coincided with both an end to formal reporting requirements for Cycles 1 to 3 (which perhaps limited commitment to continued measurement at centre level) and the natural phase-down of research activities in centres or initiatives upon completion of PhD programmes, as other research priorities emerge. The downturn does however also reflect some concern about the sustainability of the research centres and initiatives. In the survey of centres and initiatives, 61% of respondents believed that they were not operating at their full potential and that future sustainability was an issue, with reasons cited including:

- Concerns at cuts in the funding available for research activity in higher education (and doubts over the extent of its future availability).
- Loss of research staff and an inability to replace such resources due to restrictions on recruitment in the wider institution.
- The need to renew and replace facilities and equipment in order to remain an attractive proposition to high quality researchers and the lack of funding available for this purpose.
- A lack of available resources to support non-researcher human resource costs for sustaining impact-focused research centres (e.g. centre management, administration, technicians, business development)

The growth in research outcomes around invention disclosures and patent registrations provide early indications of commercialisation success in the centres and initiatives. Our research has found that they provided a focus and critical mass that facilitated access to appropriate commercialisation support and technology transfer facilities. This has sown the seed for a significant base of collaborative initiatives with industry and the generation of a base of spin-out companies. The survey of the PRTLI centres and initiatives found that investment in these entities had resulted in:

- 44 spin-outs from the PRTLI supported centres/initiatives yielding commercial impacts for companies
- 113 industry research collaboration initiatives yielding commercial impacts

These outcomes can be linked to quantifiable commercial impacts and these are considered in further detail in Chapter 6. Good examples of how basic research capability developed in this way through the PRTLI and worked with dedicated applied research competency-based resources occurred in; the work of the Focas Institute and CREST at Dublin Institute of Technology (DIT) and of the Telecommunication Software and Systems Group (TSSG) at Waterford Institute of Technology (WIT)[17].

[17] See Case Study E3 in Appendix E

5.4 Additionality of the PRTLI assistance

In order to link this expansion in research outcomes to commercial and economic impacts, we must first be absolutely clear about its additionality, with a number of factors to consider in this process. The first task is establishing any ***deadweight*** in the PRTLI assistance, which refers to the extent to which the outcomes or impacts would have occurred in the absence of the funding inputs, the findings were strong. Of the centres and initiatives assessed, 76% believed that progress towards the research outcomes generated would either not have been made at all or could only have been achieved to a limited extent.

Displacement, in terms of any adverse impact on the take-up of other programmes, does not appear to be a factor for PRTLI Cycles 1-3 as there was no other alternative source of support for research infrastructure and basic capability development. The study has found some recognition that the ready availability of Irish Exchequer funding had decreased the need to pursue EU funding in the early years of the PRTLI and SFI programmes, but this is no longer the case and all centres seem to have a robust approach to identifying and applying for all available funding sources. There is little evidence of the ***crowding out*** of private sector funding of research as there was found to be a significant research capability deficit across the higher education sector when PRTLI was established (as set out in Chapter 4). Indeed our findings would suggest that PRTLI played a strong role in stimulating impacts around private sector investment in institutions. This finding is also supported by international evidence, which suggests private investment is not adversely impacted by public investment in R&D.

While the evidence of additionality in this regard is strong, the generation of data on inputs, outputs and outcomes from the supported centres and initiatives is reliant on its supply by these entities themselves. This is a necessity as the complex funding arrangements previously discussed in this report (where research is funded on the basis of initiatives, projects, infrastructure, individual researchers, etc) mean that it is only through the management and monitoring arrangements of the centres that oversee such activity that performance can be tracked and understood. However as recipients of the PRTLI assistance, there is a risk of some bias in the returns of the centres and initiatives in setting out the results from this investment. This was recognised in the development and the delivery of the methodology, with a strong focus on ***validation*** of the centre/initiative generated data. This was done firstly by consulting with the key funding agencies to confirm that the levels of non-PRTLI investment identified had flowed through the centres and initiatives in the scale and manner articulated. It was also achieved via a robust impact validation exercise with beneficiary organisations which had realised the commercial impacts from the work of assisted centres and initiatives.

However it was also important that feedback was obtained from those with a less positive perspective on the role of the PRTLI in delivering impact. During the course of the assessment we invited input from parties which had previously communicated levels of scepticism about the benefits of investment in R&D via the PRTLI and other support interventions. We also undertook in-depth consultations with senior management at institutional level and with a wide range of non-academic stakeholders to obtain more neutral overview on whether the assistance had been correctly deployed and on what would have developed without the significant funding inputs. This included discussion with parties which had been unsuccessful in securing PRTLI assistance during Cycles 1-3. The main criticisms which emerged from this process was that the PRTLI failed to identify the potential that existed in specific areas, and that as a result of the rejection of an application specialist research propositions did not subsequently emerge. There was, for example, particular concern in the way in which the programme supported research within Institutes of Technology, which was perceived as sporadic and failing to reward the progress which had been made by particular institutions in developing research capacity. There was also concern around the very general objectives which were set for institutions applying for PRTLI assistance and how this limited the ability to demonstrate expected outcomes and impacts from

the centre and initiative if successful. This latter point has been validated to some degree from the work in this assessment itself, where the lack of a clear idea of the anticipated outcomes and impacts has constrained the ability to measure the performance of the programme.

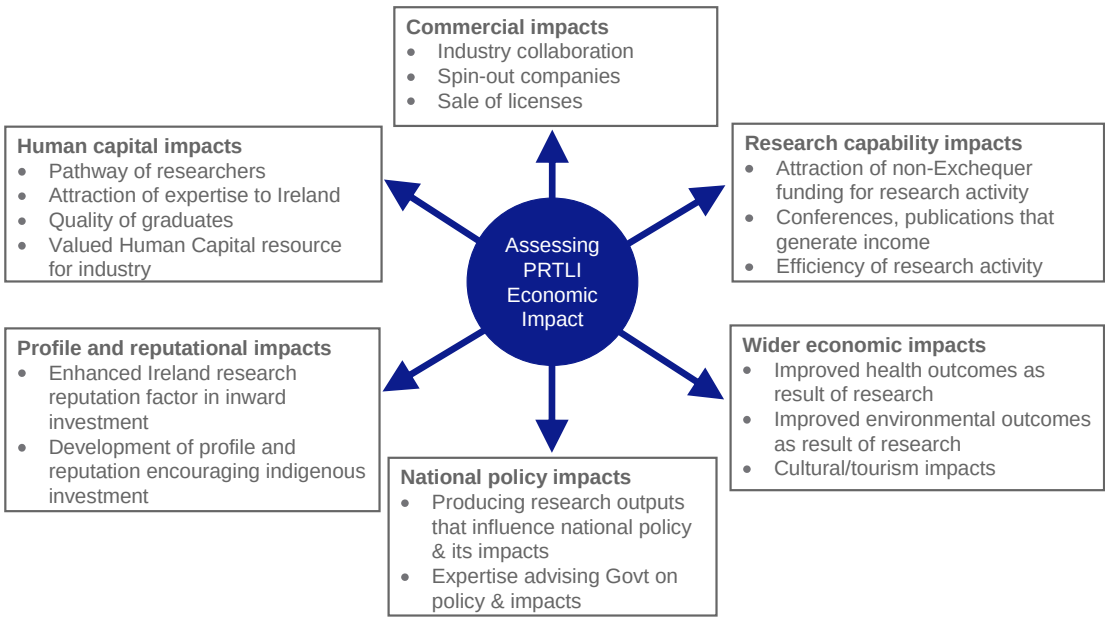
However while this qualitative feedback on the opportunity cost of investing in particular areas of research and particular institutions should be noted, it is also important to note that no examples were provided of where significant specialist research capability, with resultant economic impacts, had been generated in the absence of the PRTLI assistance. Indeed our wider analysis suggested that there was very little evidence of any deadweight from the deployment of the PRTLI support, which reinforced the findings from the centres and initiatives themselves as noted above. We would also conclude that we can find no example of significant research capability developed in Irish third level institutions which cannot be linked back in some way to the initial development of research specialisms via injection of the PRTLI assistance.

5.5 Linking to commercial and economic impacts

Throughout this chapter we have tracked how the initial investment in the PRTLI supported the development of a series of specialist research centres and initiatives that were then able to attract further funding inputs from other support interventions. The PRTLI assistance led to a series of outputs in new infrastructure, human capital resourcing and collaboration arrangements. This provided a platform for the development of research capability and generation of research outcomes, which have increased significantly over the period since the launch of the programme.

However, this progress alone does not justify the significant investment of the programmes. While the PRTLI was founded on academic objectives, the initiative was put in place with a long-term vision to make Ireland more internationally competitive in knowledge-intensive industries and safeguard future economic prosperity. Therefore it is only by linking the inputs, outputs and outcomes directly to commercial and economic impacts that a return on investment from the programme can be substantiated. From our extensive analysis of the PRTLI centres and initiatives, we believe that such impacts can essentially be grouped into 6 categories, as shown in Figure 5.9.

Figure 5.9: Impacts Emerging from the PRTLI



Of course, the realisation of these different types of impacts is highly dependent on the nature of the centre or initiative being supported. A centre based around humanities disciplines, for example, may not always be expected to generate commercial impacts in terms of spin-out companies or the sale of licenses derived from institutional IP that might prove feasible for one focused on science-related activities. However it can have an impact in developing institutional reputation and profile (and hence attracting international students or high profile conferences, for example). For centres working in the social science realm, the most feasible impact objective often lies around the ability to influence national policy and improve its efficiency and effectiveness. The one impact that should be consistent across all centres and initiatives lies in human capital development. The ability to attract thought leaders, develop research-led teaching approaches and deliver a pipeline of postgraduates with skills and expertise that could add value to the economy was a common goal and it is important to test the extent to which this has been realised.

In considering the success of the 45 centres and initiatives in generating impacts, it is therefore important to ensure a practical understanding exists of what each could achieve in the period since the initiation of PRTLI investment. In effect, there were only 30 centres and initiatives operating within the thematic areas which had significant potential for the commercialisation of their research (biosciences and biomedical; platform technologies and materials; and ICT and advanced communications). For the 14 centres or initiatives in social sciences, humanities, environment or marine related disciplines, securing commercial impacts was neither feasible nor any part of the reason for which investments were made in these areas. The distinctions between the types of impact which were realised by the centres and initiatives are reflected by the analysis in Figure 5.10. This provides our assessment of where impacts lie across the 6 thematic areas for centres and initiatives supported under Cycles 1-3.

The diagram in Figure 5.10 also indicates the stage at which the centres or initiatives were funded by the PRTLI. This is important as it allows consideration of the time period over which they have been operating. Those supported since Cycle 1 (and hence funded over the period 2000-2003) should, in theory, be further developed in terms of the expected research centre lifecycle than those which did not receive funding until Cycles 2 and 3[18]. Indeed it often took 2-3 years before infrastructure was put in place (particularly where new buildings were constructed) and this is only the beginning of an overall development process which typically characterises a research initiative of this kind. In Appendix H we set out our analysis of the lifecycle stages of a research centre based on the assessment of the PRTLI experience. Later in the report we also test whether the stage at which a centre or initiative was funded by the programme has been reflected in the extent to which it can generate impacts.

The final aspect of the analysis set out in Figure 5.10 and which also links to our analysis of the lifecycle of centres and initiatives is the current status of the centre. A dotted line from the last PRTLI cycle period under which each centre or initiative was funded represents the fact that it continues to operate in this form[19]. In any research centre landscape however, there should be a natural phase down of activity as the demand or opportunity within a particular research area declines. This has been the case for many of the initiatives, where distinct research programmes were financed around centres or schools but where research activity scaled down following the end of the funding period. However we also found a trend of centres evolving and merging into other entities with differing foci. For example:

- in NUIG, the Martin Ryan Institute recently merged with the Environmental Change Institute (ECI);

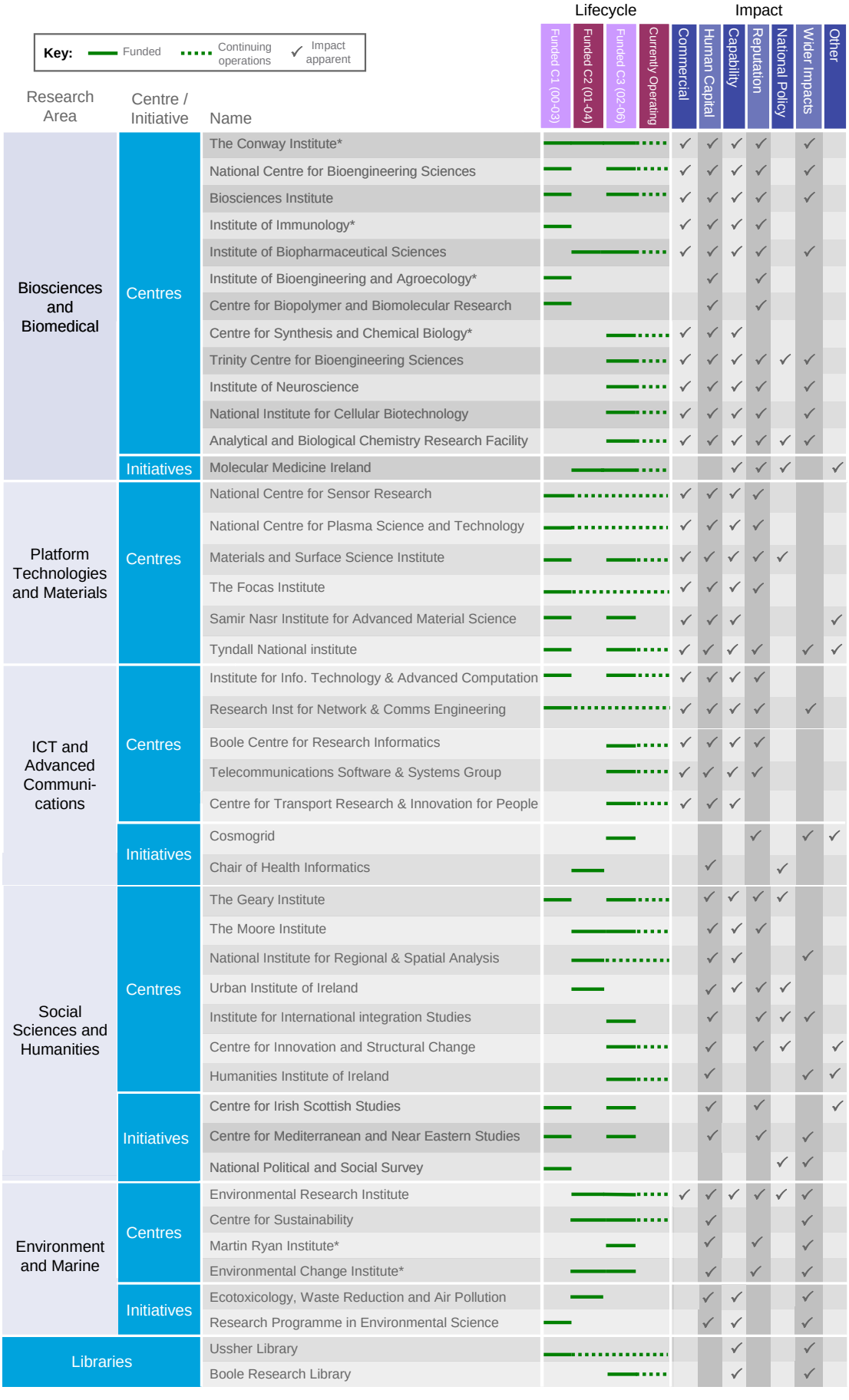
[18] Cycle 2 covers the funding period 2001-2004 and Cycle 3 covers the funding period 2002-2006.

[19] If the centre or initiative is not currently operating under the same name and parameters under which it received Cycle 1-3 funding no broken line is shown in the analysis, regardless of whether it received funding in subsequent PRTLI cycles.

- in UCD, the Urban Institute Ireland is becoming part of a new Earth Sciences Institute;
- in Athlone IT centre for Biopolymer and Biomolecular Research has been subsumed into the wider Biosciences Research Institute; and
- in TCD the work of the Samir Nasr Institute of Advanced Materials has been incorporated into the portfolio of the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN).

In the first two examples, the outcomes and impacts from these centres were considered as a collective, both in terms of a single survey return from their institution and in the follow-up impact validation work. This was also the approach for the Centre for Synthesis and Chemical Biology (CSCB) and the Conway Institute at UCD. All of these centres and initiatives are marked with an asterisk to denote the joint assessment approach.

Figure 5.10: Comparative Assessment of Impact Generation across Centres/Initiatives



6 Assessing commercial impacts in supported centres and initiatives

6.1 Commercial impacts in PRTLI supported centres and initiatives

We have noted that the PRTLI was initially allocated with explicit acknowledgement that there were unlikely to be short-term commercial impacts. However there was no doubt that the backdrop to the significant government investment was an aim to improve long-term international competitiveness in higher education and the wider economy and support future growth. A major test of its emerging success in this regard is the ability to stimulate private sector activity which can result in the generation of additional investment, revenue and associated jobs.

The definition of commercial impact in the context of this assessment is any value that can be attached to the research outcomes produced by a centre or initiative by a trading business. For the PRTLI supported centres and initiatives, this impact has been realised in many forms including where:

- Intellectual property generated by a centre or initiative has resulted in a spin-out company being established by the institution, which then generates turnover and employment.
- Intellectual property generated by a centre or initiative has led to the sale of a license by the institution to a third party and investment by that party in commercialising the research.
- A third party supports the research activity of a centre or initiative as a result of the perceived value that it will receive from the product of this activity.
- Research undertaken leads to efficiencies in the operations of a third party and generates cost savings and improved profitability.
- Development of research infrastructure or research capability has a direct impact on a company's initial decision to invest in a location or in continuing to invest in a location, subsequently generating revenue and employment from the business.

There are of course challenges in the attribution of these types of impacts to the PRTLI supported centres and initiatives. As an intervention principally focused on basic research capability, the PRTLI was dependent on progression of subsequent research, the application of this research and subsequent product and process development before any commercial value could be realised. This puts the initial intervention at a considerable distance from ultimate realisation of commercial impacts and there is an inevitable time lag before these can be attained. This also makes the tracking of such relationships more complex and there must be strong evidence on the links between each step.

Despite such complexity, and acknowledging the limitations of ex-post studies of impacts in this way, the assessment has nonetheless been able to track the generation of commercial impacts from the

development of the supported centres and initiatives. As set out in Figure 6.1, this includes direct commercial investment in centres or initiatives, generation of new commercial revenue as a result of research activity, and realisation of efficiency savings as a product of research.

Figure 6.1: Examples of Commercial Impacts Resulting from Supported Centres and Initiatives[20]

Centre/ Initiative and Commercial Beneficiary	Impact Generated
Direct Commercial Investment in Centres and Initiatives	
National Centre for Plasma Science & Technology (NCPST) - Intel, IBM, Lam Research Corporation	This has helped to generate private sector investment of over €15million. The centre depends on highly expensive equipment with relatively short lifecycles to function effectively. This has involved multi-million euro investments from these partners and includes: a Plasma Processing Facility donated by Intel; advanced plasma processing equipment provided by the Lam Research Corporation; and a laser etching device and excimer donated by IBM
Commercial Revenue Generation	
Material Surface Science Institute (MSSI) - HKPB Scientific	HKPB Scientific is an innovative R&D company with a number of patented technology platforms that service the medical device industry. The company was incorporated in 2008 from work by the MSSI to develop and commercialise a new process technology for making calcium phosphate biomaterials, compounds used extensively in orthopaedic medicine. The company closed a €500K investment in March with Tolisons Private Equity and joined forces with David O'Flynn, a successful entrepreneur who joined the company as CFO. HKPB currently employs 4 people full time and 4 part-time but has ambitious plans for the future, intending to ramp its manufacturing operation to a company employing 20 people by the end of 2011. The medical device industry is a multi-billion dollar global market with strong growth rates projected into the foreseeable future.
Trinity Centre for Bioengineering Science – Opsona Therapeutics	The research of Professors Luke O'Neill and Kingston Mills (funded by SFI) in the Trinity Centre for Bioengineering Science resulted in formation of a company called Opsona Therapeutics to commercialise the benefits of the IP. Opsona Therapeutics is a drug development company which focuses on novel therapeutics and preventive approaches to autoimmune and inflammatory diseases such as rheumatoid arthritis and is considered to be one of the most exciting companies in the bioscience area. Having initially secured financing from Enterprise Ireland, Opsona then secured €8 million in Venture Capital funding. Then in May 2009 they announced the latest round of financial investment in their clinical trials which raised them in excess of €21 million and involves significant investment from Roche, Novartis Fund, Fountain Healthcare Partners and Enterprise Ireland.
National Institute for Cellular Biotechnology (NICB) – Beemune	Beemune, an Irish spin out company, was formed on the basis of research conducted by Dr. Kevin Kavanagh who was funded under Cycle 3 of PRTLI. The research successfully discovered a method by which he could increase or decrease the immune system of a moth caterpillar. This solution was applied to bees as a way of combating CCD and safeguarding the health and well being of bees. Beemune has begun to work with market resellers to trial the solution and anticipate significant future commercial revenues.
Realisation of Efficiency Savings	
Analytical & Biological Chemistry Research Facility (ABCRF) - Pfizer	Pfizer Ireland competed with two primary locations where the drugs had been developed to carry out large-scale manufacturing of the drugs. It would obviously have been easier for a research chemist to transfer his chemistry to an engineer located in the same city than to a location several thousand miles away so Ireland clearly had a disadvantage over the other two competitors. However, Pfizer Ireland was successful in becoming the nominated site for manufacture of new products. Following scale-up of the manufacturing, the focus was on

[20] More detailed discussion of the examples in this table are provided as Case Studies E.4 to E.8 in Appendix E.

	the chemistry of the processes to make the processes less expensive and more efficient. Pfizer worked with the ABCRF to improve the chemistry, by reducing some processes from 43 hours to run on plant to 2 hours with associated cost efficiency savings. These savings also allowed Pfizer to free up plant equipment to allow production of more products.
National Centre for Sensor Research (NCSR) - Agilent Technologies	Agilent approached the NCSR with several pioneering technologies that they felt would need market validation. After the initial engagement, where the NCSR helped Agilent identify the viability of one of its new technologies, the partnership flourished with the NCSR now assisting Agilent Technologies validate their new products. This has resulted in considerable savings for Agilent and a trustworthy partner to assist them in their market validation.
National Centre for Biomedical Engineering Science (NCBES) - Smith & Nephew	Dr. Frank Barry, a world leading researcher in the area of stem cell research and director of the National Centre for Bioengineering Science in Galway, entered into collaboration with Smith & Nephew to develop a new ground breaking product. The collaborative effort was funded through the IDA but only after a short period of time, after much research by Frank Barry and his team, they realised that the commercial development of the product was not achievable given the current levels of technology available to them. Although the product had and still has much potential, exploring the development of this product without the validation of Dr. Frank Barry could have cost Smith & Nephew significantly.

6.2 Quantifying the commercial impacts

In Chapter 5, we detailed the outcomes recorded by centres and initiatives in terms of collaborating with industry and generating spin-out enterprises. The information gathered in relation to these outcomes provided us with an understanding of the potential commercial impacts generated from the work of the centres and initiatives supported by the PRTLI under Cycles 1 to 3. This was used as the foundation for a robust impact validation exercise where we have attempted to contact companies and other relevant organisations in order to confirm and quantify the commercial impacts that have arisen or are expected to arise. In all, 50 consultations were undertaken as part of this process, with key principles in recording an 'impact' involving:

- ***Confirming*** with the centre or initiative that without the PRTLI investment, such spin-out activity or industry collaboration would not have progressed and would not have realised the tangible research outcomes.
- ***Quantifying*** the value of the collaboration to the private sector enterprise, either in the form of the investment made into a project, the resultant increases in turnover or the commercial quantification of other costs such as efficiency savings made.
- ***Validating*** the quantification of the impact either by direct confirmation by the private sector enterprise which has been spun out or was involved in the collaboration, by examination of company accounts or by a published and verifiable third party source (e.g. programme documentation, promotional material with company citations, financial reports).

In Appendix B of this report we provide the questionnaire which was used in the consultations with companies to confirm, quantify and validate impacts as far as possible. Specific questions were asked about any increases in turnover, investment, efficiency savings or employment that could be ***directly attributed to the work of a PRTLI supported centre or initiative***. The consultations also probed for any future impacts that were expected to arise in the future as a result of the work of a centre or initiative (within the parameter of a 5 year future timeframe). In this way we were able to build up a database of commercial impacts which have been generated as a result of the programme. The contacts, companies and organisations that were consulted as part of this impact validation exercise are listed as Appendix C. A list of companies where impacts were identified is provided in Appendix G. The results from the impact validation exercise are presented in Figure 6.2.

Figure 6.2: Commercial Impacts from the PRTLI Supported Centres and Initiatives

Type of Enterprise	Spin-Outs	Established Companies	Total
No of company impacts identified	44	113	157
Number of company impacts in terms of commercial turnover, investment or savings identified	24	26	50
Estimated commercial impact in terms of commercial turnover, investment or savings identified	€99.6million	€654.1million	€753.7million
Estimated employment impact resulting from the research undertaken by PRTLI supported centres and initiatives	192 jobs	1,063 jobs	1,255 jobs
Number of companies where future impact in terms of commercial turnover, investment or savings is projected	12	19	31
Estimated future impact (next 5 years) resulting from the research undertaken by PRTLI supported centres and initiatives	€96.3million	€1.012billion	€1.108billion

Source: PA Consulting Impact Validation Exercise

The commercial impacts measured in terms of additional turnover, investment or cost savings totalled ***€753.7mn***. This is in addition to the investment secured from industry to support institutional research, where we found a total contribution of **€79mn**. The impact validation exercise was also able to link the creation of ***1,255 jobs*** to the research undertaken in supported centres and initiatives. However it is important to note that this figure only refers to cases where a distinct number of jobs could be identified and does not attempt to allocate additional employment impacts on a pro rata basis in line with the total commercial impacts. It also does not consider the issue of job retention due to difficulties in measuring such an indicator, but feedback from companies does suggest that the successful progression of research projects has played a part in continuing existing operational levels

It was notable that there was a 'ramping up' of commercial impacts over time, with the most significant being realised in the last 2-3 years. This is consistent with the lead-in time to successfully complete the major PRTLI infrastructure projects, with many centres not fully operational within their new facilities until 2003/04. The subsequent development of research capability and reputation and the progression of research projects and activities that followed meant that there was a natural lag before impacts were realised. This is also reflected in the significant potential future impacts which were identified by industry. These potential future impacts are more difficult to estimate, with realisation of projected future income streams dependent on numerous variables. A number of pharmaceutical companies, for example, emphasised the significant potential for commercial impacts if the infrastructure and capability to conduct major clinical trials can be put in place. From the information gathered from private sector companies, we estimate potential future commercial impacts of €1.108billion over the next 5 years.

This analysis refers only to impacts where quantification was possible. Where enterprises found it difficult to identify tangible value from such collaboration, there remained acknowledgement that the general upping of research capability will be a key determinant of the future economic success of the state and a key asset of Irish business.

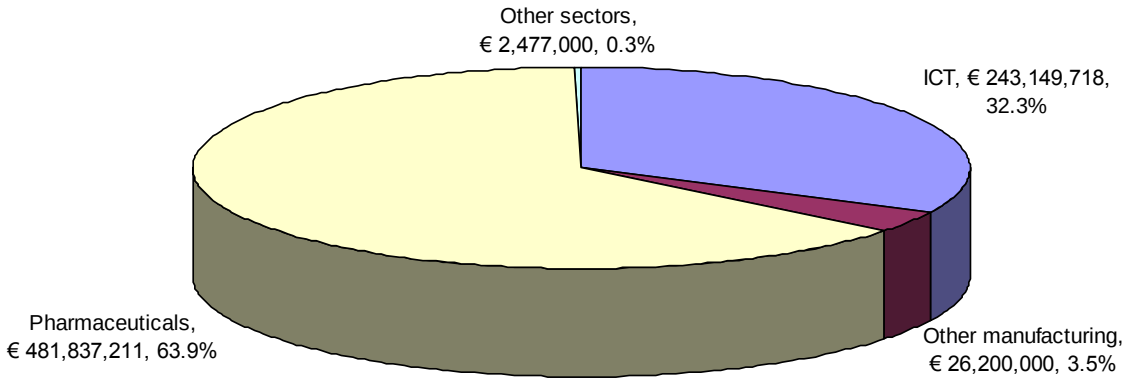
The impact validation exercise also revealed issues which have constrained the ability to realise commercial impacts from the research of supported centres and initiatives. From an industry perspective, there is concern at how negotiations and delays over IP rights hinder a process where timeliness is critical to success and establish a clearer and more user-friendly means of addressing IP issues could facilitate further license sales and other collaborative ventures. There also appear to be

wider issues around the rigidity of the technology transfer process. Many of the successful industry collaborations identified were dependent on initial contact and development work between academic scientist and industrial scientist, and there was feedback that having a separate function as the external face of the University in engaging with industry diluted the ability for such relationships to become established and prosper.

6.3 Areas of research and their link to commercial impacts

Analysis of the sectors of activity where the commercial value of research undertaken by the PRTLI supported centres was realised shows that the pharmaceuticals industry (consisting of drug manufacturing and medical technologies) dominated. As Figure 6.3 demonstrates, enterprises within this sector accounted for just under two-thirds of the total impacts that were validated. Enterprises involved in ICT-related activities accounted for just over 30% of the impacts, with other manufacturing and other sectors responsible for the remaining 4%.

Figure 6.3: Commercial Impacts Realised by Sector



While the commercial impacts were heavily concentrated in companies operating in the pharmaceuticals space, these did not spawn solely from bioscience and biomedical centres and initiatives. Indeed there were many examples of these companies working with centres involved in platform technologies and materials to improve their manufacturing performance.

Inevitably, when we look at the relative success of the centres and initiatives with regard to commercial impacts, the greatest potential lies within the science based disciplines. For the PRTLI these are the centres and initiatives that were funded around bioscience and biomedical; ICT; and platform technologies and materials. In considering performance across the supported centres and initiatives it was found:

- **Overall Funding:** The Tyndall and Conway Institutes have had access to by far the largest overall budgets across the supported centres and initiatives with both recording income of over €150mn since initial PRTLI investment. The Institute of Biopharmaceutical Sciences the third largest in scale with a budget of over €100mn. Other centres and initiatives with an overall funding budget of over €50mn include the Institute of Neuroscience, MSSI, and the NCPST.
- **Non-Exchequer Funding:** The Tyndall Institute, Institute of Neuroscience, Institute of Biopharmaceutical Sciences, NCPST and TSSG have all been able to generate over €20million of non-Exchequer funding to support ongoing research operations. The next 5 most successful centres and initiatives were the Conway Institute, MSSI, Institute of Immunology, the Environmental Research Institute and the Urban Institute Ireland.
- **Direct Industry Investment:** There are clear tiers emerging in terms of the ability of centres to attract this industry investment. There is a gap between the 3 'leading' centres in this regard (Tyndall Institute, Institute of Neuroscience and NCPST), all of whom have generated over

€10million each in industry contributions. There is then a group of 11 centres attracting investment of between €1mn and €5mn (ABCRF, Conway Institute, Institute of Immunology, Martin Ryan Institute, Geary Institute, MSSI, IIIS, Focas Institute, Institute of Biopharmaceutical Sciences, Environmental Research Institute, Urban Institute of Ireland). Other industry investment is on a much smaller scale and scattered across the remainder of the centres or initiatives.

- **Generation of Commercial Impacts:** A pattern also emerged in relation to the centres and initiatives to which ultimate commercial impacts could be attributed. It was found that ABCRF at UCC, NCSR at DCU, NCBES at NUIG, Tyndall at UCC and the TCD Institute for Molecular Medicine generated the greatest levels of validated commercial impacts from their research (with over €30mn validated in each case). Impacts of between €10mn and €20mn were validated for Institute of Immunology, National Institute for Cellular Biotechnology (NICB), the Institute of Neuroscience and the MSSI. While these figures can of course be skewed by major single investment decisions, there did seem to be commonality in the commitment to working with enterprise across these centres, with the centre visits revealing an 'account management' approach to maintaining engagement with industrial partners.
- **Potential Future Commercial Impacts:** Although heavily interdependent with numerous business and market variables, an estimate was made of where commercial impacts could be realised over the next 5 years. The greatest potential impacts were found in research originating from ABCRF, Focas Institute, MSSI, NCSR, NCBES, Samr Nasr Institute of Advanced Materials and the NICB. All of these centres and initiatives had a potential commercial impact estimate of over €60mn.
- **Reasons for Lack of Success:** The centres and initiatives where performance was more disappointing tended to suffer from the lack of a market-relevant specialised focus. A wide and quite generic approach to research within a broad area such as the environment, health or constrained their ability to build an identity with, and attract interest from, commercial partners.

Of course, it is important to note that not all centres and initiatives were able to target these commercial impacts or lever investment for industry. We noted in section 5.4 that their ability to generate different types of impact was directly related to the nature of their activities. Those based around social science, humanities or environmentally focused disciplines had greater potential to generate policy-related or wider economic impacts. However it was unrealistic to expect these centres and initiatives to realise commercial impacts and indeed to recognise that they were not funded on this basis. When we look again at the commercial impacts measured above, we find that 99.9% (relate to the work of centres and initiatives in the thematic areas of bioscience and biomedical; platform technologies; and ICT and advanced materials.

The short table in Figure 6.4 summarises the Exchequer funding inputs and commercial impact return for two categories of centre/initiative: those with commercialisation potential (i.e. operating within these 3 thematic areas) and those with a focus on wider impacts. This provides a more accurate portrayal of the 'return' from the commercial impacts generated. The ability of the centres and initiatives in the second category to deliver these wider impacts will determine their relative success (rather than the ability to generate commercial impacts which were never expected nor feasible). While this report has focused firstly on commercial and human capital impacts from the centres and initiatives, these wider impacts will be further considered in Chapter 7.

Figure 6.4: Funding Inputs and Impacts of Centres/Initiatives by Thematic Areas

Type of Centre/Initiative	PRTLI Exchqr Invt	% total invt	Other Exchqr	% total invt	Commer-cial impacts	% total impact
Centres/Initiatives in Areas with Significant Commercialisation Potential						
Bioscience and Biomedical	224.2	53%	€366.5mn	48%	€468.5mn	62%

Platform Technologies & Materials	40.1	9%	€252.7mn	33%	€267.8mn	36%
ICT and Advanced Communications	31.4	7%	€37.2mn	5%	€16.3mn	2%
Centres/Initiatives in Areas with Limited Commercialisation Potential						
Environment and Marine	67.6	16%	€42.6mn	6%	€357,000	0%
Social Sciences and Humanities	63.4	15%	€56.0mn	7%	€600,000	0%[21]
TOTAL	**€426.7mn**	**100%**	**€755.1mn**	**100%**	**€753.7mn**	**100%**

In effect, Figure 6.4 reveals that the total Exchequer investment flowing through centres and initiatives with commercial potential was €952mn. This investment has helped to yield commercial impacts from the research produced by these centres of €749mn.

The analysis also reinforces the point raised earlier in this section that while the ICT industry stimulated a significant proportion of the commercial impacts measured, its companies actually tended to work more with centres or initiatives in bioscience and biomedical or platform technologies and materials disciplines rather than those with a pure ICT and advanced communications focus.

In addition to the clear distinctions in the commercial performance of centres and initiatives in relation to their respective areas of focus, there also appears to be some relationship between the maturity of such operations and the resultant impacts. In Section 5.5 of the report we discussed the points at which the centres and initiatives were funded by the PRTLI and how this related to wider lifecycle stages of development. Those with commercialisation potential which were established under Cycle 1 of the PRTLI and which have therefore had a greater window in which to progress have tended to be most successful in generating these types of impact. NCSR, NCBES and the Tyndall Institute all received support under the first cycle, and while the ABCRF only received specific assistance in Cycle 3, it nonetheless benefited from the earlier funding for the wider Biosciences Institute in UCC. For the next 'tier' of impact generating centres and initiatives, the Institute of Immunology, NICB and the MSSI were all funded under Cycle 1.

While not an area of research per se, one aspect of performance in commercial impact generation which was identified as a gap was the ability to engage with smaller, domestic-based companies with innovation potential. With a few exceptions, indigenous companies, particularly SMEs, have struggled to realise any significant dividends from working in partnership with centres and initiatives. This is in part a consequence of the focus of the centres and initiatives on basic research in areas of more relevance to the larger multi-national corporations (particularly bioscience and biomedical). It is also perhaps a reflection that these centres and initiatives, particularly those based in the universities, are not sufficiently geared up to facilitating smaller applied research projects which are of most benefit to the SME sector. Finding a more effective means of linking higher education research and the SME sector needs to be a key focus moving forward, with the development of the responsiveness of university research centres and initiatives to meeting such needs an immediate priority. Closer links and an applied research 'broker' role by the Institutes of Technology may be one option worth considering in this regard, taking advantage of their existing links and more localised approach. Other national developments such as the Enterprise Ireland Competence Centre initiative should also assist.

[21] The impacts from the latter 2 categories represent just over 0.1% of the total measured but are shown as 0% due to rounding.

6.4 Attraction and retention of inward investment

One thing which is clear from the analysis of commercial impacts is that there is a significant reliance on multi-national enterprises for private sector investment in centre and initiative research. It was a clear finding of the assessment, borne out by quantitative analysis of impacts and almost universally endorsed by industry and other stakeholders that the development of research capability has, and will continue to have, a significant impact on the attraction and retention of inward investment. It was found that 82% of the commercial impacts generated can be attributed to inward and continued investment by multi-national corporations. However while these direct benefits were measured as a result of the work of individual supported centres and initiatives, it is also important that the wider impacts in stimulating FDI that derive from the development of a strong research system are not overlooked.

IDA Ireland, the state agency responsible for attracting inward investment, confirmed a complete turnaround in Ireland's research reputation since the inception of the PRTLI and introduction of other key research support interventions. The research infrastructure put in place and specific expertise developed around biopharmaceuticals and ICT are key sales messages deployed in marketing Ireland as a location to potential inward investors and for continued investment by existing clients. Indeed research, development and innovation capability is considered to be one of the three critical success factors in attracting such investment (alongside the taxation regime and the skills available). Combining two of these factors, the R&D tax credit available to companies in Ireland was cited as a key competitive advantage in winning new investment. An indication of how enhanced research capability in the higher education sector is becoming more relevant to investment decisions is the increasing use of research centres and initiatives in the 'pitch' to companies. IDA Ireland has also brought potential investors directly to centres including the Conway Institute, Tyndall and MSSI to demonstrate the expertise that exists in this regard.

The extent to which attraction and retention of inward investment is inter-linked with enhanced research capability is evidenced by the fact that over €500mn has been invested in research, development and innovation by IDA client companies in each of the years 2009 and 2010[22]. This represented around 50% of total multi-national investment, a proportion which had been increasing steadily since 2004, when it was less than 10%. Examples of multi-national companies that have contributed to this investment are listed in Case Study E.15 in Appendix E.

The development of such an expanding portfolio of investment projects in research, development and innovation is indicative of the fact that despite the economic downturn, Ireland remains highly successful in its ability to attract and retain foreign investment. IBM's 2010 Global Locations report ranks it 1st in the world in terms of inward investment per capita. The same report confirmed the importance of RDI related investment in this regard, with Ireland ranked 9th in the global world rankings for investment in jobs of this kind[23]

Our previous analysis of the scale of impacts from centres and initiatives realised within the pharmaceuticals sector made clear the value and importance of investment (and continued investment) in research infrastructure. This sector is highly important to the Irish economy, with 8 out its largest 10 multi-national corporations having a base here. Pharmachemical Ireland, the industry representative body, holds the view that unless investment in research infrastructure continues and Ireland moves higher up the value chain, it will be increasingly difficult for Ireland to make a case as a location for new and continued investment decisions. This position is made clear within the Pharmachemical Ireland strategy statement, 'Innovation and Excellence', where it is stated

[22] 'IDA Ireland End of Year Statement 2010', IDA Ireland, December 2010

[23] 'Global Location Trends Annual Report 2010', IBM Global Business Services, October 2010

"Companies need to be encouraged to invest in innovation. Ireland not only needs to continue its investment in R&D infrastructure, but also needs to expand this to include the processes that take place between research and manufacturing. This includes process design and development as well as product optimisation – taking the product from the clinic or design laboratory to the market. Seamless transition from R&D to manufacturing is a key step in ensuring the sector's future. This will enable the country to develop its existing manufacturing base.[24]" While this stated need may be viewed from a lobbying perspective, the impact validation exercise with multi-national companies confirmed the importance of ongoing development of research capability to securing continued investment decisions. There was also consistent feedback that if the research capability in Ireland had not developed significantly from the position set out in the base case, there would be serious threat to current operations. A good example of how inward investment has been stimulated by the work of a centre is the partnership between IBM and the NCSR. The research undertaken led to an IBM investment decision to establish their Centre for Excellence in Water Management in Ireland. This has been an incredibly successful venture for IBM and the initiative led to further investment by the company to create their first Smarter Cities Technology Centre in Dublin which looks to help cities around the world better understand, interconnect and manage their core operational systems.

[24] 'Innovation and Excellence: Pharmachemical Ireland Strategic Plan', IBEC, 2010

7 Assessing other economic impacts in supported centres and initiatives

7.1 Assessing impacts in development of human capital

A core benefit from the PRTLI was expected to lie in the development of human capital, both in terms of the jobs supported by higher education research activity and in the skills and expertise that would become available to other employers. In this section we examine how the centres and initiatives supported under Cycles 1-3 contributed to the development of the Irish human capital research base, the generation of a skills pipeline and expertise within institutions.

7.1.1 Development of the human capital research base

Both the Circa Group report[25] in 1996 and the OECD Review of Higher Education[26] in 2004 had recommended significant expansion in the base of human capital deployed in research. The latter report proposed a doubling of the PhD output. This commitment was formalised within the Strategy for Science Technology and Innovation 2006 – 2013[27] which targeted a doubling of PhD graduates by 2013 (to 1,312).

The PRTLI contribution to human resource development included facilitation of the direct deployment of post-doctorate researchers and PhD students within centres and initiatives and of centre managers, technicians, administrators and other key facilitating functions. It also provided a means by which Principal Investigators and other senior researchers could focus research activity on clear outcomes (by providing space and facilities for these staff to come together and setting a thematic research agenda to which they would all work collectively). As analysis in Chapter 5 confirmed, this deployment of human resources via the centres and initiatives has been sustained and built upon, with a research staff base of 2.5 times the levels following draw down of PRTLI funds under Cycles 1-3. Both academic and non-academic stakeholders consulted during the exercise confirmed that this research base had developed from a situation pre-PRTLI where there were much lower levels of activity and

[25] 'A Comparative International Assessment of the Organisation, Management and Funding of University Research in Ireland and Europe'. Circa Group Europe, December 1996

[26] 'Review of National Policies for Education: Review of Higher Education in Ireland: Examiners' Report', Directorate of Education, OECD, September 2004

[27] 'Strategy for Science, technology and Innovation 2006-2013', Department of Enterprise, Trade and Employment, June 2006

where the largely individualised approach to research meant that research productivity was constrained.

The PRTLI therefore, in tandem with the many other research support interventions discussed in this report, has played an important role in building the overall research human capital base in Ireland. In the pre-PRTLI base case a lag behind comparator countries was identified in terms of the number of higher education researchers relative to the labour force (per 1,000 FTEs). If we consider how this indicator has changed in the intervening period we find[28]:

- In 1992 the number of higher education researchers per 1,000 FTEs in Ireland was 1.4, lagging behind Denmark, France, Germany, the Netherlands and Spain.
- In 1998 the relative research base had risen only slightly to 1.5, but the Irish level remained well below that of these other states.
- In 2008 the number of researchers per 1,000 FTEs had risen to 5.2, only slightly below Denmark (5.6) but on a par with Spain and well above the levels of Germany, the Netherlands and France.

This represents significant change since the introduction of the PRTLI (and of other support interventions such as the SFI, the HRB and Research Councils). The total research base working in the higher education sector was recorded at 6,174 FTEs in 2008, in comparison to only 1,886 FTEs in 1992 and 2,425 FTEs in 1998.

7.1.2 Development of a skills pipeline

There is a strong support for the view that skills levels have been raised by the increasing focus on postgraduate study and post-doctorate activity in Ireland across the enterprise, government and academic stakeholders consulted during the assignment. PhD outcomes have grown significantly in recent years and the centres and initiatives. Between 2005 and 2008 the supported centres and initiatives made a contribution of 20%-30% of the overall total PhD graduate base in Ireland.

Figure 7.1: PhD Outcomes from PRTLI Supported Centres and Initiatives and overall Higher Education

	2005	2006	2007	2008	TOTAL
PRTLI Centres and Initiative Outcomes	216	210	378	310	1114
All Higher Education Outcomes	780	966	1,055	1,100	3901
PROPORTION OF PhDs FROM PRTLI Cs & Is	28%	22%	36%	28%	29%

Source: HEA Data and Survey of PRTLI Supported Centres/Initiatives

Increasing the base of PhDs in an economy should have benefits for both employers (via access to an improved skills base) and graduates (through ability to access higher value jobs). There was also evidence that PhD research programmes are now more structured and delivered more efficiently and postgraduate qualifications have become more focused on specialist needs of enterprise and on employable skills. This was reflected in the findings from the impact validation exercise, which confirmed that the skills base generated via the centres and initiatives was valued by companies, particularly in pharmaceuticals and ICT related activities.

Given these findings, it was felt important to analyse how researchers within the PRTLI supported centres and initiatives have progressed since completing their research. The assessment mapped the current roles of 100 former researchers and revealed a pattern of dispersing expertise into industry and, in a surprising number of examples, into influential public sector employment. This is encouraging, but it must also be acknowledged that the majority of these researchers have remained

[28] Statistics drawn from 'The Higher Education R&D Survey 2008', Forfas, December 2010 and 'Survey of Research in the Higher Education Sector 1998', Forfas, 2009.

in academia, albeit progressing to more senior positions either in the same or another institution. This was reinforced during the exercise when we engaged with current PhD students studying in the centres and initiatives. This revealed that there remained limited awareness of opportunities outside of academia and a strong motivation to remain in the higher education sector was apparent. Some retention in the sector is undoubtedly required to allow further development of areas of research and deliver high value solutions. However to maximise the long-term economic impact, there is a need to ensure a steady pipeline of PhD students ready to work in industry. Moving away from a culture of academia for life must be a key aim moving forward, with signs that institutions are already focusing on a more fixed-term project based approach to such research posts. UCD in particular has embedded this ethos in the planning of its research institutes.

7.1.3 Development of institutional research and teaching expertise

A further valuable aspect with regard to human capital has been the ability to attract significant thought leaders to institutions to develop and drive research. From our consultation with academic stakeholders and analysis of the survey of centres and initiatives, we have been able to identify a number of benefits that have been realised by the attraction of key academic experts in particular research areas. These include:

- Ability to attract relevant and highly experienced research staff in tandem with the expertise to support them
- Forging of new industry partnerships based on their perceived added value and expertise
- Increasing the international recognition of the institution by hosting an international expert, with all the associated benefits that brings (i.e. in increased research funding, stimulating demand from students – particularly internationally at postgraduate level)
- Using the expert's established contacts to build further institutional partnerships and generate additional research outcomes.
- Delivering high quality research outcomes is specialist areas which often attract further publicity for the institution.

Some examples of leading international experts attracted to work with centres and initiatives include Tofail Syed (MSSI), Frank Barry (NCBES) and James Heckman (Geary Institute and Conway Institute). Further details on these thought leaders is provided as Case Study E.9 in Appendix E. It is through such individuals that the centres and initiatives will be able to secure ground-breaking achievements in their research fields. Some of these are already emerging, although the fields of research involved often entail a long timeframe for realisation of outcomes and impacts.

The attraction of these leading experts in specialist fields has also led to them to teaching undergraduates. Allied to the exposure of these students to a research environment (and its infrastructure and facilities), such opportunities should have an impact in stimulating an interest in research and innovation among this cohort. A more tangible measure of impact on human capital development is the ability of the research produced to permeate across not only postgraduate activity but also undergraduate teaching. Research-led teaching should be a key attribute of an internationally competitive university and there was some evidence that the research of the centres and initiatives supported has developed the quality of undergraduate teaching. For example, the Institute of Neuroscience in TCD developed a BA (Mod) in Neuroscience as well as an MSc in Neuroscience and PhD program Neuroscience in line with the development of specialist research competency. Case Study E.10 in Appendix E provides examples of centres and initiatives that have introduced new courses or modules related to the specialist research undertaken (including the Focas Institute in DIT, the NCPST in DCU and the Centre for Transport Research and Innovation for People (TRIP) in TCD). Further detail on the development of undergraduate teaching from the research of NCSR is also provided as Case Study E.11.

While there was evidence of positive benefits from the centres and initiatives on teaching content, there was also some concern that focus on research by Principal Investigators(PIs) has taken the emphasis off teaching and that quality has in some instances suffered. During the assessment visits to centres and initiatives we engaged extensively with PIs and there was concern about the workload involved in contributing to the research portfolio of the centre or initiative on top of their existing teaching and other academic responsibilities. The vast majority were funded independently of the centre or initiative through the existing school, faculty or department structure of the institution. To some extent this has led to conflicting responsibilities and it does appear to be an area which requires focused attention at institutional and wider policy and funding level. There is a need to look at how to balance research and teaching responsibilities more effectively. It is in research-led teaching where the real longer-term impacts of building internationally competitive research capability should lie. Continuing to expand the beneficiaries of the research via the approach of insisting all researchers teach to some extent has continued value (and is the approach across many institutions), but controlling and coordinating this work to ensure expertise is fully utilised must be the central objective.

7.2 Assessing impacts in institutional development

The PRTLI was also intended to change the approach to research in institutions and ensure a more strategic and effective approach to delivering research activities. The assessment found that the PRTLI did facilitate the allocation of dedicated time and resources to research for the first time. In the period since the introduction of the programme, the core business of the institutions has development from a primarily teaching focus to incorporate research as a central component of operations. The development of physical infrastructure has also played an important role in supporting change, with the new buildings and facilities constructed providing a focal point within institutions. This has brought bring academic staff together and built identity and confidence in focusing on the development of effective research propositions. For example, DIT transformed its approach from one which was purely focused on teaching delivery to the current situation where research and innovation is an important aspect of its business model. The Focas Institute, which was funded under the PRTLI to focus on research specialism, is now the channel for development of most research activity across the institution.

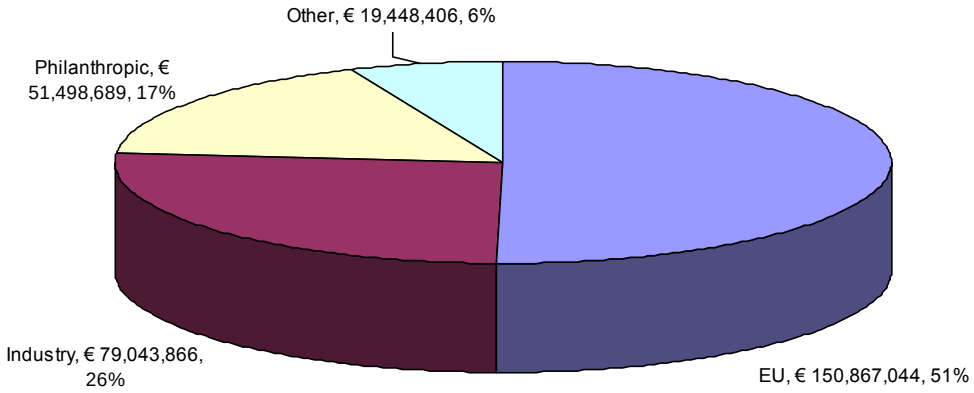
The introduction of the competitive system of funding institutions via PRTLI was also found to have had a strong impact on the behaviour of institutions and the approach to research activity. The initial cycles of PRTLI inevitably produced winners and losers in terms of funding awards. The winners tended to be those that had identified areas of potential strength and a clear plan for how infrastructure and capability needs could be addressed. Those that were less successful tended to have insufficiently prioritised areas for investment and were forced to reappraise this approach in future cycles. Over time, a more strategic approach to planning, coordinating, supporting, delivering and monitoring research became the norm across institutions. For example, the approach in UCD has demonstrated the advantages of a strong focus on planning and management of research activity and accountability for outcomes. It adopts a highly strategic approach to the coordination of work across all six of its PRTLI funded centres (4 of which were funded under cycles 1-3), with a clear vision for future development and processes including regular meetings and reports to ensure timely understanding of outcomes and emerging opportunities.

The development of the approach to research in institutions has been reflected in the extent to which they are now working as valued partners on collaborative projects with European peers. This represents a marked change from the environment pre-PRTLI, where Ireland was considered to be somewhat of a poor relation in terms of research activity and expertise. For example, the Materials Surface Science Institute (MSSI) is now leading a number of EU projects, particularly in the area of crystallisation. Many of the centres and initiatives were also able to demonstrate success outside the

EU in working with some of the foremost Universities and their leading academics on particular projects. This is apparent, for example, in the partnership between the National Centre for Biomedical Engineering Science and Georgia Tech.

The most tangible measure of the impact of greater prioritisation of research in universities and a more professional approach to its organisation and management lies in its ability to attract external funding, particularly that sourced from non-Exchequer sources. In addition to the injection of €178million by Atlantic Philanthropies via the PRTLI, €300.9million has been generated as shown in Figure 7.2.

Figure 7.2: Non-Exchequer Funding Levered by the Centres Since Initiation of PRTLI Funding



Source: Survey of PRTLI Supported Centres/Initiatives

There are also benefits in revenue generation that were found to accrue to institutions as a result of development of enhanced research capability. The ability to hold major international conferences in specialist research areas[29] was largely attributed to development of international reputation and availability of facilities and infrastructure. This brings additional expenditure to the institution and the wider economy. Similar dividends have been realised from the holding of short courses or summer schools as a result of the development of expertise (e.g. Urban Institute Ireland holds a very successful summer school every year). The expertise of some of the supported centres has also been deployed in the provision of consultancy support, generating direct revenue for the institution (e.g. CISC, IIS, Geary Institute and the Conway Institute have all attracted consultancy income).

7.3 Assessing wider economic impacts

In this section we consider the wider economic impacts from the supported centres and initiatives which, although less quantifiable, should be taken into account in considering the value of initial PRTLI investment. The centres and initiatives cover areas that are relevant to health, transport, the environment, economics, planning, social studies, history and culture. These are all important aspects of a well functioning state and in ensuring the quality of life of its inhabitants. If the centres or initiatives can be shown to influence policy or produce research that allows progress to be made or solutions to be found in relation to these areas, then there is potential for considerable long-term economic impact.

The assessment found that centres had been able to demonstrate some ability to influence policy, particularly in those focusing on social science disciplines. This took place on an expert basis, where a leading academic from a centre or initiative was invited to advise the Government on a particular issue, either independently or as part of a policy panel or forum. It also occurred as the product of research undertaken by the centre or initiative, where the findings are taken on board by Government.

[29] Examples of conferences held as a result of the development of research specialism through centres and initiatives is provided as Case Study E.12 in Appendix E

Examples of centres and initiatives achieving such policy impacts include the Urban Institute Ireland, Martin Ryan Institute, Geary Institute, Centre for Innovation and Structural Change (CISC), National Institute for Regional and Spatial Analysis (NIRSA) and the Institute of Molecular Medicine.[30] Despite this evidence, there was found to be scope to use the research expertise within the centres and initiatives more effectively as an aid to national policy-making moving forward. However the onus should not only be placed on the government to act in this regard. Centres where there is clear relevance to policy areas should actively target increasing their level of influence in this regard. Indicators such as engaging with key government stakeholders follow through from research recommendations and securing commissions of government research should be key performance indicators in the same way that a centre working in the bioscience or ICT area might target direct commercialisation impacts. Demonstrating value must be the key to future research funding and the onus will be on all centres and institutions to provide evidence in this regard.

In addition to influencing policy, the expertise that exists in the centres and initiatives also offers potential to generate direct benefits in quality of life from research. Improvements in healthcare, the environment and transport infrastructure, for example, all deliver long-term economic impacts. There is such opportunity in public health, with multi-national companies investing significantly to support research programmes around areas such as drug development, manufacturing processes, quality assurance, etc. The realisation of public health impacts from such research will involve a long-term development process and there is no evidence of their occurrence to date. However it was found that more practical and applied activities had been undertaken in centres which have had an impact on the quality, efficiency and effectiveness of healthcare delivery and this is also reinforced by HRB work to assess the impact[31]. Examples drawn from PRTLI supported centres and initiatives include:

- The funding of the Chair of Health Informatics at TCD, which was part of a wider collaborative research effort across with DIT, TCD and St James' Hospital. This led to the development of an MSc in Health Informatics and increased the recognition of the importance of good information systems in delivering effective healthcare. The practical application of such work is now evident within the HSE with informatics a central part of decision-making and performance analysis systems.
- The Institute of Biopharmaceutical Sciences, RCSI, place significant emphasis on translational research. As a result of PRTLI it established the first Centre for Clinical Research in Beaumont Hospital. This has helped to develop human capital in the delivery of healthcare and ensure that learning is gathered and used to continually improve patient outcomes.
- The National Institute for Cellular Biology has been working in collaboration with the Eye and Ear Hospital on research around damage to the cornea and initial tests have indicated that significant improvements in patient outcomes should be achieved. The Centre is also working with the Mater Hospital on development of stem cell therapies in the treatment of diabetes

The environment is another area where there is some potential for research to enact short-term improvement and change. The centres and initiatives have progressed important work around climate change and marine based science. The Martin Ryan Institute has been commissioned to deliver research by the Environmental Protection Agency on enhancing human health through improved water quality. The Urban Institute Ireland at UCD is an integral part of a European collaborative project on air quality policy, feeding into the development process for new EU regulations. The work of the

[30] Further details are provided in Case Study E.15 in Appendix E

[31] 'Health Research – Making an Impact: The Economic and Social Benefits of HRB-Funded Research', Edward Nason, Barbara Janta, Gillian Hastings, Stephen Hanney, Mairéad O'Driscoll and Steven Wooding. RAND Europe and Health Research Board, May 2008. This research found "impacts in a wide range of health areas, including work on the development of pain relief drugs, the treatment of myocardial infarction, better treatment for psychosis and improvements in dental hygiene"

Centre for Transport Research and Innovation in People (TRIP) in TCD has also demonstrated evidence of benefits around transport infrastructure and related outcomes[32].

The final aspect of wider economic impact that we have considered surrounds research capability linked to culture, heritage and tourism. It is important to note that despite the strong focus on science-based research as a driver of economic growth, Ireland remains well known as a hub of literature, rich history and language and culture. It is these characteristics which drive tourist (and international student) demand which in turn makes a significant contribution to the Irish economy and it is important that this is not neglected in the way in which research is funded.

Building research capability in humanities disciplines has also been recognised as informing scientific research by offering a "body of knowledge on all aspects of human experience, agency, identity and expression".[33] It can add value to science-based research propositions – in, for example, understanding human behaviour, applying technology or providing content for ICT projects. It was found that the supported centres and initiatives are developing in this direction, with a series of initiatives around digitisation. This is providing a means for arts based centres to work with technology focused centres to develop and deliver content to a wider audience. Examples include the Moore Institute in NUIG working on the digitisation of cultural and heritage products with a view to potentially improving Ireland's overall tourist product and the Centre for Mediterranean and Near Eastern Studies in TCD progressing work on digitising ancient texts in Greek. The project with the greatest potential impact in this regard is the Long Room Hub, part of the Humanities Serving Irish Society (HSIS) project. [34] This interdisciplinary digitisation initiative has been led by TCD and is generating significant publicity. The project has attracted industry interest with Google, Intel and IBM involved and will be an important asset in demonstrating Ireland's unique research assets internationally.

[32] Case Study provided as E.13 in Appendix E

[33] 'Leading the World: the Economic Impact of UK Arts and Humanities Research', Arts and Humanities Research Council, 2010

[34] See Case Study E.15 in Appendix E

8 Research capability in the present context

8.1 Research expenditure and infrastructure

Having tracked the inputs, outputs, outcomes and impacts from the supported centres and initiatives, it is important to set this in the context of how Ireland's research capability has changed since the base case set out in Chapter 4. The evidence gathered during this assessment and presented in this report has been clear that the PRTLI provided the foundation for significant research activity to proceed in the higher education sector. The €605mn invested via the PRTLI over the funding period 2000-2006 on its own reflects a substantial proportion of higher education expenditure on research and development from all sources. The Higher Education Research and Development (HERD) expenditure analysis in Figure 8.1 suggests that over this period, the PRTLI accounted for around 21% of total investment[35]. It also indicates that there has been a significant expansion of higher education spend on R&D in the period since establishment of the PRTLI, with HERD expected to rise further to €829mn in 2009. This has moved Ireland up from 12th to 7th in the OECD rankings for this indicator. HERD as a percentage of GNP also changed from the 1998 base case level of 0.30% to 0.48% in 2008.

Figure 8.1: PhD Outcomes from PRTLI Supported Centres and Initiatives and overall Higher Education

	2000	2002	2004	2006	2008
Higher education expenditure on R&D	€238mn	€322mn	€492mn	€601mn	€750mn
HERD as % of GNP	0.27%	0.30%	0.39%	0.39%	0.48%

Source: Forfas Higher Education Research and Development Survey 2008

The increased expenditure on research is reflected in the infrastructure that has been established. In their reflection on the Research Infrastructure in Ireland in 2007[36] the International Steering Committee recognised the transition that had happened over the previous years and the early signs of a transformation in the research base. The view was balanced by a strong signal that there was much still to do to retain and grow Ireland's international reputation, recognising that this had emerged from a history of real deficit in relation to research infrastructure. Particular weaknesses were cited in platform infrastructure serving generic research requirements, specialised infrastructure enabling

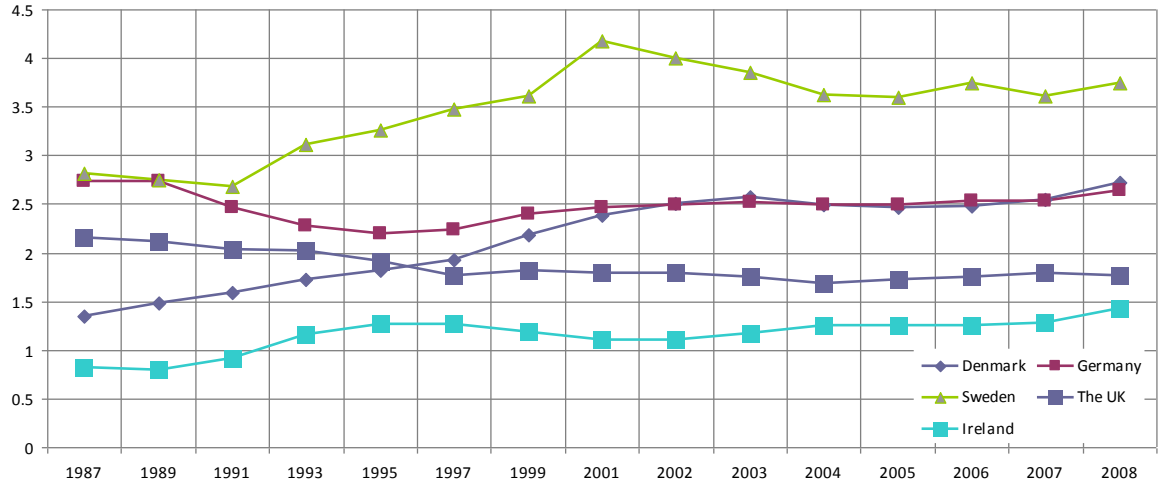
[35] This is calculated by taking the average annual HERD level from the 4 years in which the survey was undertaken during the funding period for the PRTLI (2000-2006), assuming this average was consistent with the 3 years for which such data is unavailable, and estimating overall HERD over the 7 year timeframe. The proportion of this accounted for by the PRTLI investment was then calculated.

[36] Research Infrastructure in Ireland – Building for Tomorrow. 20007. Forfas and Higher Education Authority

specific research activity to take place and broader support infrastructure (e.g. administrative and technical support needed to underpin research).

By widening the analysis to overall expenditure on Research and Development across the economy, Figure 8.1 shows that Ireland still invests a relatively smaller portion of GDP when compared to other states, with the level just below 1.5%, despite some narrowing of the gap over the 20 years to 2008.

Figure 8.1: Gross Expenditure on R&D as % of GDP



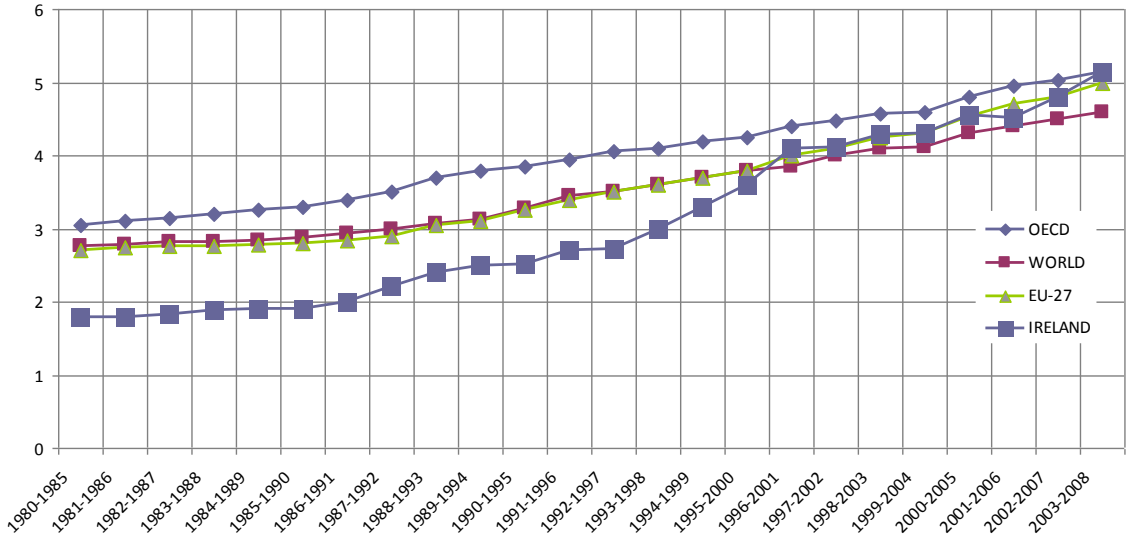
Source: OECD

While this trend in direct investment is notable, a further important characteristic is the present level of indirect government support via R&D tax incentives. Ireland is ranked 6th globally in terms of this contribution to business investment. This reinforces the findings highlighted in Section 5.4 where the R&D tax credit scheme was identified as a key factor in attracting and retaining inward investment.

8.2 Research capability and performance

With a substantial increase in investment and an expansion in infrastructure in the period since the PRTLI was introduced, it is important to examine how this has impacted upon research capability in Ireland. The assessment has considered a range of international research performance indicators to consider how the relative position has changed since 1998. In the diagram in Figure 8.2 we show how the research impact indicator measured by Thomson Reuters has grown in Ireland from the 1980s when it lagged significantly behind EU, World and OECD averages. The position has now improved to the extent that it is on a par with the OECD level and above EU and world averages.

Figure 8.2: Thomsons Reuters Research Impact Indicators 1980-2008



Source: Thomson Reuters InCites March 2010

Other useful indicators of progress in Ireland over the period since the PRTLI was introduced include:

- **Citations** – as a relative measure of how well regarded research is and the level of interest in the particular area citations provide a useful indicator at an international level. In the period from 2003 to 2008 Ireland moved from 34th in the World to 19th on relative citations[37].
- **Specialist Rankings of Research Areas** – Ireland has achieved significant improvements in specific areas of expertise, particularly in areas such as immunology and materials science, where we are considered third and eighth in the world in terms of the quality of our research by the Thomson Reuters outputs. Thomson Reuters Essential Scientific Indicators[38] have also now rated Ireland as one of the top 20 science hubs in the world.
- **University Rankings** – While rankings reflect a multitude of factors in addition to research capability and reputation this aspect of performance has been acknowledged by the institutions as playing a part in a significant improvement in the relative positions of most universities. Irish higher education institutions have moved up the global university ranking tables significantly over the period 2005-2010, research being one of the determining criteria. In the Times Higher, QS and Shanghai rankings, Irish institutions feature and in the Times Higher rankings, two Irish universities (UCD and TCD) now appear in the top 100 universities in the world for the first time. Reflecting a general rise in international reputation, the international student base has increased by 38% over the last 10 years.

These indicators and rankings indicate strong progress and deserve recognition in the sense that much has been achieved over the period of significant investment. They should provide a platform for stimulating improvements in wider innovation performance and the extent to which this is beginning to be demonstrated is considered below.

8.3 Wider innovation performance

The assessment noted some important trends in Ireland's relative position with regard to innovation:

[37] 'InCites Essential Scientific Indicators', Thomson Reuters, March 2010

[38] 'InCites Essential Scientific Indicators', Thomson Reuters, March 2010

- Ireland's international ranking in the Global Innovation Index stands at 19th for 2009/10[39], well behind the positions of Denmark (5th), Finland (6th), Germany (16th), Sweden (2nd) and the UK (14th). The most successful Irish innovation 'components' surround the quality of the education institutions (where it ranks 12th globally), exports and employment (15th) and benefits to social welfare (11th). However it compares less favourably in terms of knowledge creation (25th) and knowledge application (33rd). Despite the deployment of the significant research funding detailed in the report, Ireland still lags behind in terms of investment in education (where it is ranked 25th).
- The lag behind these peers is reinforced by the 2009 analysis of the European Innovation Scoreboard, Ireland is ranked 9th and is categorised as an 'innovation follower', behind 'innovation leaders' such as Denmark, Finland, Germany, Sweden, and the UK.
- In the IMD Business School's 2009 World Competitiveness Yearbook, Ireland was ranked 7th among 27 OECD countries in terms of knowledge transfer between companies and universities. This reflects a rise of 4 places compared to 2008. Barriers to more effective knowledge transfer included lack of knowledge of third level research projects by businesses and difficulties with intellectual property contracts.[40]

Overall, Ireland's research base has been transformed over the past 10 years and a great deal has been achieved to get us a place at the "global table". However, in many ways this was the easier stage of development given the starting point, the significant investment deployed across many interventions, the positive impact of a growing economy, and the growing reputation of Ireland as a place to do business. The next phase in this development is likely to be more challenging and will require strong policy direction and leadership if achievements to date are to be successfully exploited.

[39] 'Global Innovation Index 2009/10', INSEAD and the Confederation of Indian Industry,2010

[40] 'Annual Competitiveness Report 2010, Volume 1: Benchmarking Ireland's Performance', Forfas, November 2010

9 Conclusions & lessons learned

9.1 The PRTLI served as an important component of Ireland's developing R&D system…

The analysis set out in this report confirms that the PRTLI was pivotal in stimulating the development of research performance in Ireland over the last decade. The programme put in place the research infrastructure, built basic research capability and drove a strategic approach to research activity (and resources) in institutions via establishment of the 45 specialist centres and initiatives funded under Cycles 1-3. The development of these centres and initiatives, with each focusing on particular areas of expertise and potential, provided an initial foundation which has allowed Ireland's research, development and innovation system to progress and become more effective in delivering on market needs.

However the realisation of tangible commercial and economic impacts from the centres and initiatives funded by the PRTLI was completely interdependent with a range of other support and funding interventions. These interventions built on the infrastructure and capability put in place by the programme to support delivery of specific projects and activities that could then be linked directly to commercial and economic dividend. It was only via the additional support provided from exchequer sources such as SFI, IRCSET, IRCHSS, HRB and Enterprise Ireland that achievement of any such impacts was possible. Therefore in assessing how the centres and initiatives delivered a return on the initial investment by the PRTLI, we must consider all of the exchequer resources which have supported their research activities since that time.

9.2 …commercial and economic impacts have emerged from the centres and initiatives which the PRTLI supported…

On this basis, we have been able to track the realisation of commercial impacts from the research undertaken by the supported centres and initiatives. This shows that the €1.173billion of exchequer investment which we have recorded as flowing through the centres and investments has managed to lever around €1.232bn of further non-exchequer resources via a combination of direct investment in research and commercial value in its commercialisation. As the first exercise that has been able to validate a quantifiable impact on research, it represents a small 'return' on the exchequer investment. Generating tangible evidence of impact in this way is a significant achievement. Although the base of comparative international analysis in this area is small and has produced varying results, this return does nonetheless compare relatively favourably with the limited number of studies that have been undertaken elsewhere. Those studies which focused on validating commercial impacts directly with industry found rates of return ranging between 28% and 67%, typically over a longer-term time period (i.e. 15 years after the first investment for the oft-cited Mansfield study) and a short consideration of

the international literature in this area is provided as Appendix I. The analysis of the non-exchequer investment and commercial impacts that have been realised in this way is shown in Figure 9.1. The impact validation exercise was also able to confirm that the commercial activity has supported the generation of 1,255 additional jobs.

Figure 9.1: Analysis of Investment and Commercial Impacts from the Supported Centres and Initiatives

Component	Value	
Exchequer Investment in Centres and Initiatives		
PRTLI investment	€418mn	
Other Exchequer investment	€755mn	**€1,173mn**
Non-Exchequer Investment in Centres and Initiatives		
PRTLI investment	€185.0mn	
Industry investment	€79.0mn	
Other non-Exchequer investment	€221.9mn	**€486mn**
Commercial Impacts from Centres and Initiatives		**€753.7mn**

Source: PA Consulting Impact Validation Exercise

In considering the 'return on investment', it is also important to note that not all of the centres or initiatives had the potential for generating commercial impacts. The 16 centres and initiatives within the social sciences and humanities and environment and marine thematic areas fall into this bracket and considering success in terms of human capital, reputational, policy-related and wider economic impacts is more appropriate. However from the €952mn recorded as flowing through the other 29 centres in biosciences and biomedical; platform technologies and materials; and ICT and advanced communications; a return in terms of commercial impact could be expected (although it should also be acknowledged that this was not a specific objective of the initial PRTLI funding). This is borne out by the fact that 99.9% of all commercial impacts validated emerged from the work of these 29 centres and initiatives.

This analysis of commercial impact does not represent the economic dividend, as a decision was taken within the study to focus purely on measuring that impact that could be directly validated by industry. It does not take account of factors such as:

- the wider impacts derived in the stimulation of Foreign Direct Investment from having a strong research system in place.
- the employment generated through construction in the significant infrastructure projects progressed;
- income 'dividends' realised by individuals due to the increasing supply of PhDs;
- additional international student income generated due to the improvement in global institutional reputation due to enhanced research capability;
- visitor impacts arising from the holding of high profile conferences and events based on new facilities and international research reputation;
- multiplier effects of the investment in higher education in terms of indirect and induced expenditure

As such, in some respects it presents a minimum valuation of impact based only on that which was directly quantifiable by industry beneficiaries. However it is also important to note that leakage in an area like R&D can be significant, making calculations on how commercial impact relates to economic dividend extremely difficult. This is especially the case in a small, open economy like Ireland with a predominance of multi-national corporations (which the report has shown to be the source of the majority of commercial impacts). Identifying accurate levels of displacement and deadweight from the

investment would also require a controlled longitudinal economic exercise which was not the purpose of this study. However, the additionality of the PRTLI in generating the research outcomes and impacts was confirmed from stakeholder analysis and by mapping the logical relationships between inputs, outputs, outcomes and impacts. Consideration of the base case in terms of research infrastructure and capability pre-PRTLI and the present situation also underlines our finding that the PRTLI was an important driver of development in this area alongside the other key support interventions.

The assessment also focused on more qualitative assessment of other economic impacts that had been realised as a result of the research of centres and initiatives:

- Development of specialist research centres and initiatives has contributed significantly to the expansion of the human capital research base in Ireland. The assessment found that they had also played a role in the development of a pipeline of skilled postgraduates, with some evidence of an increasing base moving into industry positions rather than academia (although there is a need for further progress in this area). The attraction of thought leaders to institutions and development of undergraduate teaching were further benefits identified.
- On the generation of other economic impacts, there is more evidence of the humanities and social sciences based centres and initiatives making a contribution. The assessment was able to identify examples of where they had influenced relevant policy and secured benefits in relation to public health and environmental improvement. Emerging impacts were also identified around the role of humanities disciplines in digitisation activity.

9.3 …development of research capability is a key driver in attraction and continuation of inward investment…

One thing which is clear from the analysis of commercial impacts is that there is a significant reliance on multi-national enterprises for private sector investment in centre and initiative research. It was a clear finding of the assessment, borne out by quantitative analysis of impacts and almost universally endorsed by industry and other stakeholders that the development of research capability has, and will continue to have, a significant impact on the attraction and retention of inward investment. Specifically:

- 82% of the commercial impacts generated can be attributed to inward and continued investment by multi-national corporations.
- The impact validation exercise with companies confirmed that, if the research capability in Ireland had not developed significantly from the position set out in the base case, there would be serious threat to current operations and little likelihood of further inward investment.
- The growth of research and development investment by IDA client companies (with €500mn invested in each of the last two years) indicates the move up the value chain by industry and the need for continued development of specialist research capability to service their needs.

However the strength of the relationship between centres and initiatives and commercial impacts realised by multi-national companies also indicates one of the remaining weaknesses in the Irish innovation system. With a few exceptions, indigenous companies, particularly SMEs, have struggled to realise any significant dividends from working in partnership with centres and initiatives. This is in part a consequence of the focus of the centres and initiatives on basic research in areas of more relevance to the larger multi-national corporations (particularly bioscience and biomedical). It is also perhaps a reflection that these centres and initiatives, particularly those based in the universities, are not sufficiently geared up to facilitating smaller applied research projects which are of most benefit to the SME sector. Finding a more effective means of linking higher education research and SMEs needs

to be a key focus moving forward, with developments such as the Competence Centre initiative an indication that this is now being recognised in national policy.

9.4 …but the PRTLI investments in different research areas have demonstrated mixed levels of success…

The importance of the development of research capability via the centres and initiatives to inward investment is reflected in the main areas of research where commercial impacts were realised:

- The pharmaceuticals manufacturing and medical technologies industry is immensely important to the Irish economy and has proved to be the dominant source of commercial impacts from the research emerging from the PRTLI supported centres and initiatives. Multi-national companies working in this industry have invested significantly in commercialising such research and show a commitment to continued investment moving forward. To some extent this is to be expected given the proportion of PRTLI resources allocated to bioscience and biomedical centres and initiatives, but it also illustrates this was justified by the subsequent expertise developed which facilitated a commercial return.
- The expertise that exists in Ireland in advanced materials and nanotechnology has also been utilised by these firms and by other enterprises involved in wider manufacturing activities. A real international reputation is developing in this area but the translation of this reputation into commercial impacts will be a key challenge in the next few years.
- The other area where success was apparent and future prospects seem encouraging is in ICT, with strong multi-national companies (e.g. Intel, IBM, Google) highly proactive in research and with commercial impacts identified across these MNCs and also other smaller indigenous enterprises. This area also offers potential for overlap with humanities disciplines as a growing expertise and focus on digitisation is attracting significant commercial interest

The assessment found that success in generating non-exchequer funding and realising commercial impacts from research tended to be concentrated within a 'leading' group of 9 or 10 specific centres or initiatives. While good performance was largely in line with those operating in the research areas noted above, there was not always consistent performance in this regard. Centres and initiatives that proved effective at sustaining a base of non-exchequer funding and generating commercial impacts included NCBES, the Tyndall Institute, MSSI, ABCRF and the NCSR. However it is important to note that there is a significant base of centres and initiatives for which securing commercial impacts was never feasible nor envisaged. For these entities success must be judged in different ways, and there are indicators of effectiveness here in addition to more qualitative impacts. For example, centres such as the Geary Institute, NIRSA, Urban Institute Ireland and CISC, while lacking the opportunities to yield commercial impacts in such a manner, nonetheless were able to attract a diverse range of research funding and remain relatively self-sufficient. The centres and initiatives where performance was more disappointing tended to suffer from the lack of a market-relevant specialised focus. A wide and quite generic approach to research within a broad area such as the environment, health or humanities constrained their ability to build an identity with, and attract interest from, commercial partners.

9.5 …future research funding must be carefully planned and targeted on areas with greatest potential for success…

Ireland now has the benefit of a significant and sustained programme of investment targeting the development of an effective research and innovation system. In many respects a generalist approach to intervention has been required to date in recognition of the need to address a research deficit across the entire higher education sector. In terms of research priorities, there has also been a need

to allow a certain amount of flexibility in how funding could be deployed, given the low base from which the process began and the fact that key areas of strength had still to emerge. Funding across many areas facilitated this and took cognisance of the many variables that affect the development of specialist research expertise and resultant outcomes.

This has had the effect of raising research capability levels across a wider range of disciplines in higher education institutions. It was an essential adjustment step, but given the current fiscal challenges and pressing need to return to economic growth, future investment must now be prioritised to build on excellence and the most successful areas of research in Ireland and link these to internationally competitive industry sectors. This assessment should help this decision-making process as it demonstrates the relationships between investment and the returns across the different centres and initiatives. There is now a need to build on the work in the most successful centres and realise the potential that remains within such specialist research areas. The impact validation exercise conducted estimated a potential future commercial impact of €1.08bn. Although this should only be taken as a very broad indication of the potential that exists, given its interdependency with numerous business and market variables, it does indicate that if investment can be channelled effectively in the right areas, there is scope for significant further success.

9.6 …with a focus from the outset on tracking impacts from any future research investment

Overall, we have found that the establishment of the PRTLI and subsequent investment programmes resulted in the improvement of research capability in Ireland and the realisation of a modest level of commercial impacts. Ireland is now at a point where we need to reflect on our approach to research and development, how and where we invest and how we manage and organise the policy agenda strategically. We are at a different stage in the maturity of our research base and in the development of the economy. These conditions mean that there is an urgent need to ensure value for money across all future investment areas and to maximise return on investment. From the assessment of commercial and economic impacts conducted, the difficulty in trying to measure these benefits after such a long time period has elapsed since the initial intervention demonstrates a need to more closely track outputs, outcomes and impacts in research centres as they arise. Targeted commercial and economic impacts must be made clear at the point of funding and monitored and pursued at every stage of the research process. By doing this and taking a very strategic approach to the support of research, focused on building on success and key areas of strength, a platform exists for securing future economic success.

Acronyms

AIT	Athlone Institute of Technology
ABCRF	Analytical and Biological Chemistry Research Facility
BCRI	Boole Centre for Research Informatics
CBBR	Centre for Biopolymer and Biomolecular Research
CCD	Colony Collapse Disorder
CFF	Central Fabrication Facility
CFO	Chief Financial Officer
CIPA	Centre for Image Processing and Analysis
CISC	Centre for Innovation and Structural Change
CIT	Cork Institute of Technology
CPA	Combat Poverty Agency
CRANN	Centre for Research and Adaptive Nano Structures and Nano devices
CREST	Centre for Research in Engineering Surface Technology
BMW	Border, Midlands and Western Region
DCRGA	Department of Community, Rural and Gaeltacht Affairs
DCU	Dublin City University
DIAS	Dublin Institute for Advanced Studies
DIT	Dublin Institute of Technology
DMMC	Dublin Molecular Medicine Centre
ECI	Environmental Change Institute
EI	Enterprise Ireland
EPA	Environmental Protection Agency
ESI	Environmental Science Institute
EU	European Union
FBIM	Functional Brian Imaging Machine
FDI	Foreign Direct Investment
Focus Institute	Facility for Optical Characterisation and Spectroscopy
FP7	Framework Programme 7
FSA	Food Safety Authority
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GIS	Geographic Information Systems
HEA	Higher Education Authority
HE	Higher Education
HEIs	Higher Education Institutions
HERD	Higher Education Research & Development
HRB	Health Research Board
HSDS	High Speed Devices and Systems Centre
IBA	Institute of Bioengineering and Agroecology
ICT	Information, Communication Technologies

IAMS	Institute for Advanced Materials Science
IBEC	Irish Business Employers Confederation
IDA	Industrial Development Agency
IIS	Institute for International Integration Studies
IMM	Institute of Molecular Medicine
IoT	Institute of Technology
IMD	International Institute for Management Development, Switzerland
IP	Intellectual Property
IRCHSS	Irish Research Council for the Humanities and Social Sciences
IRCSET	Irish Research Council for Science, Engineering and Technology
ITTAC	Institute for Information Technology and Advanced Computation
ITT Dublin	Institute of Technologt, Tallaght
MMI	Molecular Medicine Ireland
MNC	Multinational Company
MSc	Masters of Science Qualification
MSSI	Material and Surface Science Institute
NCAOP	National Council of Ageing and Older People
NCBES	National Centre for Biomedical Engineering Science
NCCRI	National Consultative Committee on Racism and Interculturalism
NCSR	National Centre for Sensor Research
NCPST	National Centre for Plasma Science & Technology
NDP	National Development Plan
NHNES	National Health and Nutrition and Examination Survey
NIC	Networks Innovation Centre
NICB	National Institute for Cellular Biotechnology
NIRSA	National Institute for Research and Spatial Analysis
NMRC	National Microelectronics Research Centre
NUIG	National University of Ireland, Galway
NUIM	National University of Ireland, Maynooth
OECD	Organisation for Economic Co-operation & Development
OPW	Office of Public Works
PG	Postgraduate
PI	Principle Investigator
PRTLI	Programme for Research in Third Level Institutions
RCSI	Royal College of Surgeons, Ireland
R&D	Research and Development
RDI	Research Development and Innovation
RINCE	Research Institute for Networks and Communications Engineering
RoI	Republic of Ireland
S&E	Southern & Eastern Regional Assembly
SFI	Science Foundation Ireland
SME	Small Medium Enterprise

SPRU	Science Policy Research Unit
SSTI	Strategy for Science, Technology and Innovation
STIAC	Science, Technology and Innovation Advisory Committee
S&T	Science and Technology
TCD	Trinity College Dublin
TCIN	Trinity College Institute of Neuroscience
TRIP	Centre for Transport Research & Innovation for People
TSSG	Telecommunications Software and Systems Group
UCC	University College Cork
UCD	University College Dublin
UL	University of Limerick
UII	Urban Institute Ireland
WIT	Waterford Institute of Technology

Appendix A: PRTLI Centre/Initiative Questionnaire

Section 1 Background and Remit of Centre / Initiative

In this section, we would like to set the context for the development of the PRTLI centre / initiative, examining the main drivers for its development, the areas of research on which the centre / initiative focused, the research infrastructure in place and the role of the wider institution in supporting the centre / initiative.

1.1 Status prior to PRTLI support

Please provide an overview on your institution's approach to this research area prior to receiving support from PRTLI. For example, to what extent did a physical 'centre' exist, was there a formal/informal research partnership in place, on what scale was research activity in this area being progressed?

1.2 Role of centre/initiative and research portfolio

Please describe the role of the centre / initiative, how that role has evolved over time and the main components of the centre / initiative's research portfolio:

1.3 Research infrastructure in place in the centre/initiative

Please describe the research infrastructure in place in the centre / initiative (buildings, equipment, facilities, etc.) and how this has developed over its lifetime

1.4 Current research expertise based in the centre/initiative

Please could you provide an indication of the current deployment of research expertise within the centre/initiative	
Director	**FTE staff**
Senior Research Fellows	**FTE staff**
Research Fellows	**FTE staff**
Post Doctoral Fellows	**FTE staff**
Post Graduate Students	**FTE staff**
Research Assistants	**FTE staff**
Technicians	**FTE staff**
Please list below any other staff resources not included in the categories above that are deployed in the delivery of research activity in the centre/initiative	
Category -	**FTE staff**
Category -	**FTE staff**
Category -	**FTE staff**

1.5 Access to wider research expertise

Does the centre/initiative have access to any other research expertise outside of the centre/initiative (e.g. in the wider institution, in external partnership institutions/bodies, on an associate basis). If yes, please give details

1.6 Wider institutional support for centre/initiative research activity

Please could you summarise the additional support provided to the centre or initiative from the wider academic institution in terms of financial support; infrastructure and facilities; human capital and expertise; and other support

Summary of the financial support provided by the wider institution (both initial and ongoing)	
Summary of the infrastructure and facilities provided by the wider institution	
Summary of the human capital and other expertise provided by the wider institution	
Summary of other support provided by the wider institution	

Section 2 Ongoing support and development of centres/initiatives

In this section, we would like to explore how investment from PRTLI worked in tandem with other sources of funding to support the ongoing development and sustainability of the centre/initiative. In this section we wish to identify whether funding continued to be sourced after the initial PRTLI investment, the sources of ongoing funding and investment received (including private sector investment).

2.1 Funding for the centre/initiative

In the templates below, please provide summary details with regard to funding and investment received from individual sources. Please feel free to add additional completed templates to reflect additional sources of funding where appropriate.

Please provide details of all PRTLI funding received by the centre / initiative to date	
Cycle	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of all other national public funding received by the centre / initiative to date (e.g. Science Foundation Ireland, Research Councils , Enterprise Ireland) (1)	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of all other national public funding received by the centre / initiative to date (e.g. Science Foundation Ireland, Research Councils, Enterprise Ireland) (2)	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of all other national funding received by the centre / initiative to date (e.g. Science Foundation Ireland, Research Councils, Enterprise Ireland) (3)	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of Framework Programme funding received by the centre / initiative to date	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of other EU funding received by the centre / initiative to date	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of private sector investment received by the centre / initiative to date (1)	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of private sector investment received by the centre / initiative to date (2)	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

Please provide details of any other funding received by the centre / initiative to date	
Funding Source	
Title of Project Funded	
Period for which Funding Secured	
Total Funding Secured	
Summary of Purpose of Funding	

2.2 Involvement of enterprise

Please provide details of enterprise involvement in shaping the centre / initiative activities (this includes enterprise involvement in wider governance/management/advice for/to the centre or initiative)		
Nature of enterprise involvement and support	**Any funding provided (€'000)**	**Purpose of and outcomes from enterprise involvement and support**

2.3 Ongoing sustainability of the centre/initiative

Please identify the extent to which the centre/initiative is operating to its full potential and why this is the case				
Is the centre/initiative currently operating to its full potential	**Yes**		**No**	
Please explain				

Please identify whether the centre/initiative is currently in a position of surplus and to what extent this should remain the case moving forward				
Is the centre/initiative currently in a position of surplus?	**Yes**		**No**	
Please explain				
To what extent is this expected to remain the case over the next few years				

Please identify the key sustainability issues faced by the centre/initiative in order to continue to build research capability and impact within your specialist area

2.4 Additionality from PRTLI support of the centre/initiative

To what extent would research capability and impact have developed without PRTLI assistance?			
To the same extent		**To some extent, but on smaller scale**	
To a limited extent		**Would not have developed**	
Please explain to what extent research capability and impact within this specialist area would have developed without PRTLI assistance			

9.6.1 Section 3 Research activities and capability

PRTLI has aimed to develop research capability around key specialist areas and in this section we wish to identify how such capability has developed over time. To achieve this, we would ask you to consider the key research achievements of the centre/initiative, the impact of the work on wider research and teaching activity and capability within the wider institution, the quantifiable research outcomes generated to date and the facilitation of research collaboration with other institutions and private enterprise.

3.1 Research achievements

Please provide a summary of what you believe to be the key research achievements by the centre or initiative since PRTLI funding was secured

3.2 Relationship to delivery of wider research and teaching activities

Please describe how the development of research capability has been reflected in the delivery of teaching activity within your institution (if possible, highlighting evidence in the form of courses/modules developed, graduate destinations, enterprise involvement in UG provision)

Please describe how the development of research capability within this specialist area has been reflected in the wider research activities of your institution

3.3 Measuring research outcomes

Please provide details of the research outcomes from the centre / initiative since PRTLI funding was first sourced (but including all outcomes after the period on which PRTLI support was focused)											
Activities	**'00**	**'01**	**'02**	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**

Research Activities											
Number of Publications Published											
Number of Citations											
Number of Conference Presentations											
Conferences Hosted											
Number of PhDs graduated											
Number of Patent Applications submitted											
Number of Patent Registrations secured											
Number of Invention Disclosures											

Please provide details of other research outcomes/outputs not covered above that have been generated in the period since initial PRTLI assistance

3.4 Research collaboration activities

Please provide a brief summary of the most influential collaborative research activities undertaken since initial PRTLI funding was secured and the benefits/outcomes resulting from such collaboration. This can reflect academic, enterprise and other collaborative activity and include multi-disciplinary, inter-institutional and international collaboration		
Collaboration partners	**Summary of collaborative research activity**	**Outcomes and benefits**

Section 4 Efficiency and effectiveness of PRTLI

In examining the economic impact of PRTLI, it is important to consider the efficiency and effectiveness of its delivery from the perspective of the funded institutions. This section of the questionnaire examines perceptions of the overall effectiveness of the PRTLI programme, on the approval, management and monitoring processes in place and the barriers related to delivery of the programme that impeded its performance.

4.1 Effectiveness of the PRTLI intervention

The PRTLI was established in order to strengthen national research capabilities via investment in human and physical infrastructure. As an institution that received funding from PRTLI, how would you rate its overall effectiveness in achieving this aim?			
Highly effective		**Quite effective**	
Of limited effectiveness		**No effect**	
Please explain your reasons for rating the effectiveness of PRTLI in this way			

4.2 Clarity of objectives and rationale for funding decision

Please comment on the extent to which the objectives of PRTLI funding and rationale for funding decisions were made clear during the process				
Were the objectives of PRTLI funding made sufficiently clear at the outset?	**Yes**		**No**	
Please explain				
Was the rationale for PRTLI funding decisions made sufficiently clear?	**Yes**		**No**	
Please explain				

4.3 Satisfaction with PRTLI approval process, management and monitoring

Please rate your satisfaction with the PRTLI selection and approval process, overall management ongoing programme monitoring on a scale of 1-10, where 1 = very unsatisfactory and 10 = very satisfactory			
Cycle	**Selection and Approval Process**	**Management and Organisation of PRTLI**	**Ongoing Monitoring of PRTLI funded centres/initiatives**
Cycle 1			
Cycle 2			
Cycle 3			

Please provide any additional comments on to support your analysis and scoring of the approval process, the speed of the approval process and the management of the PRTLI programme	
Cycle 1	
Cycle 2	
Cycle 3	

4.4 Barriers to effectiveness of the scheme and areas of improvement

Please identify any particular barriers that impeded the performance and effectiveness of PRTLI and any areas for improvement in this regard

9.6.2 Section 5 Generation of current and future economic impacts

The focus of this exercise is to understand how PRTLI facilitated development of research capability and activity that could then yield economic impacts. In this section we attempt to identify existing and potential links between the work of your centre/initiative and such economic impacts. This need not only include work undertaken during the period for which PRTLI funding was received, but any activity in the interim which you believe was facilitated by the initial PRTLI investment.

5.1 Commercialisation of research

Please highlight all examples of commercialisation activities undertaken as a result of research facilitated by PRTLI investment, the outcomes, commercial benefits (as far as these can be estimated and understood) and any wider economic benefits that were generated.			
Research activity	**Commercialisation Outcomes (licenses, spin-out companies, etc.)**	**Commercial Benefits of Activities**	**Wider economic benefits generated (e.g. public health, environmental, skills development, etc.)**

5.2 Potential for commercial application of past and current research activity

In addition to the examples of commercialisation activity please identify any further potential that exists for commercial application of past and current research activity		
Research Activity	**Potential commercial application of this research**	**Timeframe for realization of benefits**

5.3 Human capital development and associated economic benefits

Do you monitor the destination and ongoing career progression of former centre/initiative staff and researchers				
	Yes		**No**	
If yes, would it be possible to have access to this analysis during the undertaking of the economic impact assessment?				

While direct commercialisation of research activity demonstrates clear economic impacts, an important yield from PRTLI lies in the development of human capital facilitated by an intervention of this kind. Former researchers within centres/initiatives may have moved on but used their experience, for example, in key business or management positions (perhaps even within the wider institution), as a stimulator of entrepreneurial activity or as a driver of further commercialised research with subsequent economic benefits generated.
Please could you provide an overview of how human capital benefits have resulted from the work of former staff and senior researchers within the centre/initiative
Please could you also consider the human capital benefits that have resulted from early career researchers (e.g. PhDs, postdocs) progressing through the centre/initiative

5.4 Driving research reputation and associated economic benefits

Please describe the impact that commercialisation and wider research activities have had on the reputation of the centre/initiative and host institution as a hub of industry-relevant R&D activity

Please describe any impact from research activities on the reputation of the centre/initiative in influencing national policy or in other areas which might lead to subsequent economic benefits (e.g. public health, environmental, enterprise/skills development, cultural development)

Please describe the role of the centre / initiative in developing national research capability and reputation in a particular field and provide any evidence to support this growth in status

Please identify whether, in your view, this development of research capability in a specialist area has had any impact on inward investment decisions in relevant sectors or on new investment by companies already based in Ireland

5.5 Other commercial benefits from centre/initiative activities

Please identify any other commercial benefits from the activities of the centre/initiative (e.g. consultancy advice, hire of facilities or equipment for industry, hosting of conferences, etc) which have been facilitated by the initial PRTLI investment

5.6 Stimulating further economic impact

Please give details of any other actions or interventions that need to be progressed in order to stimulate further economic impacts from the work of your centre/initiative or for similar centres/initiatives supported by PRTLI

Section 6: The wider Irish support system for R&D and innovation

As a programme which primarily focuses on putting in place research infrastructure, it is recognised that PRTLI can only generate the desired economic impacts in tandem with a range of other interventions and activities. As part of this assessment exercise, a key challenge will be on identifying the relationships between initial PRTLI funding and further support, interventions and activities that ultimately were able to yield long-term impacts. PRTLI must therefore be considered in the context of the wider innovation system and this final section focuses on securing the views of institutions on how this works and needs to be improved.

Please provide your views and comments on the wider Irish support system for R&D and Innovation? What are the strengths and weaknesses of the of the Irish R&D and innovation system? Can you suggest improvements for the existing system?

Profile of research and other staff

Research Staff				
	No. of Staff approved (FTEs)	**No. of Staff appointed (FTEs)**	**Salaries approved**	**Salaries paid**
Post-doctoral Fellowships				
Post-graduate Students				
Other academic staff				
Professor				
Lecturer				
Research Assistant				
Other				
Non-academic staff				
Total				

Appendix B: Impact Validation Questionnaire

Relevant Centre / Initiative:	
Organisation:	
Contact Person:	
Position:	

1. Please describe the nature of your organisation's work with the centre/initiative?

2. Has your partnership with the centre / initiative helped to increase the turnover of your

organisation directly or indirectly?

Can you please estimate the impact that your partnership with the centre has had on the organisation’s turnover (quantitatively (€))?

3. Has the centre/initiative's work resulted in any increase in employment by your organisation or ensured that staff could be continued to be employed?

Can you please estimate the impact that your partnership with the centre has had on the organisation’s employment (quantitatively (FTEs))?

4. Has the centre/initiative's work resulted in any efficiency savings or improved

productivity as a result of engagement?

Can you please estimate the efficiency savings that the organisation's partnership with the centre has had (quantitatively (€))?

5. Please provide details of any projected impacts that are expected to result in the future (increased turnover, increased employment, or efficiency savings)?

6. MNC only: Has the improved research capability in this area been a motivating factor in your initial investment or continued investment in Ireland? (to what extent)

7. How important is a strong research capability to the continuity of your business? Please explain

Appendix C: Stakeholders Consulted

Key National Stakeholders

- John Healy, Atlantic Philanthropies
- Martin Shanagher, Department of Jobs, Enterprise and Innovation
- Helen Nugent, Department of Jobs, Enterprise, and Innovation
- Aidan Hodson, Department of Jobs, Enterprise and Innovation
- Ronnie Breen, Department of Jobs, Enterprise and Innovation
- Patrick Cunningham, Chief Science Adviser
- Tom McCarthy, Advisory Science Council
- Ruth Barrington, Molecular Medicine Ireland
- Bill Dawson, Discovery 2 Medicine
- Gerry Finn, BMW Regional Assembly
- Brendan Ellison, Department of Finance
- Grainne McGucken, Department of Finance
- Kieran Moylan, BMW Regional Assembly
- Elaine Walsh, Dublin City Council
- John Shaw, Department of An Taoiseach
- Imelda Lambkin, FP7 National Support Network, Enterprise Ireland
- Martin Lyes, Enterprise Ireland
- Kevin Flynn, Enterprise Ireland
- Marcus Breathnach, Forfás
- Leonora Bishop, IDA Ireland
- Brendan Curran, Health Research Board
- Maura Hiney, Health Research Board
- Michael Gillen, IBEC
- Dipti Pandya, IRCHSS
- Martin Hynes, IRCSET
- Des Fitzgerald, Vice President of Research, UCD
- David Lloyd, Dean of Research, TCD
- Stephen Blair, S&E Regional Assembly

- Graeme Love, Science Foundation Ireland
- Gerry Doyle, Teagasc

C.1 Consultations on validation of impact

- Robert J. McCarthy, IBM
- Matt Moran, Director, Pharmachemical Ireland
- Pharmachemical Ireland Strategy Group
- Diarmuid O'Brien, CRANN
- John Colreavy, CREST
- Audrey Crosbie, Creme
- Robert Higson, VitrA
- Drew Burdon, Smith and Nephew
- Fergal Ward, Intune Networks
- Gerald O'Neill, Amarach
- Brendan McDonagh, IDA Ireland
- Enda Moran, Pfizer
- Damien O'Connell, Pfizer
- Tom O'Neill, Pfizer
- Kevin Kavanagh, Beemune
- David Moody, Beemune
- Paul McDonald, Sonitus Systems
- Ronan Thornton, Medtronic
- Conchúr O'Bradaigh, Eire Composites
- Declan Moran, DCU (formerly Bristol Myers Squibb)
- Robert Deans, Athersys
- Brian McEvoy, Isotron
- Ivan Coulter, Sigmoid Pharma
- John D. Lambkin, Firecomms,
- Carl Jackson, SensL
- Padraig McDonnell, Agilent Technologies
- Mike Kamarck, Merck
- Triona McCormack, UCD
- Jennifer Edmond, Long Room Hub
- Jim O'Hara (formerly Intel Ireland)
- Rosaleen McGuchan, Beemune
- John Neilan, Cook Medical
- Shay Lavelly, Cook Medical
- Vivienne Williams, Cellix
- Sean Lyons, Zimbie
- Donncha Haverty, HKPB Scientific
- Conchur O'Bradaigh, Eirecomposites

- Damien Woods, Caltech
- Humphrey A Moynihan, Eli Lilly
- Iain Shaw, Ovagen
- Ronan McGloughlin
- John O’Donoghue, Enbiomaterials
- Mary Galvin, Novartis
- Aine Keating, Sanofi Aventis
- Ciaran O’Morain, Qualflow
- Chris Chedgey, Headway Software
- Donal O’Sullivan, Impedans
- Anthony Davies, Biocroi

Appendix D: Schedule of Centre/ Initiative Visits

Centre/Initiative	Date of Visit
The Conway Institute for Bio-molecular and Biomedical Research (incorporating Centre for Synthesis and Chemical Biology)	12/08/2010
National Centre for Bioengineering Science [NCBES]	20/10/2010
The Biosciences Institute	15/09/2010
Institute of Molecular Medicine	01/09/2010
Institute of Immunology	29/09/2010
Institute of Biopharmaceutical Sciences	26/10/2010
Institute of Bioengineering and Agroecology	29/09/2010
Centre for Biopolymer and Bio-molecular Research	15/09/2010
Trinity Centre for Bioengineering Science	27/08/2010
Institute of Neuroscience	26/08/2010
National Institute for Cellular Biotechnology	25/08/2010
Molecular Medicine Ireland (Formerly Dublin Molecular Medicine Centre)	06/09/2010
Analytical and Biological Chemistry Research Facility	17/09/2010
Carlow IT School of Science	05/10/2010
Ussher Library	18/08/2010
Boole Research Library	31/08/2010
National Centre for Sensor Research [NCSR]	11/08/2010
National Centre for Plasma Science and Technology	01/09/2010
Materials and Surface Science Institute [MSSI]	08/09/2010
The Focas Institute	17/08/2010
Samir Nasr Institute for Advanced Materials Science	14/09/2010
Tyndall National Institute	29/09/2010
Centre for Sustainability	20/09/2010
Martin Ryan Marine Institute	13/09/2010
Institute for Information Technology & Advanced Computation [IITAC]	02/09/2010
Research Institute for Network and Communications Engineering [RINCE]	03/09/2010
Boole Centre for Research Informatics	16/08/2010
TSSG Integrated Research Building	16/09/2010

Centre/Initiative	Date of Visit
Centre for Transport Research and Innovation in People	30/08/2010
Chair of Health Informatics	04/10/2010
Cosmogrid	22/09/2010
The Geary Institute	24/08/2010
The Moore Institute	20/08/2010 & 02/09/2010
National Institute for Regional & Spatial Analysis	25/08/2010
Urban Institute of Ireland	28/09/2010
Institute for International Integration Studies	07/09/2010
Centre for Innovation and Structural Change	10/09/2010
Humanities Institute of Ireland	21/10/2010
Irish Scottish Studies	26/08/2010
Mediterranean and Near Eastern Studies	14/09/2010
National Social and Political Survey Programme	06/10/2010

Appendix E: Case Studies

E.1 PRTLI funded research infrastructure in DCU: RINCE

Located at Dublin City University, the Research Institute for Networks and Communications Engineering (RINCE) is situated within the Research and Engineering Building and occupies 1,583 square metres of space, including custom designed offices and labs for the three main centres within RINCE (HSDS, NIC and CIPA). Specialist equipment and facilities is currently valued at approximately €7 million. This includes a full suite of nanomaterials processing facilities, clean rooms, and state-of-the-art equipment such as a Micro-Raman Spectroscopy system, DC, RF & Magnetron Sputtering Facilities, and a High resolution X-Ray Diffractometer (HR-XRD). Image processing and analysis facilities include a high capacity networked image data server, a cluster computer, and 3D face imaging system.

Prior to the establishment of RINCE, the pre-existing research facilities were much smaller in scale, dispersed in separate locations across the campus, and lacked advanced, specialised equipment.

The DCU Research and Engineering Building was custom designed and built, with substantial support for three separate research institutes/centres under PRTLI Cycle 1 (The RINCE Institute, National Centre for Plasma Science & Technology and National Centre for Sensor Research). Cycle 1 also funded the initial equipment investment in RINCE.

Additional equipment and facilities have been obtained through SFI, EI, and EU grants, in addition to Cycle 4 of PRTLI. This includes, for example, a 50GHz network analyser, 12.5 Gb/s test sets, high resolution optical spectrum analysers, high speed oscilloscopes, short optical pulse generators and multiplexers, state of the art optical components and devices, wireless sensor network motes, FPGA development systems, etc.

E.2 Building a collaborative approach from the Institute for Molecular Medicine (TCD)

The Institute for Molecular Medicine in TCD was funded under Cycles 2 and 3 of the PRTLI to provide a physical centre where only a virtual centre had previously operated. The funding provided a physical facility at St. James' Hospital site and also funded the creation of a network of research in molecular medicine between UCD and TCD known as Dublin Molecular Medicine Centre (DMMC). This collaboration has since grown to a national network, including the Royal College of Surgeons, UCC and NUIG and is now called the Molecular Medicine Ireland.

Situated on the St. James' Hospital campus, the IMM was the first university research lab to be located on a hospital site in Ireland. It is now a 4,500m2 state-of-the-art facility dedicated to the research into the molecular basis of human disease. IMM's location on a hospital site permits close interaction between basic science and clinical sciences, promoting bench to bedside approach in molecular medicine.

The IMM's key research themes are infection and immunity, cancer and neurosciences. The centre provides a critical mass of high quality biomolecular and biomedical researchers closely affiliated to clinical centres of excellence. Currently, the IMM houses approximately 180 residents in 16 research teams.

The IMM is recognised as a true centre of excellence in its field and researchers from the Institute are recognised as global leaders in their field of expertise:

- The IMM has a strong international reputation as a centre of excellence in the methodologies of determining folate and Vitamin B12 status and it currently maintains a standard of quality assurance that is compatible with requirements of the US Food and Drugs Administration. This success has been crucial to the laboratory's success in gaining contracts from several high profile agencies concerned with monitoring population folate status, including the United States National Health and Nutrition and Examination Survey (NHANES) and the Food Safety Authority of Ireland (FSAI). Dr. Anne Molloy is recognised as a global expert in this field. The centre has also been involved in a number of other collaborations in the UK and Europe.
- Padraic Fallon is a Professor of translational immunology at the Institute of Molecular Medicine. Previously, a Wellcome Trust Fellow at the Department of Pathology at the University of Cambridge, Professor Fallon is an international expert in translational immunology and his research involves the use of mouse transgenics and disease models to investigate inflammatory disorders. Professor is involved in a number of international collaborations to bring his expertise in animal models of human inflammatory diseases.
- Dr. Joseph Keane leads the IMM team that is dedicated to the basic research of the host response to tuberculosis. Research is carried out on the background of clinical activity, which includes running a super-regional service for tuberculosis patients and a number of research projects that investigate the role of TB-diagnostics in different patient settings. In response to the TB outbreak at a primary school in Ballintemple, Dr. Keane's expertise were called upon to advise on an appropriate response to the issue.

E.3 The Approach to Applied Research by the Telecommunications Software & Systems Group (TSSG)

The TSSG was established in Waterford Institute of Technology in 1996, funded by Enterprise Ireland and EU funding. The TSSG received PRTLI funding under Cycle 3 of the programme, where €5mn was provided for a new purpose-built TSSG building, completed in 2005. The building was co-funded by Enterprise Ireland with the dual purpose of establishing a joint research and innovation centre. Arclabs was established to accommodate R&D, entrepreneurship training and company incubation under one roof. This co-location of entrepreneurs with researchers working in similar areas provided a culture of entrepreneurship, a flow of ideas between researchers and industry partners and a natural environment for sharing ideas, knowledge transfer and exploring new opportunities.

The co-location of research and commercial activities in the same building had a very positive impact and proved successful in attracting additional funding. TSSG became the most successful Irish research centre in the EU FP6 and FP7 programmes in ICT. The centre also established itself as one of the most successful centres at winning EI commercialisation funding (CF-TD, PoC, Innovation Partnerships, and ILRP), creating meaning full links with Irish industry, and creating 14 spin out companies. Most recently the TSSG has diversified to allow engagement with smaller Irish SMEs though the EI Innovation Voucher scheme, and the TSSG has delivered on 52 vouchers with 40 companies. TSSG provides a unique model for academic R&D in Ireland:

- Based in academia with the advantages of an industrial mindset, TSSG provides a critical mass of basic research, applied research, experimental development and emerging cluster of spin-out and spin-in companies
- Strong collaborative links with 425 academic and industrial partners worldwide in 35 countries: a real understanding of industry problems
- Leading the Communications Management for networks and services in Europe, providing World class excellence across all areas of the Research and Innovation lifecycle.
- Creating jobs both in TSSG (140) and in wider Economy (60)

E.4 National Centre for Cellular Biotechnology (NICB) and Beemune

"If the bee disappeared off the surface of the globe then man would only have four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man." - Albert Einstein

Bees, via pollination, are responsible for 15 to 30 percent of the food that U.S consumers eat and 40 percent of all fruit and vegetables globally. But in the last decade, commercially managed honey bees have suffered from increasing ill health due to factors including diseases spread as a result of mites and other parasites as well as the spraying of crops with pesticides. This problem came to a head in 2007 when nearly two thirds of the entire commercial bee population was wiped out during the winter hibernation season. This phenomenon known as Colony Collapse Disorder (CCD) is not yet fully understood however the problem is quite severe in the United States, parts of mainland Europe and Australia.

Beemune, an Irish spin out company, was formed on the basis of research conducted by Dr. Kevin Kavanagh who was funded under Cycle 3 of the PRTLI. Kevin, who is a senior lecturer in the Department of Biology at the National University of Ireland Maynooth, has had a long standing interest in the immune systems of insects and in studying structural and functional similarities with the innate immune system of mammals. In 2007, Dr. Kavanagh successfully discovered a method by which he could increase or decrease the immune system of a moth caterpillar. This discovery led to Dr. Kavanagh successfully applying his solution to bees, as a way of combating CCD and safeguarding the health and well being of bees.

In 2009, Dr. Kavanagh alongside David Moody and Rosaleen McGuckin founded Beemune and have begun to work with market resellers to trial the solution. It has been estimated that honeybees contribute over $200 billion to the global economy and the commercial bee industry is worth an estimated $3.5 billion alone.

According to Dr. Kevin Kavanagh; “PRTLI transformed the research environment in Ireland. Funding from PRTLI Cycle 3 allowed fundamental research to be performed on the insect immune system which was then applied to developing a therapy for the treatment of diseases in bees. This step was the foundation for the launch of Beemune, a company which will target the problem of colony collapse disorder that is affecting bee populations in the USA and in other intensive farming regions.”

E.5 The Materials and Surface Science Institute (MSSI) and HKPB Scientific

HKPB Scientific is an innovative R&D company with a number of patented technology platforms that service the medical device industry. The company was incorporated in 2008 by two scientists, Donncha Haverty and Brendan Kennedy, from the University of Limerick and the MSSI to develop and commercialise a new process technology for making calcium phosphate biomaterials, compounds

used extensively in orthopaedic medicine. Since its incorporation the company had been engaged in extensive research and development in collaboration with the MSSI and Dr Seamus McMonagle. Having taken their technology to the point where it was proven and sufficiently protected internationally as intellectual property, in 2009 the attention switched to building a business by sourcing equity funding. The company closed a €500K investment in March with Tolisons Private Equity and joined forces with David O'Flynn, a successful entrepreneur who joined the company as CFO. The blend of scientific and commercial talent is proving a recipe for success, with the company establishing a manufacturing operation in Nenagh, Co.Tipperary with plans to make sales in the highly regulated market by the first quarter of 2011. HKPB currently employs four people full time and four part-time but has ambitious plans for the future, intending to ramp its manufacturing operation to a company employing 20 people by the end of 2011. The medical device industry is a multi-billion dollar global market with strong growth rates projected into the foreseeable future.

The company's CEO attributes significant importance on the work with the institute. "Innovative companies need access to centres of excellence like the MSSI both in terms of the human resources and expertise and to access the equipment and R&D facilities required to build companies like HKPB. As a company we continue to invest in research and intend to maintain and deepen our relationship with the MSSI as it is a vital part of our strategy for growth and sustainability. We recently received approval to co-fund a research project with IRCSET to facilitate development of a second technology that we have in the pipeline. This will be run at the MSSI under the auspices of Prof. T. Pembroke, Prof. T. McGloughlin and Dr A. V. Piterina, a collaboration of internationally recognised expertise in biochemistry, molecular biology, proteomics and biomedical engineering. In addition to benefiting the company we expect the research findings to be published in world class journals thereby enhancing the international scientific reputation of the company, the MSSI and the university. If HKPB is to thrive and grow successfully in Ireland it is critical that we continue to have access to this level of expertise on our doorstep."

E.6 The National Centre for Plasma Science & Technology (NCPST) and Industry Contribution to Research Infrastructure

The NCPST at Dublin City University (DCU) is a multi-disciplinary centre bringing together scientists and engineers from the faculties of science and health and engineering and computing. Since receiving funding from the PRTLI under Cycles 1 and 3 (and then subsequently 4 and 5) has a long track record of working successfully with industry partners. This has helped to generate private sector investment of over €15million. The centre depends on highly expensive equipment with relatively short lifecycles to function effectively. However it has been able to counter this issue by securing substantial donations in-kind of state of the art equipment from its industry partners. This has involved multi-million euro investments from these partners and includes:

- A Plasma Processing Facility donated by Intel
- Advanced plasma processing equipment provided by the Lam Research Corporation
- Laser Etching Device and Excimer donated by IBM

The NCPST became the hosts (with RINCE) of the new 'Precision' Strategic Research Cluster when it was set up in 2009, which includes Intel and seven other industry partners. It has worked closely on research projects with Hewlett Packard and Oxford Instruments as well as the companies noted above and has generated five spin-outs since 2005

E.7 Analytical and Biological Chemistry Research Facility, UCC and Industry Collaboration

The Analytical and Biological Chemistry Research Facility (ABCRF) was established in UCC in 2002 and the ABCRF building, located in the Cavanagh Pharmacy Building, was opened in 2006. Funded under Cycle 3 of the PRTLI, the ABCRF was established to develop the relationship and interactions between Chemistry, Biology and Pharmacy, in line with international developments in the area. The Chemistry-Biology interface forms the core basis for research in the pharmaceutical industry and the process of drug discovery and development.

The centre received a total of €7.7Mn under Cycle 3, which included €6.2Mn in Capital funding and €1.5Mn in recurrent funding. The role of the ABCRF is to:

- Provide state-of-the-art research infrastructure;
- Develop inter-disciplinary research teams of relevance to the pharmaceutical industry;
- Provide high quality training to PhD students and post-doctoral researchers.

The co-location of the ABCRF with the pharmacy school provides a seamless interface and active research culture that offers a state of the art centre of excellence in UCC. The ABCRF uses this facility to link key Principal Investigators and researchers across the disciplines of chemistry, biochemistry and pharmacy and this provides an ideal portal for interaction between UCC and the pharmaceutical industry nationally and internationally.

The ABCRF has, as one of its core objectives, collaboration and liaison with the pharmaceutical industry with 14 of the world's top 15 pharmaceutical companies located in Ireland. The pharmaceutical sector is at a critical phase in its development in Ireland with a shift from a manufacturing focus to a renewed focus on Research and Development activities. Ireland can no longer compete with low-cost economies for manufacturing and needs to become the site where all major companies do their first scale-up of any new compounds and then ship them to cheaper sites for later stage, low-cost manufacturing. The strategic development of the industry is essential to ensure the Irish sector remains ahead of global competition.

The ABCRF plays a critical role in facilitating many of the companies in the pharmaceutical sector as they move up the value chain, providing access to research infrastructure, PhD and post-doctoral researchers, state-of-the-art technical services and research collaboration. The ABCRF is a member of the Solid State Pharmaceutical Cluster with four PIs and ten full-time researchers at PhD and post-doctoral level working on the solid state cluster research programme. A laboratory has been dedicated to accommodate the work of the solid state pharmaceutical cluster, providing access to state-of-the art equipment. Other industry partners with whom the centre works include: Almac, Pfizer, Eli Lilly, CCDC, Stiefel, GSK, Luxcel, Boston Scientific, NIST, Nycomed, Shire, Corden, Schering Plough, Trident Bioanalytics, Leo Pharma, GE Healthcare, Janssen, Johnson Matthey, Novartis, Cognis, EiRx, Innocoll, NIST, Merck, Waters, Tanaud and Shire BioChem.

E.8 Materials and Surface Sciences Institute working with Industry to Deliver Efficiency Savings

The Materials and Surface Science Institute (MSSI) was established in 1998 with the mission to provide a centre of excellence generating state-of-the-art fundamental research on topics of industrial significance in the fields of surface science and materials. MSSI received a total of €15.75Mn during Cycles 1 and 3 of the PRTLI. The bulk of this investment was in Cycle 1 of the programme (€14.5Mn) and the outstanding €1.25 was provided in Cycle 2.

The Institute houses a multidisciplinary team of scientists (chemistry, materials science, physics and biochemistry) and engineers (mechanical, aeronautical, biomedical, manufacturing and electronic), who undertake research focused on the design of materials for (i) Health, (ii) Transport, (iii) Energy and (iv) Clean Technology.

Since it's founding in 1998 MSSI has focused on fundamental research on topics of industrial significance. This has resulted in achievements that have added significant commercial value to a number of industrial partners:

- Rusal Aughinish Alumina (RAL) operate an alumina refinery on the Shannon estuary ca. 20 km from Limerick The application of in situ x-ray diffraction methods to optimise the Bayer process has enabled RAL to improve processing yields from bauxite (annual savings of €1.5 M), making the plant the most efficient of its type worldwide. A direct outcome of this and related projects has been the establishment of research expertise at RAL, which has ensured continuity for the plant and safeguarded 400 jobs in the region.
- Design of a new low-cost alloy with improved radio-opacity is now under development for use as a stent material by Cook Medical, Inc. This work and the associated research programme has enabled Cook Ireland to establish an R&D facility near UL.
- Discovery of piezo and pyroelectric properties of hydroxyapatite. Two spinout companies have been established on the basis of this technology (EnBio and HKPB).
- Development of the Bone Quality TestTM, a portable, point of care screening test for osteoporosis. The test is currently undergoing clinical trials by Crescent Diagnostics, a spinout company from UL.

Key research achievements within MSSI's current research themes include:

- Pharmaceutical Materials: Demonstrated how nucleation, crystal growth and agglomeration, processes affect crystallisation processes, leading to an improved understanding of the role of the solvent and the influence of mixing on the process of crystallisation.
- Biomedical Engineering: Developed method to assess drag forces in endovascular devices for treatment of aneurysms. Applied Dean flow model in aneurysm flow mechanics to enable modelling of blood flow in a bend and developed models to assess aneurysm rupture behaviour. Developed patented (US7651526) vascular graft.
- Biomaterials: Invented a radiopaque NiTi alloy to provide a superior solution to radiopacity issues for NiTi devices. This alloy is currently being commercialised by Cook Medical, Inc.

E.9 Examples of thought leaders attracted to work with centres and initiatives

Tofail Syed, Materials and Surface Science Institute - UL

Tofail came from Bangladesh's top university, Bangladesh University to do his PhD in MSSI, with the top scores in his class. He had the opportunity to study at some of the top materials science centres in Europe, including Cambridge, Sheffield and Birmingham as well as in Canada and the United States but opted for MSSI in UL. Following his PhD, Tofail opted to do a fellowship in his specialist area of material characterisation at MSSI. Through his work at MSSI, Tofail has gained international acclaim from his ground-breaking work and discovery of a new crystal phase with hydro-electric properties in bone. His work has been presented internationally and he continues to work with global leaders in his field. As well as raising his own reputation, Tofail's success has raised the profile of the centre internationally. MSSI is now seen as a centre of excellence in its field of expertise and the centre is the lead partner on a number of European funding projects in the area in recognition of the unique expertise available at the centre.

Frank Barry, National Centre for Biomedical Engineering Science (NCBES) - NUIG

Frank Barry is the centre director at the National Centre for Biomedical Engineering Science at NUIG. Frank spent fifteen years working for a stem cell technology company, called Osiris, a global leader in stem cell research. As a result, Frank does not have a typical academic background and is well-positioned to provide an appropriate bridge between researchers and industry. Frank's position as a senior manager with Osiris provided him with the experience and understanding to liaise effectively with industry partners and this has provided the basis for his success. Frank understands how industry works and what the drivers and this allows him to manage research that is focussed on a practical end point and a commercial purpose.

Frank was attracted back to NUIG by the momentum that had gathered pace for research in Ireland under PRTLI. This investment represented a fundamental shift in the pace, approach and attitude to research and as a result, some very talented were coming to Ireland to do interesting work in ground-breaking areas. Thus, a culture of innovation developed and was nurtured across Irish universities and Institutes of Technology. There was a particular focus on biomedical sciences at the time both at national level and in NUIG and Frank saw that this provided an opportunity to engage in translational research in Ireland with a focus on manufacturing and testing as opposed to traditional academic research. Frank's focus has always been research that is commercially meaningful and industrially relevant.

James Heckman, Geary Institute and Conway Institute - UCD

As a consequence of the developing reputations of the Geary and Conway Institutes within UCD, they were able to build strong links with the University of Chicago and appoint Professor James Heckman as Professor of Science and Society. Professor Heckman won the 2000 Nobel Prize in Economics and has a significant global reputation. He has significantly increased the profile of the two institutes, helping to lever additional funding, stimulate research outcomes and increase student demand for courses.

Jean-Pierre Colinge, Tyndall National Institute – UCC

The Nanoscale Science and Technology Initiative funded under Cycle 3 of the PRTLI allowed the Tyndall National Institute to put in place world class research infrastructure with a focus on stimulating inter-disciplinary and inter-departmental collaborative research activity. This provided a platform to attract international thought leaders, with Professor Colinge appointed as an SFI Principal Investigator focusing on 'Advanced Scalable Silicon-on-Insulator Devices for Beyond End of Roadmap Semiconductor Technology'. Prior to joining Tyndall, he was professor at the University of California from 1998 to 2006 and at Université catholique de Louvain from 1991 to 1997. His work in Ireland has achieved notable success, with Professor Colinge named SFI Researcher of the Year in recognition of his position as a world leader in semiconductor research. A key breakthrough has been his work in fabricating the world's first ever junctionless transistor.

E.10 Examples of centre/initiative research leading to development of undergraduate teaching

The FOCAS Institute based at DIT has created 3 modules as a direct result of research conducted at the centre namely, Science with NanoTechnology, Forensic & Environmental Analysis and Physics with Medical Physics and Bioengineering

National Centre for Plasma Science & Technology (NCPST) developed a Masters programme in Plasma and Vaccuum Technology and subsequently built this into an industry training programme

TRIP at TCD developed four new postgraduate modules focused on transportation

Institute of Neuroscience in TCD developed a BA (Mod) in Neuroscience as well as an MSc in Neuroscience and PhD program Neuroscience.

Environmental Research Institute in UCC supported the development of a Masters in Coastal Zone Management and an MSc in Marine Biology.

E.11 The National Centre for Sensor Research (NCSR) and the development of undergraduate teaching

The NCSR has had significant impact on the teaching modules delivered within the schools under the faculty of Science and Health. A Good example of this is the creation of a course entitled Physics with Biomedical Sciences. This course has been designed to provide both a solid background in physics and in the principles which underpin chemical, biological and life sciences, and a good understanding of the most recent developments such as nanosystem design or ultrafast molecular switching. It is ideally suited to the needs of students who intend to pursue a career in physics and technology related to medical research, clinical services or biomedical industries. St James's Hospital, Dublin, is a partner in both the development and the running of the Physics with Biomedical Sciences course. This course is directly related to the evolution of biomedical research at NCSR. Recently as part of an additional approach for this course a six week laboratory programme has been designed that will enable third year students to partake in the design, creation and characterisation of medical microfluidic devices. This course will use personnel and instrumentation from NCSR to deliver the programme. This is a practical intervention arming these students with skills that will hopefully be employed in the Medical device companies in Ireland during their INTRA industrial placements which take place in the following semester from the programme. Due to the fact that all NCSR PIs have teaching responsibilities the research outcomes from NCSR have helped shape course content over the past decade. Often examples of cutting edge research are used to underpin the fundamentals being taught and to share real world examples with students. NCSR is contributing the distance education programme in the newly offered MSc in Management of Sustainable Development and is engaged with teaching the MSc in Bioprocess engineering offered through the School of Biotechnology. In addition, bespoke workshops are offered to industry and academia on niche areas of interest.

E.12 Examples of conferences held as a result of research specialism developed through the centres and initiatives

Examples of some of the conferences that have been held include:

- European Physical Society Conference hosted by NCPST in DCU with 750 delegates
- CISC Innovation System Conference in Galway with 400 attendees
- Urban Institute Ireland GIS Conference in UCD with 1,000 participants

E.13 Centre for Transport Research and Innovation in People (TRIP) and the generation of environmental impacts

TRIP in TCD was funded under Cycle 2 of PRTLI to bring together different academics with an interest in transport research and create a critical mass to examine the issues around traffic congestion and capacity and its wider economic, societal and environmental effects. The Centre has grown to become the leading transport research centre in Ireland and can demonstrate a number of research achievements to date;

- Contributing to road safety improvement by developing research around driving simulation, with the simulation kit in place within the centre.
- Undertaking a scoping study for establishment of a national cycle network for the National Roads Authority and this has the potential to deliver both environmental and tourism impacts in the future.
- Working on a FP7 collaborative research project with ESB, involving significant funding by the company on the Green E Motion project on electric vehicle trials
- Delivering transportation noise monitoring services to clients including local authorities via a spin-out company, Sonnitus.

E.14 Research into Digitisation in the PRTLI supported centres leading to development of the Long Room Hub

With 420 years of scholarly tradition, Trinity College Dublin is one of the leading universities globally in the area of arts and humanities. However, during the 2000's you could be forgiven for thinking innovation was restricted to the areas of Science, Technology and Engineering. But with hundreds of years of tradition to build on, TCD decided to shift some of their focus back to what made Ireland the land of "Saints and Scholars".

After securing funding in Cycles 1 & 3 in the areas of Mediterranean and Near Eastern Studies and Irish Scottish Studies, TCD decided to grow its expertise in the area of Arts and Humanities by developing a dedicated institute for the advanced studies in the arts and humanities, but positioned high technology alongside its high thinking. Despite the economic downturn, that has put a dampener on the growth aspirations of many universities; the Irish government through PRTLI 4 gave €10.8 million to TCD for the construction of the Long Room Hub as part of the Humanities Serving Irish Society (HSIS) project.

The work going on in the centre has already begun to change people's views of the impacts that arts and humanities can have on business. Trinity is drawing on the past to inform the future, creating new scholarships and consolidating existing fields of enquiry through innovative use of digital technologies. Although the word computer preceded the collection of the 1641 depositions by almost 30 years, only in this century are they coming together. Using the witness statements made after an Irish Rebellion nearly three and half centuries ago to teach today's IBM computers how to understand language is just one way the arts and humanities are helping a multinational corporation to innovate.

E.15 Examples of multi-nationals investing in research, development and innovation

The following companies have been recorded by IDA Ireland as having invested in research, development and innovation projects within the last 3 years:

- Smith and Nephew
- United Technologies Research Centre
- Alcatel-Lucent /Bell Labs
- HP Galway
- Biotrin
- Accenture's Global Analytics Centre
- Alps Electric
- SITA
- Siemens
- IBM
- Boston Scientific
- Citi
- Intel
- Pfizer
- Helsinn
- Paypal
- Colgate-Palmolive
- Merck

- Analog Devices
- Cisco
- Wyeth
- Aon
- Medtronic
- Pawels Trafo
- Johnson and Johnson
- GSK

E.16 Examples of policy impacts generated by the supported centres and initiatives

- Within the Urban Institute Ireland at UCD, the former head of the institute, Professor Peter Clinch, was appointed as a special adviser to the government on the economy. The Institute also deployed its expertise in feeding into the development of regional planning guidelines. The Institute itself will shortly be merged into a larger Earth Sciences Institute which should further raise the profile of the research conducted.
- The Martin Ryan Institute in NUIG has advised Sustainable Energy Ireland (SEI) on offshore development policy with regard to renewable energy. As above, the Institute has been merged to form a wider research initiative to further build reputation and profile, now coming under the umbrella of the Environmental Change Institute.
- The Geary Institute at UCD has advised Irish and UK Governments in relation to economic policy and has also helped support the work of the Commission on Taxation.
- The Centre for Innovation and Structural Change (CISC) in NUIG has developed a reputation around understanding the innovation system and the development process in establishing clusters and sector specialisations. The Centre has advised the Border Midland and Western (BMW) Regional Assembly on innovation policy and Professor Seamus Grimes is currently working with Forfas on innovation-related policy work. The centre has also developed journals on business and housing that are widely circulated to relevant stakeholders, including Government contacts.
- The National Institute for Regional and Spatial Analysis (NIRSA) is currently carrying out extensive research on the impact of the property collapse in terms of the ghost estates that have been left in cities and towns around Ireland. The research and analysis that NIRSA is feeding into national policy dialogue on this current topical issue. NIRSA has also developed considerable expertise around local development and planning issues and has worked extensively with local authorities, City and County Development Boards, the former Department of Community, Rural and Gaeltacht Affairs and the Department of Environment, Heritage and Local Government to provide advice and inform policy development.
- Experts from the Institute for Molecular Medicine have been involved in advising governments nationally and internationally on relevant policy issues. For example, IMM experts were called to advise on the TB outbreak in a Cork school in September 2010. Another PI is advising the relevant US standards authority in relation to Vitamin B12 guidelines. She is the only non-US adviser on the expert panel. The same expert has advised the UK Food Safety Authority on similar issues. As a result, the Institute for Molecular Medicine is regarded as a global centre of excellence in this particular field.

Appendix F: Summary of Focus of the PRTLI Supported Centres & Initiatives

Centre/Initiative	Overview of Activities
The Conway Institute for Bio-molecular and Biomedical Research UCD	The Conway Institute was established to foster interdisciplinary, collaborative research with an initial overarching theme of 'molecules to man'. With a competitive approach to selection of members of the Institute, it brought together PIs across chemistry and animal and human clinical sciences, while also incorporating expertise in related disciplines such as computer science and chemical engineering. The Institute has developed into a hub of interdisciplinary research focusing on cutting edge technologies in molecular cell and systems biology to explore major questions in biology and biomedicine. Specific expertise has been attracted in the Institute in areas including proteomics, bioinformatics, epidemiology, glycochemistry, translational science, glycobiology and comparative genomics.
Centre for Synthesis and Chemical Biology (CSCB) UCD	One of the three pillars of the Conway Institute was synthesis and chemical biology and this led to the establishment of a dedicated research centre under this theme. A collaborative initiative between UCD, TCD and RCSI, the Centre was established after being awarded funding under Cycle 3 of PRTLI, which supported a new Centre building covering 2,300 square metres and which included six state-of-the-art laboratories.
National Centre for Bioengineering Science (NCBES) NUIG	Since its establishment in 1999, the National Centre for Biomedical Engineering Science (NCBES) has prioritised four major research themes; Biomedical Engineering, Cancer, Neuroscience and Regenerative Medicine. These themes are underpinned by enabling expertise and technologies in bioanalytical sciences, imaging, biomedical informatics, and glycosciences. It is an interdisciplinary centre of research excellence, which brings together scientists, engineers, information technologists and clinicians in a team-based, problem-centred approach to research. The Centre's research is focused on innovative therapeutic solutions to current medical challenges including cardiovascular disease, orthopaedics, reproductive medicine, and cancer.
The Biosciences Institute UCC	Biosciences Institute is the research arm of the School of Life Sciences in UCC. It brings together disciplines of Anatomy; Biochemistry; Microbiology; Physiology; and Pharmacology and Therapeutics).
Institute of Molecular Medicine (IMM) TCD	The IMM was established in 2003 to provide a multi-disciplinary research centre for collaborative molecular medicine research, linking directly with areas of research into cancer, leukaemia and the molecular basis of disease, providing a major contribution to graduate education in the life sciences. The PRTLI supported the development of a 4,500 m^2 state-of-the-art facility dedicated to research into the molecular basis of human disease. The Institute has worked closely with Molecular Medicine Ireland and its predecessor the Dublin Molecular Medicine Centre on maximising the impact from its research.

Centre/Initiative	Overview of Activities
Institute of Immunology NUIG	The Institute of Immunology was established from the work of the Department of Biology in NUIM with a small group of researchers coming together with a vision to establish an internationally recognised centre of excellence in immunology. Its research portfolio ranges from studies on inflammatory diseases that are highly prevalent in Ireland, such as multiple sclerosis , rheumatoid arthritis and asthma to early clinical studies on new vaccines and defining the immunomodulatory potential of stem cells.
Institute of Biopharmaceutical Sciences RCSI	The Institute of Bipharmaceutical Sciences, now termed the RCSI Research Institute, has an overall mission to promote translational medical research, aiming to conduct laboratory research informed by clinical problems, translated into improved diagnostics and therapies and into the community. The work has involved biomedical research in selected disease areas, with access to hospitals and clinical expertise a core focus (and with a core activity involving the training of clinician scientists to PhD level. Key research themes have included clinical research (via the Clinical Research Centre at Beaumont Hospital); biobanking; in vivo modelling of diseases and technologies; drug discovery and synthesis of chemical probes; molecular, cellular, animal and human imaging; and human genomics.
Institute of Bioengineering and Agroecology (IBA) NUIM	The Institute of Bioengineering and Agroecology (IBA) builds on a pre-existing consortium of six academic laboratories at NUI Maynooth. Between them, the labs dealt with cell and molecular biology (including genetic transformation) of plants, and various aspects of biochemistry, physiology and ecology of biological control agents. Its overall concern is the benign manipulation of organisms for field use, in pursuit of food security, human health, environmental enhancement, and novel materials.
Centre for Biopolymer and Bio-molecular Research (CBBR) AIT	The CBBR was a multidisciplinary research centre engaged in research on biopolymers and pharmacologically active compounds and materials specifically in biodegradable materials, cell and molecular science, environmental science & chemical analysis and Biomedical and health sciences. It was the first research intensive centre established in AIT and increased capabilities in areas such as bioinformatics.
Trinity Centre for Bioengineering Science (TCBS) TCD	The Trinity Centre for Bioengineering provides a structure to bring bioengineers, basic scientists and clinicians together to focus on particular clinical needs. It has 5 research themes: biomaterials; regenerative medicine; musculoskeletal research; cardiovascular systems; and neural engineering. These themes are based on the intersection of biomedical science and engineering and form the research foundation for enabling technologies for advances in key areas of active and passive implantable devices; surgical and medical device design; and in informing clinical studies and interventions in ageing, neurodegeneration and rehabilitation. TCBE has 9 high specification laboratories covering areas including tissue engineering and testing, microscopy and biomechanics.
Institute of Neuroscience (TCIN) TCD	The Institute serves as a national research centre for neuroscience, having built up critical mass over the last decade from a position where only a loose affiliation of researchers across different schools and faculties with an interest in the subject. The particular research strengths of TCIN lie in neurodegeneration; psychiatric diseases; neural development and plasticity. A core aim is to bring therapies from bench to bedside and an important translational theme lies in ageing research.
National Institute for Cellular Biotechnology (NICB) DCU	The NICB is the designated national centre for cell culture research. It looks to take basic research into cell and molecular biotechnology and translate the outputs from this research into practical application in collaboration with clinicians and industry. The NICB built on the research base established by the National Cell and Tissue Cultural Centre which was formed in 1987. Core research programmes include: translational research on cancer therapeutics,

Centre/Initiative	Overview of Activities
	pharmacology and drug resistance; cancer biomarker discovery; cell and molecular biology underpinning biopharmaceutical production; research directed towards stem cell therapy/tissue engineering for ocular diseases and diabetes; molecular virology; and synthesis of bioactive chemicals.
Molecular Medicine Ireland (Formerly Dublin Molecular Medicine Centre) TCD, UCD, RCSI (plus NUIG and UCC post Cycle 3)	The Dublin Molecular Medicine Centre was formed through funding in Cycle 2 of PRTLI as a partnership between TCD and UCD. It increased its activities with support under Cycle 3, with RCSI then joining the partnership. It expanded to become Molecular Medicine Ireland under Cycle 4 in 2008, with NUIG and UCC then joining. Its overall mission is to improve healthcare through development of diagnostics and therapies from concept to realisation, coordinating, supporting and promoting translational research via a sustainable national system.
Analytical and Biological Chemistry Research Facility (ABCRF) UCC	The ABCRF was established in 2002 to build on previous informal relationships and bring together researchers from disciplines of chemistry (including organic, pharmaceutical and analytical) and biochemistry. It provides state-of-the-art research infrastructure to underpin research at the Chemistry-Biology interface – NMR, LC-MS, XRD etc. It has developed interdisciplinary research teams across the various areas of research in Biochemistry, Chemistry and Pharmacy of relevance to the pharmaceuticals sector including organic, analytical and pharmaceutical chemistry and formulation and drug delivery. It has a core focus of meeting the research and skills needs within this industry sector and works closely with commercial partners in this regard.
Research Programme in Environmental Science IT Carlow	PRTLI supported the Biotechnology and Molecular Environmental Science (BMES) Research Programme at the Institute. This programme consisted of various project areas which have been designed to exploit bioinformatics, genomics, proteomics, microarray and biocatalyst technologies to strengthen the scientific base for beneficial developments in bioremediation for environmental pollutants, agricultural practices for crop protection and environmental management, stereospecific biosynthesis of food and healthcare products, diagnostic biomedical / biochemical methodologies.
National Centre for Sensor Research (NCSR) DCU	The National Centre for Sensor Research is a multidisciplinary research facility focused on the science and applications of chemical sensors and biosensors. A key feature of the NCSR is the multidisciplinary composition of the research team, which includes physicists, chemists, biotechnologists and engineers. The research programme of the NCSR includes both fundamental and applied projects, ranging from basic studies of molecular interactions to prototype development for industrial partners. NCSR is focused on developing future sensing technologies for economic and societal benefit for application in personal health monitoring and diagnostics, environmental monitoring, (bio) process optimization and nano/bio-medicine.
National Centre for Plasma Science and Technology (NCPST) DCU	The National Centre for Plasma Science and Technology is a multidisciplinary research centre with research staff from the faculties of science and health and engineering and computing at DCU and with affiliations to groups at NUI Maynooth and IT Tallaght. With approximately 80 members focusing on programmes in basic scientific research, technological applications and industrial collaborations, the centre aims to be a world class centre for plasma related research. There are 5 core research themes: sustainable energies from plasmas; nanoscience, photonics and materials; mathematical and computational modelling; sources, diagnostics and measurement; and astrophysics.
Materials and Surface Science Institute (MSSI) UL	The Institute was established in 1998 to provide a centre of excellence generating state of the art fundamental research on topics of industrial significance in the fields of surface science and materials. It brings together a multi-disciplinary team of scientists from chemistry, materials science, physics and biochemistry disciplines. The main research themes are: (1) Nanomaterials (2) Biomaterials (3) Composite and Glass Materials and (4) Bio/Catalysis and Clean Technology.

Centre/Initiative	Overview of Activities
	Within these core research themes, MSSI is committed to focusing research activity on the topics of Nucleation, Growth and Microstructure of Materials.
The Focas Institute DIT	The facility addresses the common needs of research activities in Science and Engineering. It aims to promote interdisciplinary collaborations within the Institute and with other national and international bodies, and to provide a support service for national industry. It contributes strongly to the development of self-sustaining research teams in a number of strategic areas, such as bio and nano technologies. The Institute provides state of the art core laboratory support for a range of research groups and seminar and meeting room facilities.
Samir Nasr Institute for Advanced Materials Science TCD	The Institute for Advanced Materials Science (IAMS) provided a new fully-commissioned building and an associated interdisciplinary research programme. The research addresses key scientific and engineering topics with an aim to expand Trinity's role as a nationally and internationally leading centre in Advanced Materials by fostering top-quality research in this field. Activities include strategic basic and applied research, technology transfer, industry services and training, and research support and liaison with related spin-off and campus companies
Tyndall National Institute UCC	The Tyndall National Institute was established by bringing together researchers from the National Microelectronics Research Centre (NMRC), UCC Physics and Chemistry departments and Cork IT. Tyndall's vision for its contribution to Ireland's future lies in the work of world-class teams performing ground-breaking research on new materials, devices and systems with a "from atoms to systems" philosophy and focusing on "delivering value from research" to the Irish economy. This will be delivered through the focusing of ICT research activities into three strongly inter-related technical areas: Micro/nanoelectronics; Photonics and Microsystems. The drive to develop systems is based upon leading research in materials (especially nanomaterials), electronic and photonic devices and advanced packaging/sub-systems integration. It is supported by strong activities in Theory, Modelling and Design, and a high quality Central Fabrication Facility (CFF) for materials and devices.
Centre for Sustainability IT Sligo	The Centre for Sustainability was established in 2001 to focus on interdisciplinary research in sustainability. The PRTLI support helped to significantly enhance the research facilities, management structure and culture at the Institute. To date, the Centre's activities have been in six main thematic areas: biosolids treatment and reuse; treatment of and energy recovery from farm wastes; access to environmental information, decision making and justice; renewable fuels from marine biomass; bog rehabilitation; and wastewater Treatment Optimisation. Projects are currently being planned in renewable fuel from wood, development and promotion of hydrogen fuel cells, biodiesel production process development and environmental technology development.
Environmental Research Institute (ERI) UCC	The Environmental Research Institute was established in 2000 with a mission to support environmental research, training and development. It brings together expertise in the biological, chemical and environmental sciences as well as in environmental engineering, energy and environmental law. The main aims of the Institute are to foster collaborative, multi-disciplinary environment based research; facilitate the development of a number of key research thematic areas; train postgraduate research students for careers in the environmental sciences and engineering; and to facilitate the transfer of technology to industry.
Martin Ryan Marine Institute NUIG	The Martin Ryan Institute for Marine Research at NUI Galway aimed to modernize traditional marine biology and research through the use of biology, chemistry, physics and IT to generate the best possible understanding and usage of seas while preserving and enhancing them for continuing benefit. PRTLI supported the construction of a new Institute building which houses both a robotic laboratory and PhD lab. Its recent merger with the Environmental Change Institute means that it

Centre/Initiative	Overview of Activities
	now focuses on 6 thematic areas: climate change; energy; marine and coastal processes; environment and health; biodiversity and bioresources; and sustainability and built environment.
Institute for Information Technology & Advanced Computation (IITAC) TCD	The goal of the institute was to become the focus for TCD's world class research work in Computer Science and in HPC. It was set up to encourage and enable clustering of research activities from a variety of schools including Physics, Chemistry, Genetics, Pharmaceutics, Computer Science and Maths. The PRTLI funding contributed to the construction of the Lloyd Building where the IITAC is currently housed. The work of IITAC currently supports multidisciplinary research programmes involving over 100 researchers.
Research Institute for Network and Communications Engineering (RINCE) DCU	RINCE is a national centre for excellence focused on innovations in targeted engineering technologies, located within the Faculty of Engineering and Computing at DCU. Working through a centre sub-structure, RINCE has supported work in areas including network innovations, image processing and analysis and high speed devices and systems. Smaller research groups also exist around e-accessibility, speech processing and artificial life.
Boole Centre for Research Informatics (BCRI) UCC	The Centre was constituted to explore the area of research at the boundary between computer science and mathematics. The research conducted was around 3 thematic areas: information theory; theory of computation and computing paradigms. In total, the Centre funded in excess of 16 distinct projects in these areas. In recent years the Centre broadened its focus to include associate members from electrical engineering, civil engineering, medicine, dentistry, microbiology, bioscience, environmental science and atmospheric chemistry.
Telecommunications Software and Systems Group (TSSG) Waterford IT	The TSSG was established in 1996 with an initial focus on network management which then expanded into the area of pervasive computing. The PRTLI supported the development of a dedicated Integrated Research Building for the TSSG and facilitated the development of a PhD programme via the M-Zones project (including the recruitment of its first postdoctorate researchers). This project takes smart space management to a new level by representing them as managed zones which encompass ones or more smart spaces and the context of these spaces for people, information, time, IT etc.
Centre for Transport Research and Innovation in People (TRIP) TCD	The centre focuses on transportation research, embracing such topics as traffic congestion and transportation safety. By taking a strongly interdisciplinary approach, TRIP is aiming to address the critical research questions concerning the movement of people, exploiting, in particular, the emergence of new technologies and the scope they offer in optimising transportation systems and network usage.
Chair of Health Informatics TCD, DIT	This was a collaborative project between DIT and TCD to look at improving health informatics through several ICT based projects and research in the area of patient information.
Cosmogrid DIAS	DIAS was the lead organisation for the Cosmogrid initiative but it was highly collaborative in nature, with eight other participating institutions. The project is driven by fundamental science, the physics of natural phenomena. It is enabled by computer science. Three large PC clusters will be interconnected through middleware. This middleware will run on dedicated gateway machines connected to the basic network infrastructure provided by HEAnet and create a shared virtual resource available to all members of the Cosmogrid collaboration. The computation grid will enable a wide range of scientific projects involving the simulation of natural phenomena outlined in more detail below. The four main research areas are astrophysics, geophysics, atmospheric physics/climatology and computer science

Centre/Initiative	Overview of Activities
The Geary Institute UCD	Founded in 1999, the Geary Institute has attained a strong reputation in Ireland and Europe as a centre of excellence in microeconomics, quantitative social sciences and behavioural social science, leveraging the concept of Ireland as a unique laboratory for evidence-based policy formation. A large part of the allocated PRTLI funding in Cycle 1 was used to construct and equip a new Institute building, which became operational in January 2002 and provided a focal point for research activity. The Irish Social Science Data Archive was also funded in Cycle 1 and is held by the Geary Institute, bringing all social science datasets together within one resource.
The Moore Institute NUIG	The Moore Institute was previously known as the Centre for the Study of Human Settlement and Historical Change and brought together the faculty of arts, celtic studies and law to drive and focus research. 7 research themes were prioritised, focused around the vitality and endurance of social formations and networks that are smaller or larger than the nation in scale, and newer or older than the nation in time. The research was underpinned by the support under Cycle 2 for a purpose-built dedicated research building which included postgraduate and postdoctorate research areas and a seminar room.
National Institute for Regional & Spatial Analysis (NIRSA) NUIM	NIRSA is a collaborative partnership led by NUIM between scholars from a number of social science disciplines, located in 4 partner institutions (the others being Mary Immaculate College, IT Sligo and Queens University Belfast). The Institute's remit is to undertake fundamental, applied and comparative research on socio-spatial processes and their effects on social and economic development in Ireland and to provide high quality graduate education to the next generation of Irish social scientists. Work is coordinated around 3 research clusters: building knowledge economies; planning environments; and sustaining communities.
Urban Institute Ireland (UII) UCD	Urban Institute Ireland was established with the ambition of transforming understanding as to how urban areas function generally and in Ireland in particular; advancing the ability to model and analyse spatial information to improve decision-making; understanding the role of transport infrastructure in promoting sustainable development; integrating environmental and economic performance; and contributing to the development and implementation of policy. A new building and 2 purpose built labs, URBIS and BPL, were built with the PRTLI support.
Institute for International Integration Studies (IIIS) TCD	The IIIS brings together researchers in all relevant disciplines, both inside and outside Trinity College, to study the many intellectual and policy issues relating to international integration. The current range of disciplines involved include economics, political science, sociology, law, history, business studies, drama, theology & religions, and ecumenics. While the range of disciplines involved is large, the research is highly focused, being solely concerned with issues of international integration.
Centre for Innovation and Structural Change (CISC) NUIG	CISC was established in 2002 as an inter-disciplinary research institute focused on building an internationally recognised programme of research and education on innovation processes and policies that are fundamental to the development of a knowledge-based economy. Research at the Centre is divided into 5 areas: innovation systems; industry clustering; internationally traded services; inter-organisational systems; high performance work systems.
Humanities Institute of Ireland (HII) UCD	The Humanities institute was established to serve as a national and international centre for excellence and innovation in human sciences and to act as a catalyst for leading edge scholarship and research. It complements research undertaken within related UCD Schools and research institutes while concurrently providing a neutral space for the delivery of interdisciplinary or post-disciplinary research that transcends the intellectual boundaries of a particular subject or discipline.
Centre for Irish Scottish	The PRTLI Cycle 1 support was intended to create a research infrastructure within the Humanities to examine comparative Scottish and Irish development.

Centre/Initiative	Overview of Activities
Studies TCD	This commenced a three stage development process: (1) the establishment of a cluster of six complementary regional clusters (Medieval Ireland, Scotland and Europe; National Literatures; the World of Print; Ireland and Empire; Language and Translation; and the 17th Century Origins of Modern Ireland. (2) establishment a TCD Centre for Irish-Scottish Studies as an inter-disciplinary body with the remit to coordinate research in the field, to encourage the development of undergraduate courses, and to promote conferences and lectures directed to a wider public; (3) overseeing the development of a sustainable future research programme.
Mediterranean and Near Eastern Studies TCD	This project was established to enable TCD and collaborating institutes to explore common overlapping aspects of the ancient world by focusing on two overlapping zones at epochal periods in human history - The mediterranean and the near eastern worlds in antiquity. The overall objective was to combine expertise form different academic disciplines in the study of the interaction of east and west in the ancient world and to take a leading role in re-examining and redefining these interactions.

Appendix G: List of Companies Identified as Realising Impacts from Supported Centres/Initiatives

Aceno Mobile Services
Adaptive Information Centre (AIC)
Aerogen
AFC Pharmachem
Agilent Technologies
Agilent Technologies
Altay Ireland Ltd
Amarach Research
Ark Therapeutics
Asthma Friendly Products
Astra Zenika
Athersys (US)
Aughinish Alumina
Babylink
Bearna Medical Ltd.
Beemune
BioBode Ltd
Biocroi
Biouetikon
Bord Gais
Boston Scientific
BrePco Biopharma Ltd
Bristol-Myers Squibb
Buxco
Cellix
Celtic Oil
Centocor Biologics Ireland
Cervassist
Clearstream Technologies
CMI
Cook
Covidien
Creagh Medical
GoMoNews
GSK
GSS
Headway Software
Hewlett Packard
HKPB Scientific
IBM
Impedans
Innocoll Technologies
Institut de Recherches Internationales Servier
Intel
Intune Networks Ltd
Irish Bodycare Ltd
Isotron Ireland Ltd
ITI
Johnson & Johnson
Lexas Ltd.
Long Room Hub
Luxa
Mater Hospital
Mayo Healthcare
Medtronic
Merck
Merco
Met Eireann
Moorings Mediquip
Muzu TV
Nanocomms Ltd
Nanosense
Nemo
Novartis
Nubiq
OMI, Optical Metrology Innovation

Creganna
Crème Software
Crescent Diagnostics
Crest
Crovan
De Puy
Dell
Diosynth
Dolomite
Dualsystems
EADS
Eblana Photonics Ltd
Eil Lily
Eire Composites
Eirgrid
EnBio
Episensor
ESB
Integra LifeSciences
Exerscale
Feed Henry
Finesse Medical Ltd
Firecomms Limited
Frontline Medical
FSW Coatings
GE
Genemedix
Genzyme Ireland Ltd
Opsona
Ovagen
Pfizer
Pharmaplaz
Phive
Prism
Process Development Engineer Transitions Optical
Protagen
Protectas health
Qualflow
RealSIM
Regenesys
ReMind
RESC
SensL Ltd
Siemens Ireland
Sigmoid Pharma
Slidepath
Smith & Nephew
Sonitus Systems
Sygnature
TE Laboratories
Thermofisher
Unwins Safety
Visibility Mobile
VitrA
Waterford Technologies
Wyeth
Zolk-C

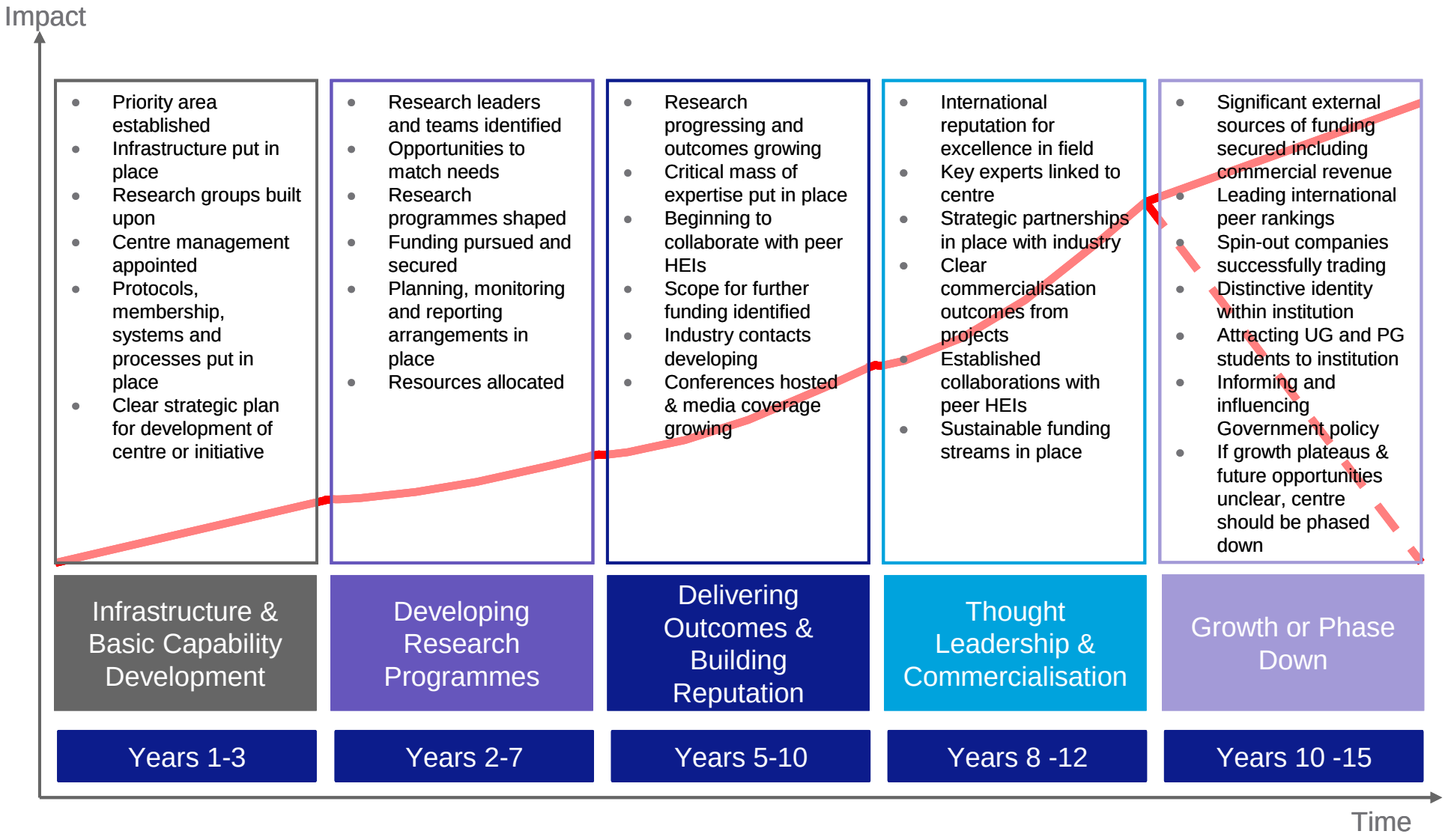
Appendix H: Analysis of the Lifecycle Stages of PRTLI Supported Centres

The PRTLI delivered a range of infrastructure elements and provided the basic capability to allow progression of strategic research projects and activities as we have set out in this chapter. However it often took 2-3 years before this infrastructure was put in place (particularly where new buildings were constructed) and this was only the beginning of an overall development process that involves a significant lead time to get to an effective level of performance. While this lead time varies across different centres (e.g. those in IT often evolve more rapidly than those in Life Sciences) we have identified a development path of five broad stages during our analysis of PRTLI funded centres, including:

- **Infrastructure and Capability** - establishment of the initial infrastructure (which in the case of buildings in itself sometimes takes 2-3 years) and development of the basic research capability around specific themes (often building on existing capability);
- **Programme Development** - identification of research opportunities and development of programmes around particular problem areas;
- **Outcomes and Reputation** - securing of funding to support realisation of these opportunities; development and delivery of research outcomes and building a reputation among peers;
- **Thought Leadership and Commercialisation** – being recognised Thought Leaders internationally and securing support in commercialisation of research where such potential exists; and
- **Redevelop or Decline** – having established success in a key area it is necessary to review and redevelop particular programmes to continue to sustain and grow. Alternatively it may be that the research area is no longer of the same significance and decline/closure may be a suitable option.

While the journey through all five phases is not strictly sequential, i.e. particular activities overlap, it can take considerable time to reach the latter stages. Within this assessment of economic impact we must recognise that some of the centres are still in the earlier phases of development. In the figure over the page we outline a typical development cycle for a research centre or initiative given our analysis of those supported under the initiative.

Analysis of a Typical Development Cycle for a Specialist Research Centre or Initiative



Appendix I: International Literature on the Impact of Research Investment

The measurement of the economic impact of the development of research capability is highly complex but is a subject that has received increasing focus in recent years. As fiscal pressures grow, there has been increasing scrutiny on all aspects of expenditure and the returns that can be demonstrated. In the UK, the STI published a policy framework document[41] that set down guidelines for the measurement of impact, in which they acknowledged a number of difficulties in the process including:

- The time taken from an increase in R&D spend to an increase in welfare
- The global nature of science and innovation makes it particularly difficult to attribute domestic economic impacts to domestic science and innovation investment and policies
- The research base having direct as well as indirect effects on economic impact also complicates the attribution of impacts to inputs of the research base

Given these factors, it was acknowledged that it was difficult to undertake an ex-post assessment of the impact of research investment, and that the only means of attaining such a gauge in future lay in the establishment of robust monitoring systems to collect the right type of data that would feed into output frameworks defined by the Research Councils, facilitating time series analysis of performance. In order to help establish an understanding of the relationship to economic impacts, PA Consulting was commissioned by Research Councils UK to evaluate their impacts[42]. This produced interesting analysis on a case study basis but it was noted that assessment of impact was constrained by the fact that such impacts were not specifically sought at the release of Council funding to higher education institutions and hence the monitoring framework did not facilitate collection of data to facilitate ongoing analysis of impacts.

This is a similar challenge to that faced in assessing the impact of the PRTLI supported centres and initiatives, with no focus on commercialisation of research at the outset and no collection of ongoing data to feed into an understanding of emerging economic impact. The analysis in this report has demonstrated that while investment in basic infrastructure and research capability quite correctly cannot be expected to yield immediate impacts, it is a critical factor in achieving these impacts in the long-term. Hence while commercialisation outcomes may not be sought in the short-term from such funding, the onus should be on the recipient in future to gather data to show the relationships to outcomes and impacts that are emerging, with a coordinated approach to understanding impact across all relevant public interventions.

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[41] 'Measuring Economic Impacts of Investment in the Research Base and Innovation: a New Framework for Measurement', Department of Trade and Industry

[42] 'Study on the Economic Impact of the Research Councils', Research Councils UK, PA Consulting, SQW Consulting. October 2007

So while direct assessment of the impact of enhanced research capability is difficult, there is nonetheless evidence drawn from international literature that can inform a general understanding of the scale of the economic impacts that have emerged. For example, work undertaken by the OECD in 2001[43] which compared data from 1980-1998 across 16 countries found that a 1% increase in public R&D expenditure increases Total Factor Productivity by 0.17%, as against 0.13% for an increase in business R&D spend. A later OECD study in 2004[44] also concluded that no evidence existed for crowding out of private investment by public investment in R&D.

More comparative analysis was facilitated by a study undertaken by the SPRU in 2006[45] on the benefits of publicly funded research. This included a literature review and cited a number of studies which had estimated the rate of return from academic research.

Commercial Benefits from Enhanced Research Capability

Researcher	Year	Conclusions on Rate of Return from Academic Research
Mansfield	1991	28%
Toole (Biomedical industry only)	1999	12%-41%
Beise and Stahl	1999	28% (confirmed Mansfield findings)
Huffman and Evenson (Agricultural research only)	1993	43%-67%
Cockburn and Henderson	2000	Over 30%

Source: SPRU 2006

[43] 'R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries', Dominique Guellec, Bruno van Pottelsberge de la Potterie, OECD, 2001

[44] 'From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter?', Dominique Guellec, Bruno van Pottelsberge de la Potterie, OECD, 2004

[45] 'The Benefits of Publicly Funded Research', SPRU, July 2006

Appendix J: Terms of Reference for the Study (2010)

J.1 About The Programme for Research in Third-Level Institutions (PRTLI)

The Programme for Research in Third-Level Institutions (PRTLI) was initiated in 1998 and over four cycles has provided the bedrock for the Irish higher-education research programme. Cycle 5 was launched in January 2009 in the wake of the tenth anniversary of the PRTLI and is funded under the National Development Plan 2007-2013, with assistance from the European Regional Development Fund and with private funding through a public/private financial framework. The process for Cycle 5 is currently underway with an announcement of results expected in 2010.

The management of the Programme and the allocation of funds are co-ordinated by the Higher Education Authority (HEA) on behalf of the Irish Government.

The PRTLI provides funding to strengthen national research capabilities via investment in human and physical infrastructure. The ultimate aim of the programme is to propel Ireland toward establishing an international profile as a premier location for carrying out world class research and development. The PRTLI provides integrated financial support for institutional strategies, programmes and infrastructure in key areas of research spread across all disciplines. The programme supports research in humanities, science, technology and the social sciences, including business and law.

To 2010, under PRTLI Cycles 1-4, a total of €865m has been allocated (includes exchequer and private matching funds), for both capital and programmatic funding to 23 out of a total of 40 eligible institutions. 18 institutions receive funds as lead institutions and 5 as partner institutions. A total of 79 research programmes, covering science and engineering, arts, humanities and social sciences have been supported. PRTLI Cycle 5, launched in 2009 will fund projects from 2011 – 2015.

Table 1: PRTLI Allocations to date

	Year	Funding Period	Buildings & Equipment €(M)	Research Programmes & People €(M)	Total €(M)
Cycle 1	1999	2000 - 2003	177.5	28.6	206.1
Cycle 2	2000	2001 - 2004	48.8	29.7	78.5

Cycle 3	2001	2002 - 2006	178	142.4	320.4
Cycle 4	2007	2007 - 2010	131.3	129.4	260.7
TOTAL			**535.6**	**330.1**	**865.7**

An impact assessment focused on the progress and impact on the higher education and research system was conducted in 2004; five years after the results of Cycle 1 were announced and available on www.hea.ie.

Five years on, it is now proposed to carry out an assessment of its progress and impacts to date over the last ten years. This assessment of the impact of the PRTLI will involve a review of the economic dividend arising from the PRTLI investment to date, as well as an assessment of the contribution of the programme to academy and society. At a later time, this could also include an impact of the PRTLI investment on the higher education system in Ireland and its contribution to teaching, learning and research and the health, environmental and societal gain arising from the PRTLI investment.

NB. The subject matter of this procurement will focus solely on the first aspect of the assessment, i.e. the economic impact of the PRTLI investment.

J.2 Minimum Requirements of the Proposed Solution

It is envisaged that the assessment would encompass an examination of the growth of the PRTLI Centres/initiatives from their commencement. The scope of this review will focus on the PRTLI Centres/initiatives funded under Cycles 1 – 3 which are now complete. A list of the completed Centres/initiatives is included in Appendix E.

The evaluation should take place in a comparative framework, having regard to the ten year cycle of funding, the relative funding period for each initiative/ Centre and international norms. The evaluation will:

- Review the PRTLI initiated centres/initiatives to examine the amount of funding they have attained from PRTLI and other sources.
- Consider whether the PRTLI Centres/initiatives have performed and developed as would be expected based on the level of investment received, regardless of source, also taking cognisance of their maturity. This includes a review of individual centres/initiatives to determine if they are having economic impact using a multilayered approach to include less quantifiable economic impact such as effects on the environment, public health and quality of life.

- Determine the impact of PRTLI on the basis of a 'roll-up' of the above and its contribution to the 'Innovation and Ideas Economy'.
- Determine the measures in place to ensure utilisation and sustainability of Centres/initiatives.
- Have regard to the early stage of development of some initiatives/centres and provide indications of future success and direction.

The evaluation should identify areas/platforms where PRTLI initiatives are having a collective economic impact in particular areas/disciplines.

J.3 Expected Outcomes

It is expected that an assessment of the impact of funding for PRTLI may include provision of evidence of productivity, economic growth and wealth creation, enhanced skills base, increased employment, the employability of PhD graduates, increased innovation capability, increased global competitiveness, attraction of other external funding, indicators of commercialisation and IP and invention disclosures.

It is envisaged that such an assessment would take account of the effect of external factors such as the wider economy and issues such as variances in higher education institutions, disciplines, available funding etc.

J.4 Status Report Delivery

In addition to providing regular updates on progress to the HEA and its advisors, the successful tenderer will be required to deliver a Status Report to the HEA Advisory Group on the conduct of the assessment two months following the award of tender.

J.5 Interim Report Delivery

The successful tenderer will be required to deliver an Interim Report, to include progress to date, tasks achieved and work schedule for the remainder for the project, to the HEA Advisory Group four months following the award of tender.

J.6 Final Report Delivery

The successful tenderer will be required to deliver the Final Report to the HEA Advisory Group by 5th November 2010 and present their findings to the Authority on 30th November 2010.

At a minimum, the Final Report must be in MS Word or compatible format and should include the following:

- A review of the PRTLI initiated centres/initiatives to examine the amount of funding they have attained from PRTLI and other sources.
- In terms of economic impact and benefit, identification of the key drivers in terms of the PRTLI centres/initiatives and an aggregation of this data to form an opinion on the impact of the centres/initiatives funded under Cycles 1-3
- Benchmarking of the economic impact of the centres/initiatives with the impact of similar investments internationally at a centre/initiative level and based on the level of overall investment.
- An identification of the measures in place to ensure utilisation and sustainability of the Centres/initiatives.
- An indication of the future success and direction of Centres/initiatives.

The HEA will be the exclusive owner of the deliverables and of all titles, rights and interests in and to the deliverables, including any associated intellectual property rights and copyrights on acceptance and payment for the deliverables.

J.7 Insurances

The Tenderer awarded the contract will be required to carry the following insurances:

Employers Liability: €13 million

Public Liability: €6.5 million

Professional Indemnity: €2.6 million

Tenderers are required to submit with their proposals a letter from their insurance company or broker confirming the level cover above or, alternatively, that such cover will be put in place if the Tenderer is awarded the contract. Evidence of such cover must be provided to the HEA on award of the contract.

J.8 Payment Milestones

Tenderers should note that payments to the successful Consultant will be made on the basis of achieved milestones summarised as follows:

Deliverable Milestone	Payment (% of total fee)
Signing of contract	30%
Delivery of status report	20%
Delivery of interim report	20%
Sign off on final report	30%

J.9 Project Management and Support available

During the performance of this contract, the successful tenderer will be required to liaise closely with HEA.

Tenderers should note that a member of HEA staff will be available to support the work of the successful tenderer, which in turn will facilitate knowledge and skills transfer from the Consultants to HEA.

In particular, HEA will appoint Sheena Duffy as internal Project Manager, to act as a liaison officer with responsibility to resolve day to day problems occurring during the project together with the Consultant's designated liaison officer.

J.10 Conditions of contract

Tenderers are advised that the contract will be awarded on the basis of terms and conditions included in Appendix D of this Document.

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