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OPTIMISING POLICY INTERVENTION TO STRENGTHEN THE IMPACTS OF ENTERPRISE RD&I IN IRELAND

An independent report for the Department of Jobs, Enterprise and Innovation

Contents

Executive Summary

Innovation is one of the major factors driving global economic growth. Indeed, in some leading OECD economies, investment in innovation – including spending on research and development, software, databases and skills – is already the main driver of growth.

This study is focused on addressing enterprise research, development and innovation (RDI) performance and the potential, through evolving public policy intervention, for growing and strengthening the impacts of enterprise RDI.

By encouraging innovation, RD&I policy measures typically help to renew national economies, refresh existing competitive strengths and build potential new areas of economic activity. A critical challenge facing Ireland is to maintain economic growth at a time when there is also a pressing need to address various societal challenges and innovation will be crucial here too.

Despite recent increases in business expenditure on R&D and Innovation, the RDI performance of the enterprise base in Ireland is still below selected comparator countries. Further, while Ireland's considerable RD&I investments of recent years have had an impact in respect of its innovation performance, there is an imperative to maintain a focus on increasing the level of enterprise engagement with R&D.

While public investment in science technology and innovation (STI) has enabled significant progress to be made, by international standards, and in comparison with other small innovative economies, Ireland remains a comparatively low spender and a comparatively low performer and Ireland's experience to date suggests that creating capacity in the enterprise base is a greater challenge than building the science base. In this respect, the environment for enterprise RDI activities could be improved by focusing efforts on achieving a more balanced innovation ecosystem.

Ireland needs to take action to address some specific challenges that have an impact on enterprise RD&I. In addition, while maintaining a focus on the strategic tasks of 'delivering enterprise policy goals' and capitalising on science and technology research investment', Ireland should also explore opportunities for enterprise by increasing its focus on the strategic task of 'meeting global and national societal challenges'. This is relevant because innovation policy measures and strategy development are increasingly being recognised as a whole-of-government issue where addressing national strategic and societal issues is an active policy area amongst comparator countries, and one in which there are untapped opportunities for enterprise in Ireland.

Further, Innovation in Services and Business Processes remains an area of high potential in Ireland which, if harnessed effectively, could play an important role in maximising the returns from investment in R&D in the priority areas identified by Ireland.

While a review of comparator countries' innovation policies shows that the policy instruments in Ireland are broadly in line with those currently in place in leading innovative economies, a small number of additional initiatives offer potential promise for Ireland.

While maintaining funding for research excellence and human capital in the science base, and a focus on direct and indirect supports for RDI in firms, Ireland also needs to:

- increase focus on commercialisation and translation of research,
- widen our view of innovation beyond R&D,
- further exploit opportunities for enterprises in societal challenge areas,

- develop new ways to create linkages between the science base and enterprises, and
- double the number of researchers in the enterprise base.

Actions at the level of policy systems and the policy framework are required while interventions are also possible at the level of individual RD&I instruments:

Policy System Action 1: Ireland must significantly increase both public and private investment in RD&I if the returns from public investment in RD&I are to be maximised and the overall aim of building a strong economy and a better society is to be achieved.

Policy System Action 2: Ireland should follow international best practice by adopting appropriate 'whole-of-government' structures for the governance of its national innovation system.

Policy System Action 3: Ireland's funding agencies and Departments should adopt a wider view of innovation embracing innovation in services and business processes as a central component of Ireland's enterprise RD&I funding landscape.

Policy System Action 4: Ireland's funding agencies and Departments should place a greater emphasis on policies and funding for the testing and deployment of new technologies in real-life problem-solving settings, going beyond the current PAG focus on input funding.

Specific policy framework recommendations and actions also arise from the analysis, aimed at helping to achieve the policy system level actions:

Framework Recommendation 1: In allocating future funding for RDI, Ireland should aim for an appropriate balance of funding across policy instruments that maximises the returns of public and private investment in RDI and should direct additional funding towards instruments that facilitate the development and deployment of emerging technologies.

Framework Recommendation 2: Increased investment in Innovation in Services and Business Processes must be a key priority, given the increasing contribution of internationally traded services and global business processes to Ireland's economy.

Framework Recommendation 3: Ireland should explore additional opportunities for enterprise RD&I by increasing its focus on synergies between enterprise goals and the strategic objectives being pursued by other government Departments in 'meeting global and national societal challenges'.

Framework Recommendation 4: Ireland should follow international best practice by devising and adopting appropriate whole-of-government governance structures for implementing the successor to SSTI.

Framework Recommendation 5: Ireland should adopt the goal of achieving a more balanced performance across the EU Innovation Scoreboard indicators as a guide in making future public investments in RD&I.

Specific operational recommendations and actions are aimed at underpinning the achievement of the policy system and framework actions:

Operational Recommendation 1: Successful implementation of the approach outlined above will require training and deploying the requisite human capital. It is recommended that Ireland adopt the necessary policies to ensure the skills required to implement this new approach are in place.

Operational Recommendation 2: A review of comparator countries' innovation policies has identified a number of additional initiatives as being of potential promise for Ireland. These programmes should be adapted and adopted in Ireland, within the context of the new SSTI.

Chapter 1: Support for Enterprise RD&I in Ireland

An Introduction

The Importance of Innovation

Innovation - which includes the invention and diffusion of new technologies, the development of new and improved products, processes and services, and innovations in organisational models - is one of the major factors driving global economic growth.

In many OECD countries, the traditional sources of growth – increased labour inputs, and investments in physical capital – are declining in importance, leading to an increasing need to develop innovation as a new source of growth. Further, in some leading OECD economies, investment in innovation – including spending on research and development, software, databases and skills – is already the main driver of growth.

Public supports to promote the development and exploitation of new products, processes and services are an important component of national research, development and innovation (RD&I) systems. Government support for innovation makes a critical contribution to enterprise policy and, through the stimulus given by innovation to high value economic activities and jobs, to a competitive national economy. Therefore, by encouraging innovation, RD&I policy measures help to renew national economies, refresh existing competitive strengths and build potential new areas of economic activity.

After a number of years of severe recession, the Irish economy is once again experiencing significant growth, albeit in the context of a still tentative global recovery, providing an opportunity to optimise the contribution that innovation makes to Ireland's future prosperity.

A critical challenge facing Ireland is to maintain economic growth at a time when there is also a pressing need to address various societal challenges - such as climate change, healthy aging, and energy security. Innovation will be crucial here too if Ireland is to play its role in addressing such problems in an affordable and timely manner while an increased focus on societal challenges presents opportunities for Irish based enterprises to develop and export new technologies and services.

Significant increases in Government Investment

The importance of investment in science, technology and innovation (STI) to Ireland's on-going and future economic and social development has been well recognised by Government. This has been reflected in the appreciable allocations for investment in STI.

Government budget appropriations and outlays on RDI (GBAORD) have increased over recent years, rising from €727m in 2005 before peaking at €948m in 2008. However, GBAORD has since fallen and is expected to reach €724m in 2014.

Prior to a Government policy decision to make a significant investment in science, technology and innovation, research funding in Ireland was at very low levels. However, from 2000, an ambitious strategy was adopted - investing in people, infrastructure and associated facilities to build the science base across many areas of scientific research in both higher education institutions and other public research organisations; and providing direct support to the enterprise sector to help individual companies build their capacity for research and development. As a result, Ireland has successfully built up research capacity and a significant reputation for research excellence and has an increasing base of enterprises engaging in R&D and innovation activity.

Focusing investment to achieve impact

In recent years, the recognition that a country of Ireland's size can only excel in a limited number of fields of research has been increasingly acknowledged. Through the Report of the Research Prioritisation Steering Group, formally adopted by Government in 2012, Ireland aims to accelerate the delivery of economic and societal outcomes from Government investment in public research organisations by aligning public investment by research funders to fourteen opportunity areas.

Four key criteria were used in identifying the fourteen priority areas, namely:

1. Each priority area is associated with a large global market or markets in which Irish based enterprises already compete or can realistically compete

2. Publicly performed R&D in Ireland is required to exploit each priority area and will complement private sector research and innovation in Ireland

3. Ireland has built, or is building, strengths in research disciplines relevant to each priority area

4. Each priority area represents an appropriate approach to a recognised national challenge and/or a global challenge to which Ireland should respond.

Through the Research prioritisation process, Ireland aims to reinforce the development of critical mass in areas of research where Irish enterprise can compete and Irish society can benefit.

Optimising the impacts of public investment in Enterprise RDI

In preparation for the development of a successor to the Strategy for Science, Technology and Innovation 2006-2013 (SSTI), in 2013 Forfás engaged in a strategic review to assess the performance of Ireland's STI system.

One of the primary policy goals of the SSTI has been that of building technological and applied research and development capability in firms to support the development of high-value products and services across the entire enterprise base to support jobs and wealth creation. This still remains a key national policy goal.

The Forfás review in 2013 indicated that, largely as a result of government investment, the Irish RD&I policy mix has evolved considerably with the development of a diverse range of policy measures in support of enterprise innovation for both indigenous firms and foreign owned companies. Many of these measures are now well-established and have helped to increase RD&I activity and investment.

Further, the Forfás review provides evidence that significant advances have been made through public policy and STI investment in strengthening the research capacity and performance of the enterprise sector. The Forfás review indicates that in firms where innovation capacity has improved, these firms have performed and even grown through the recession. This is exhibited, for example, by the resilience shown in terms of employment and exports in research and innovation intensive enterprises in Ireland since the onset of the global recession in 2008.

The review also provides evidence that STI investment has led to the development of a strong public research environment including the establishment of scientific excellence in a number of strategic areas.

At the same time, despite recent increases in business expenditure on R&D and Innovation, the review shows that the RDI performance of the enterprise base in Ireland is still below

selected comparator countries. In addition, the rate of progress towards the targets set in Science, Technology and Innovation 2006-2013 (SSTI) for enterprise R&D has not been as high as envisaged even where some progress has been made.

While, it needs to be acknowledged that the global recession which began in 2008 has had a detrimental impact on enterprise RDI in Ireland, nevertheless, given the onset of economic recovery and the preparation of a successor to SSTI, it is prudent to examine how Ireland might further optimise the impacts of public investment in enterprise RD&I.

Terms of Reference for this Study

This study is focused on addressing enterprise research and innovation performance and the potential, through evolving public policy intervention, for growing and strengthening the impacts and outcomes of enterprise RDI.

The objectives of the study have been to:

1. Undertake an analysis as to how public policy can best support and more effectively optimise the impacts of enterprise RD&I investment, given the enterprise structure in Ireland and knowledge of other national innovation systems and policy mixes.

2. Conduct a series of workshops with key stakeholders to validate the study's findings and develop recommendations on specific policy measures that Ireland could take to strengthen the performance and impacts of enterprise RD&I in Ireland.

The study builds largely on pre-existing analysis and data collected by Forfás, and informed by the work of the OECD in their recent reviews of Ireland's innovation performance and policies, and the EU Innovation Union Scoreboard.

The OECD policy mix framework which considers the policy domains, programme rationales, strategic tasks as well as individual measures is used to analyse Ireland's enterprise RD&I policy mix. The analysis also considers the wider framework and policy environment conditions for enterprise RD&I.

The study draws conclusions on Ireland's existing enterprise RDI policy and makes recommendations for strengthening the policy mix in support of enterprise RDI covering both short-term and medium-term practical actions.

Chapter 2: Ireland's position in the European innovation landscape.

Ireland's Innovation performance in an International context

The annual EU Innovation Union Scoreboard provides a comparative assessment of the research and innovation performance of EU Member States and the relative strengths and weaknesses of their research and innovation systems.

The Scoreboard measures Innovation performance using a composite indicator (based on 8 sub indicators) – the Summary Innovation Index. Member States are then categorised into four groups based on their performance across the composite indicators and relative to the EU27 average:

1. Innovation Leaders are Member States in which the innovation performance is well above that of the EU, i.e. more than 20% above the EU average.
2. Innovation Followers are Member States with a performance close to that of the EU average i.e. less than 20% above, or more than 90% of the EU average.
3. Moderate Innovators are Member States where the innovation performance is below that of the EU average at relative performance rates between 50% and 90% of the EU average.
4. Modest Innovators are Member States that show an innovation performance level well below that of the EU average, i.e. less than 50% of the EU average.

The European 'Innovation Union Scoreboard 2014'[1] describes Ireland as an 'Innovation Follower' amongst its EU27 peer group[2] with an overall innovation performance close to the average for the EU Member states.

Innovation Leaders in 2014 were Denmark, Finland, Germany and Sweden. Alongside Ireland, the Innovation Followers in 2014 were Austria, Belgium, Cyprus, Estonia, France, Luxembourg, Netherlands, Slovenia and the UK.

The sub-indicators used to create each of the eight dimensions of the Innovation Union Scoreboard are listed below:

[1] "Innovation Union Scoreboard 2014", Directorate-General for Enterprise and Industry, European Commission 2014

[2] ***Innovation followers*** include Austria, Belgium, Estonia, France, Ireland, Luxembourg, UK and the Netherlands - performing close to that of the EU27 average while ***Innovation leaders*** such as Denmark, Finland, Germany and Sweden have innovation performances more than 20% above the EU average.

Table 1. Composite indicators used in the EU Innovation Scoreboard

Human resources	
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	*In countries that score well on this composite indicator, a high share of the workforce has the skills needed to participate in and further develop the knowledge-based economy.*
Percentage youth aged 20-24 having attained upper secondary level education	
Percentage population aged 30-34 having completed tertiary education	
Open, excellent research systems	
International scientific co-publications per million population	*Countries that score well on this composite indicator are open for cooperation with partners from abroad, researchers are well networked at international level and the quality of research output is very high.*
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications	
Non-EU doctorate students as a % of all doctorate students	
Finance & support	
R&D expenditure in the public sector as % of GDP	*Countries that score well on this composite indicator are characterised by a public sector which is well endowed to perform R&D activities and by the availability of risk capital for private firms to develop new technologies.*
Venture capital investment as % of GDP	
Innovation investments by firms	
R&D expenditure in the business sector as % of GDP	*In countries that score well on this composite indicator, companies invest significantly in innovation activities, both for science-based R&D activities and non-R&D innovation activities.*
Non-R&D innovation expenditures as % of turnover	
Linkages & entrepreneurship	
SMEs innovating in-house as % of SMEs	*Countries that score well are characterised by an SME sector that has more deeply rooted innovation capabilities as they combine in-house innovation activities with joint innovation activities with other companies or public sector organisations.*
Innovative SMEs collaborating with others as % of SMEs	
Public-private co-publications per million population	
Intellectual assets	
Patents applications per billion GDP (in PPS€)	*Countries that score well on this composite indicator are characterised by firms protecting their new ideas and innovations, whether by using patents to protect new technologies or by using trademarks or designs which protect new goods and services.*
Patent applications in societal challenges per billion GDP (in PPS€) (environment-related technologies; health)	
Community trademarks per billion GDP (in PPS€)	
Community designs per billion GDP (in PPS€)	
Innovator Outputs	
SMEs introducing product or process innovations as % of SMEs	*Innovation systems in these countries are characterised by high rates of firms involved in innovation activities: innovation seems a natural strategy for firms to meet their customers' demands and to face competitive pressures.*
SMEs introducing marketing or organisational innovations as % of SMEs	
Employment in fast-growing firms of innovative sectors	
Economic output effects	
Employment in knowledge-intensive activities as % of total employment	*Countries that score well on this composite indicator are characterised by firms engaged in knowledge intensive activities (manufacturing and services).*
Contribution of medium and high-tech product exports to the trade balance	
Knowledge-intensive services exports as % total service exports	
Sales of new to market and new to firm innovations as % of turnover	
License and patent revenues from abroad as % of GDP	

Figure 1 below shows how Ireland's performance across the eight dimensions included in the Innovation Union Scoreboard Summary Innovation Index compares to the EU27 average.

Figure 1. Ireland's innovation union scoreboard compared with EU 27

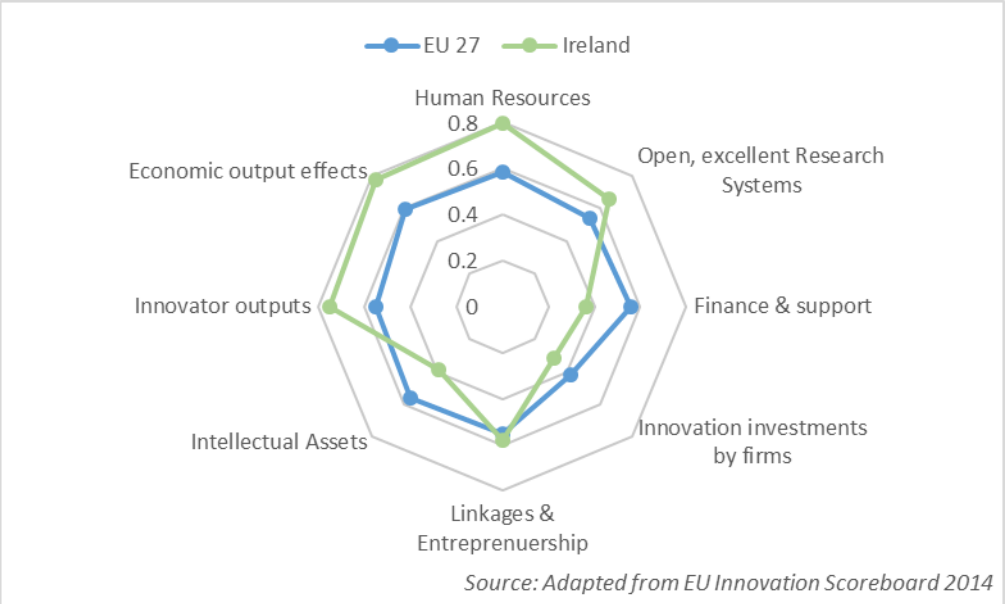


Figure 1 shows that while the profile of the EU27 average for all dimensions is rather steady at around 0.6, Ireland's performance fluctuates from a high point of close to 0.8 for its *Human resources*, *Innovator outputs* and *Economic output* dimensions to a low of 0.4 or less for dimensions such as *Innovation investments by firms*, *Finance and support for RD&I* and *Intellectual asset* creation.

The two dimensions of innovation where Ireland scores the highest directly reflect Ireland's recent investment in its research capacity and in its foreign direct investment business base.

The '*Human resources*' dimension, for example, measures the extent to which the national workforce has the skills needed to participate in, and further develop, the knowledge-based economy.

The '*Economic effects*' dimension measures a range of outputs including employment in knowledge-intensive activities; knowledge-intensive services exports, and, sales of new to market and new to firm innovations. Here Ireland is, in fact, ranked as the best performer amongst the EU27.

One key difference between Innovation Leaders and Innovation Followers identified by the Innovation Union Scoreboard is the consistency of their performance across all eight of composite dimensions. This suggests that to achieve a high level of innovation performance, countries need a balanced innovation system performing well across all dimensions.

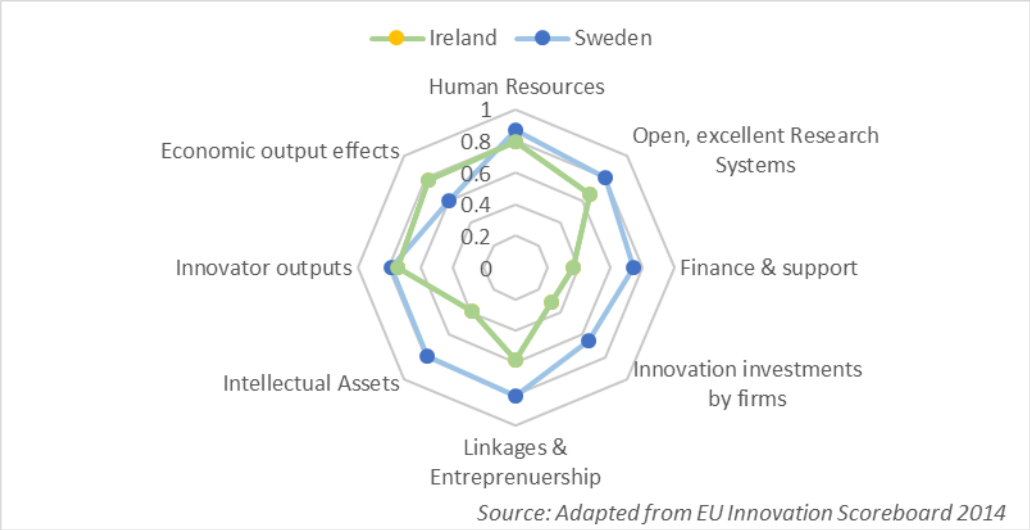
The importance of a balanced innovation ecosystem lies in the fact that, according to the innovation systems view of innovation, the performance of individual firms depends on there being a conducive environment across a wide range of factors. If one or more of these factors, for example, access to finance, is deficient, this will have a detrimental impact regardless of the fact that the other factors are in place.

The importance of achieving balanced scores across all innovation dimensions for overall national innovation performance can be observed when Ireland's performance is compared to that of an Innovation leader – Sweden - against whose performance Ireland often benchmarks itself.

Overall, the Innovation Union Scoreboard places Sweden as the best performer across all measures and dimensions.

The comparison between Ireland and Sweden can be seen in Figure 2.

Figure 2. Ireland's Innovation Union Scoreboard compared to Sweden's



Ireland 'outperforms' Sweden only in the dimension of 'Economic output effects' due to the high level of knowledge intensive services exported by Ireland's MNC sector, compared to a more balanced manufacturing base amongst Sweden's business sectors.

By contrast, in almost all other dimensions covered in the EU Innovation Union Scoreboard, Ireland falls below Sweden's performance.

Ireland also falls consistently below the performance of other comparator countries, including Denmark, Finland, Norway and the Netherlands. This is shown further in Annex 1.

To achieve a more balanced performance on the EU Innovation Union Scoreboard Summary Innovation Index, Ireland will need to improve its performance, in particular, in relation to *Innovation investments by firms*, *Finance and support for RD&I* and *Intellectual asset creation*.

Business Expenditure on R&D in Ireland

Enterprises lie at the forefront of a national innovation ecosystem, developing and driving the commercialisation of new products, processes and services. Business enterprise expenditure on research and development (BERD) is therefore considered important for innovation and economic growth.

BERD covers R&D activities carried out in the business sector by performing firms regardless of the origin of funding. While the government and higher education sectors also carry out R&D, industrial R&D is arguably most closely linked to the creation of new products, services and production techniques.

Although BERD is an input indicator it is widely used by policymakers as a proxy for expected economic outcomes. The use of BERD in this manner is based on the assumption that R&D investment decisions at the level of the firm are being made on the basis of expected economic returns.

In OECD countries, business R&D accounts for the bulk of R&D in terms of both funding and performance.

BERD and Ireland's Enterprise base

In EU economies, across all sectors, enterprises that perform research, development and innovation make a major contribution to overall wealth and job creation compared with enterprises who do not perform RD&I.

In practice, BERD intensity (BERD as a percentage of GDP) is often used as an indicator, rather than the absolute BERD figure. The R&D/GDP ratio is used in two primary ways:

First, it is used to characterize industries. High BERD/GDP ratios for an industry are held to identify high technology activities.

Second, a high BERD/GDP ratio for a country is used to indicate an innovative enterprise base and a commitment to knowledge intensive enterprises.

The OECD has suggested a classification of industries using a four-tier model according to their BERD/Production ratio:

Table 2. Industry classification based on BERD/GDP ratio

High-tech industries		>5%	R&D/Production
Medium to high-tech industries	>5%	>3%	R&D/Production
Medium to low-tech industries	>3%	>1%	R&D/ Production
Low-tech industries	>1%	>0%	R&D/ Production

Source: Smith K "Measuring Innovation" in 'The Oxford Handbook of Innovation' 2005 p156

Naturally, industries vary considerably in their BERD/GDP ratios, and it therefore follows that the industrial structure of a country will reflect the aggregate BERD/GDP ratio for its different industry sectors. A country with large concentration of high-R&D industries, for example, will have a higher aggregate BERD/GDP ratio than a country with a preponderance of industrial activities in low R&D industries.

However, it must be cautioned that BERD does not capture the full range of innovation activities in firms. For example, within any industry there will be a wide distribution of R&D intensities amongst firms and it will be common, even amongst low R&D performing industries, to find some firms that are high R&D performers. Similarly, in all industries, some firms will not undertake their innovation through a structured internal R&D investment or access knowledge for their innovation through externally visible knowledge transfer activities, consequently, BERD may not capture the innovation activities that are carried out.

Ireland's recent BERD performance

Innovation expenditure and activity by enterprises in Ireland has grown substantially in recent decades. This period has not only seen growth in the numbers of R&D performing firms but

the overall scale of their investment is also growing. Business Expenditure on R&D in Ireland, for example, rose from 0.93% of GNP in 2003 to an estimated 1.47% of GNP in 2012[3].

Ireland's RD&I performing firms are gaining an increasing share of sales, export sales and are accounting for increasing shares of employment. In addition, RD&I performers have demonstrated better employment retention during the recent challenging economic period i.e. innovative firms exhibit greater resilience than non-innovative firms.

After a number of years of severe recession, the Irish economy is once again experiencing significant growth and there is the expectation that innovation and in particular, business enterprise investment in innovation will be at the forefront of improved economic performance as a whole and Ireland's future prosperity.

However, although significant progress has been made, when compared with other small innovative economies, Ireland's BERD intensity remains comparatively low.

Progress towards SSTI 2006-2013 Targets

A further insight into Ireland's BERD performance can be gained by examining progress under the Strategy for Science, Technology and Innovation 2006-2013.

The SSTI set a number of targets for enterprise R&D performance. These targets, along with Ireland's performance, as measured by the Forfás review in 2013, are shown in Table 3 below.

Table 3. Enterprise R&D Targets in SSTI 2006-2013

SSTI Target	2003 (base)	2013 (target)	Performance to 2011/12 (most recent data available)	
Number of indigenous companies with minimum scale R&D activity (in excess of €100,000) to reach 1,050 by 2013;	462	1050	732	(2011)
Number of indigenous enterprises performing significant R&D (in excess of €2 million) to reach 100 by 2013;	21	100	40	(2011)
Number of foreign affiliates companies with minimum scale R&D activity (in excess of €100,000) 520 by 2010;	213	520	338	(2011)
Number of foreign affiliates performing significant levels of R&D (in excess of €2 million) to reach 150 by 2010;	60	150	114	(2011)
Business Expenditure on R&D in foreign-owned companies to grow to €1.675bn by 2013		€1.675bn	€1.323bn	(2011)
Business Expenditure on R&D in indigenous companies to grow to €0.825bn by 2013;		€0.825bn	€0.537bn	(2011)
Total BERD to grow to €2.5billion by 2013 - constant prices	€1.076bn	€2.5bn	€1.962bn	(2012)

It can be seen that while progress has been made towards the targets set in SSTI 2006-3013, that progress has not been as rapid as envisaged.

[3] An extensive suite of evaluations of public RD&I supports for enterprise in Ireland, carried out by Forfás showed positive outcomes arising from state support for firm RD&I.

Of course the global recession which began in 2008 has had a major impact on Ireland's enterprise base. In addition, there is evidence of an increase in enterprise R&D activity since the Forfás review was completed in 2013. It is currently estimated that BERD will have increased to €2.099m in 2013.

Nevertheless, it is clear from this analysis that a renewed focus on optimising the impacts from public support for enterprise R&D, including further development of the ecosystems and infrastructures that encourage enterprise RD&I, is warranted.

Conclusion

The analysis in this chapter demonstrates that while Ireland's considerable RD&I investments of recent years have had an impact in respect of its innovation performance, there is an imperative to maintain a focus on increasing the level of enterprise engagement with R&D.

The analysis also shows that the environment for enterprise RDI activities could be improved by focusing efforts on achieving a more balanced innovation ecosystem.

Chapter 3: Ireland's Enterprise Innovation Characteristics & Performance

Forfás Review of Ireland's National Innovation System

In preparation for developing a successor to the Strategy for Science, Technology and Innovation 2006-2013 (SSTI), in 2013 Forfás engaged in a strategic review to assess the performance of Ireland's STI system.

This was a wide ranging review of Ireland's national innovation system, including an update on progress towards the targets set in SSTI 2006-2013.

The template for the review was based on that used by the OECD in their Country Reviews of Innovation. The main findings of the review are summarised in Annex 2 under the following headings:

- High Level International Benchmarking of National Innovation Performance
- RDI Performance in the Enterprise Sector
- RDI Performance in the Higher Education Sector
- RDI Performance in the Public Sector
- Human Capital for STI

A number of countries were selected as comparator countries for the analysis. The countries chosen were essentially small innovative economies, and were Belgium, Denmark, Netherlands, Finland, Sweden, Israel, New Zealand and Singapore. Data for these countries was included in the review in so far as it was readily available.

The review provides a valuable snapshot of our national innovation system across a wide range of indicators in international perspective, as it stood in 2013, towards the end of the Strategy for Science, Technology and Innovation 2006-2013.

While more recent data has become available since the review was completed, the findings are still useful in giving an overview of Ireland's performance across a wide range of metrics, particularly with respect to Ireland's performance in relation to our key competitors.

Three top level findings emerged from the Forfás review:

1. Public investment in STI has enabled significant progress to be made.

From a very low base by international standards, Ireland has made huge strides in building the science base; in putting in place infrastructures and policy instruments; in building the linkages between the science base and enterprises; and, in making progress in increasing the level of RDI in the enterprise base.

Some of the indicators from the Forfás review that illustrate this progress include:

- Government budget appropriations and outlays on RDI have increased considerably over the past decade, increasing from €504m in 2002 to €801m in 2011, peaking at €948m in 2008.
- The numbers of R&D performing firms in Ireland and the scale of their R&D effort are growing while Business Expenditure on R&D in Ireland rose from 0.93% of GNP in 2003 to an estimated 1.47% of GNP in 2012.

- RD&I performing firms are gaining an increasing share of sales, export sales and are accounting for increasing shares of employment. In addition RD&I performing firms have demonstrated better employment retention during the current challenging economic period.
- Higher Education expenditure on R&D (HERD) has increased in absolute terms over the last decade from €238m in 2000 to €708m in 2010. (HERD has, however, fallen to an estimated €630m in 2012.)
- Ireland has made major progress in building a science base that, in some niche areas, is among the best in the world and supplies vital highly skilled human capital to enterprise.
- Ireland is in the top 20 countries ranked by citations per thousand population and Ireland's scientific output is now of leading international quality in a number of niche but important areas, such as immunology, and molecular genetics and genomics, as measured by citations per paper.
- Researchers active in the higher education sector almost trebled from 2,148 FTEs in 2000 to 5,729 FTEs in 2010. PhD graduates from the university sector increased from 774 in 2005 to 1,153 in 2010.
- Employment in RD&I jobs has increased significantly in the last 20 years. Total R&D personnel, for example, more than doubled between 1997 (10,826) and 2011 (21,817).

2. By international standards, and in comparison with other small innovative economies, Ireland remains a comparatively low spender and a comparatively low performer.

Another message that emerges from the data is that, although Ireland has built areas of excellence, Ireland still lags comparator countries across a broad range of metrics.

Some of the indicators from the Forfás review which show this include:

- Ireland's public investment in innovation (GBORD) is low by international comparison and is falling. Therefore while Ireland's GBAORD has increased over the last decade, it's intensity (as a % of GDP) is still low by comparison with selected comparator countries (less than half that of Denmark (1.02%) and Finland (1.01%)) and below the EU average of 0.64%. Moreover, GBAORD intensity as a % of GDP is now falling again - from 0.64% in 2009 to an estimated 0.47% in 2014.
- While enterprise investment in R&D in Ireland has increased over the last decade, it is still low by international comparison and although BERD in Ireland increased to 1.47% of GNP in 2012, Ireland's BERD still lags behind that of leading small innovative economies.
- HERD, as a percentage of GDP, is now above the EU27 and OECD averages but still lags behind leading small innovative economies and has decreased in more recent years from a high of €750m in 2008 to an estimated €630m in 2012 largely as a result of the economic crisis.
- Irish research output is focused on a relatively small number of important but niche areas and is towards the bottom of the range of comparator countries in terms of both scientific output (as measured by papers per thousand population) and impact (citations per thousand population)[4]. Further, the number of triadic patents per capita registered in Ireland rose over the last decade, but still lags comparator countries.

[4] Forfás (2013) 'Data Review of RDI in Ireland', May. Internal Working Document.

- Ireland's expenditure on its direct government R&D activities expressed as a proportion of GDP (GOVERD) at 0.08% is now below the OECD average of 0.28% having dropped from a high of 0.11% in 2003[5] and from 0.08% in 2008.
- Venture capital funding in Ireland has increased both in absolute terms and in numbers of companies funded, but still lags the funding availability of comparator countries.

3. Based on experience to date, it appears that creating capacity in the enterprise base is a greater challenge than building the science base.

An analysis of progress towards the targets set in the Strategy for Science, Technology and Innovation 2006-2013 was conducted in the Forfás review and is summarised in Chapter 2 and Table 3 above.

One key message that emerges from the analysis is that progress towards meeting the targets for the science base has been more rapid than progress towards the targets set for enterprise R&D activity.

In particular, as seen in Chapter 2, progress towards the targets set for the number of companies with minimum and significant scale R&D, and business expenditure by indigenous companies and by foreign owned companies was slower than envisaged.

As already stated, there has, of course, been a major recession which impacted severely on enterprise, and there is evidence of an increase in enterprise R&D since the review was completed.

Nevertheless this analysis highlights the importance of exploring additional ways to build RDI capacity and activity in enterprises.

The characteristics of Ireland's Enterprise RD&I Base

The Forfás review also provides important insights into RDI activities within Ireland's enterprise base which form a knowledge base for further policy interventions.

In particular the review shows that Ireland's enterprise R&D expenditure is dominated by a relatively small number of large firms, mostly foreign-owned and around 300 firms accounted for almost 70 per cent of total R&D expenditure in 2012. However, over half (54%) of foreign-owned multinational firms in Ireland are not active in RD&I with a high proportion of indigenous firms (62%) reported themselves as RD&I active. Although the term 'indigenous firms' does not equate directly with SMEs, the data shows that, when compared with the OECD average, SMEs make a higher contribution to BERD in Ireland than in many comparator countries.

Ireland's foreign direct investment in R&D is amongst the highest in the OECD, and not only makes an important contribution to Ireland's innovative activities but also facilitates innovation by transferring and developing technological capability to Ireland and being responsible for the a significant amount of new intellectual property.

Foreign-owned firms are also responsible for the development of a significant amount of new intellectual property, with almost 40% of the patents filed in Ireland over the 2009-2011 period accounted for by foreign owned firms and they employ more in RD&I activities (circa 11,000) than indigenous firms' (approximately 9,500 engaged in RD&I).

Of four typically R&D intensive industries, Ireland's share of total OECD exports has held up in 'Pharma' and 'Instruments industry', but has declined somewhat in 'Electronics', and

[5] Forfás (2013) 'Data Review of RDI in Ireland', May. Internal Working Document.

declined sharply in 'Office machinery and computer industry'. For foreign-owned firms, four sectors - 'Chemicals', 'Computer, Electronic and Optical Products', 'Medical Device Manufacturing', and 'Computer Programming' - together account for around 80 per cent of R&D expenditure; by contrast, when taken together, these four sectors account for only 15 per cent of R&D expenditure by Irish-owned firms.

Ireland has also seen its economy evolve towards having a higher contribution from serviced-based activities, with R&D expenditure by services firms now exceeding that for manufacturing firms. However, while for example, Ireland's share of firms engaged in new product and services development represents 22% of innovating firms, this is low compared to other countries[6].

Globally, Ireland's Technology Balance of Payments (TBP) [DEFINE] has remained negative over the last decade. This is in contrast to Sweden, for example, which shows a strong net positive TBP.

Conclusion

The analysis in this chapter indicates that while public investment in Science technology and innovation (STI) has enabled significant progress to be made, by international standards, and in comparison with other small innovative economies, Ireland remains a comparatively low spender and a comparatively low performer. Further, Ireland's experience to date suggests that the objective of creating capacity in the enterprise base is a greater challenge than building the science base.

[6] Forfás rationale paper based on EU CIS data.

Chapter 4: Policies and Priorities for Enterprise Innovation in Ireland

The policy context

The importance of enterprise RD&I and its contribution to economic development has been recognised in Irish policy and strategy statements since the late 1990s. This has been reflected in key policy priorities for developing science, technology and innovation activity and capacity in the Irish economy.

This policy focus was initially formulated in response to the comparatively low historic levels of RD&I activity and capacity in Ireland, through support for business R&D and research resources and quality, and higher education links to enterprise. In recent years, however, this focus has increasingly emphasised the importance of such investments producing economic development and employment growth.

The following key related policies already emphasise the important strategic priority placed on support for enterprise innovation:

- **National Research Prioritisation Exercise (NRPE)**[7]

The NRPE seeks to ensure that Ireland achieves greater economic and social returns from its investment in research, by prioritising research towards the needs of the enterprise sector, and the solution of societal challenges.

Fourteen priority research areas have been identified with separate action plans developed to support implementation over a five year time horizon.

More than 90% of the Research Prioritisation actions have been or are close to completion.[8]

- **Action Plan for Jobs**[9]

Launched in 2012 the Action Plan firmly established job creation as a central policy objective and highlighted the importance of ensuring that economic growth was accompanied by jobs. The Action Plan included a range of actions such as developing supports for job-creating businesses and removing barriers to employment-creation.

Innovation has been identified as a central 'theme' in successive Action Plan with prioritised actions focused on:

- The commercialisation of research into specific goods and services
- Effective collaboration led by enterprise in undertaking research, development and innovation.

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[7] Forfás and the Department of Jobs, Enterprise and Innovation (2014) 'National Research Prioritisation Exercise: First Progress Report, June 2014'. Available at: http://www.enterprise.gov.ie/en/Publications/National_Research_Prioritisation_Exercise_First_Progress_Report_June_2014_PDF_1_3MB_.pdf

[8] Forfás and the Department of Jobs, Enterprise and Innovation (2014) 'National Research Prioritisation Exercise: First Progress Report', June. Available at: http://www.enterprise.gov.ie/en/Publications/National_Research_Prioritisation_Exercise_First_Progress_Report_June_2014_PDF_1_3MB_.pdf

[9] http://www.djei.ie/enterprise/apj.htm

- The improved performance of enterprises through the effective absorption of new technology into their businesses.
- Funding and other opportunities under EU Horizon 2020 for specific sectoral activities of national importance.
- The placement of research personnel in Irish-based enterprises to enhance their development capability.

The Action Plan for Jobs is a whole of government plan.

- **'National Strategy for Higher Education to 2030'**[10]

The National Strategy for Higher Education to 2030 sets out a vision for higher education to play a central role in promoting '*innovation, competitive enterprise and continuing academic excellence'* In particular, it calls for research to be driven by innovation underpinned by new ways of linking higher education to the needs of the both the public sector and the enterprise sector.

Ireland's policy mix in support of enterprise innovation

The concept of the innovation policy mix provides a lens through which the coherence and coordination of existing policy measures can be examined.

The policy mix concept explicitly acknowledges that policy interventions may interact with '*the existing interventions for a given target group, technology, sector or societal issue'*[11] and produce unanticipated or sub-optimal outcomes. They may also share competing rationales, and overlap, leading to inefficiency and, in the worst case, ineffectiveness.

As RD&I policy has extended beyond the domains of science and technology, considering the policy mix for innovation has become increasingly important in many countries. Innovation policy mix models have, for example, identified key issues such as the need to avoid compartmentalisation of policies into different department or agencies; the requirement to accept that there are trade-offs to be made between different policy outcomes; and, ensuring that the diversity of agencies does not cause organisational inefficiencies or confusion amongst recipients.

Four dimensions of innovation policy are identified by the OECD with respect to policy mix analysis:[12]

- ***Policy domains*** - the policy areas supporting different aspects of innovation performance, e.g. enterprise, RD&I, education etc
- ***Rationales*** - the justification for policy action in policy domains
- ***Strategic tasks*** - broad task areas which address the policy rationales, e.g. business R&D, collaboration, skills etc

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[10] http://www.hea.ie/files/files/file/DoE/DES_Higher_Ed_Main_Report.pdf

[11] Flanagan, K., Uyarra, E. and Laranja, M. (2011) 'Reconceptualising the policy mix for innovation', Research Policy Vol. 40(5). Available at: https://www.escholar.manchester.ac.uk/api/datastream?publicationPid=uk-ac-man-scw:119191&datastreamId=POST-PEER-REVIEW-NON-PUBLISHERS.PDF

[12] OECD (2010) 'The innovation policy mix', in OECD Science, Technology and Industry Outlook 2010. Available at: http://www.keepeek.com/Digital-Asset-Management/oecd/science-and-technology/oecd-science-technology-and-industry-outlook-2010/the-innovation-policy-mix_sti_outlook-2010-48-en

- ***Policy instruments*** - the instruments or measures employed to address strategic tasks.

The position of Ireland, and its respective innovation policy mix, in these areas is considered below.

Policy domains:

Ireland's policy context in support of innovation is characterised by policies that directly promote and support enterprise RD&I, as well as wider framework policies to promote innovation in firms.

Other policy domains, however, also influence innovation in Ireland. For example, the Department of Education and Skills has a remit for pure and applied research, while other government departments and their agencies, for example, Teagasc, the Health Research Board and the Environmental Protection Agency, have remits that include research for policy as well as research aimed at solving societal challenges such as Sustainable food production, Climate change and Public health.

In many areas of research conducted by the Government agencies there is a strong underlying enterprise focus alongside the policy and sector interest. This underlines the importance of considering policy domains as a 'system', providing a platform through which innovation, including enterprise innovation, can be supported.[13]

Rationales:

Policy objectives underpinning the support for RD&I are principally economic in focus, and this is reflected in the rationales established for the main enterprise agencies including IDA, Enterprise Ireland, and Science Foundation Ireland.

These DJEI agencies, by funding enterprises and researchers to collaborate and undertake RD&I, are seeking to build enterprise activity and capacity.

Non-DJEI agencies, by contrast, tend to have a broader focus with goals that are typically related to the creation of a better society through improved health, low carbon energy, sustainable food production, sustainable transport etc.

This focus on societal goals, to a large extent, reflects the priorities of their funding departments (Department for Health, Department for Education and Skills and Department of Agriculture, Food and the Marine etc.).

Evidence of collaboration across departmental/agency departments is beginning to emerge at the policy and operation levels and is being encouraged and facilitated by the various working groups around the fourteen action areas under the Research Prioritisation Exercise as well as in other areas.

There is further potential for those Departments and agencies conducting RD&I in their own policy domains and sectors to play a cross-departmental working role and promoting the possibility that innovation, in and by enterprises, can be mobilised to support policy objectives beyond economic impact.

Strategic tasks:

The primary strategic tasks embedded in Irish policy for enterprise RD&I include encouraging business RD&I activity and exploiting HE research for commercial benefit. These strategic

[13] Warwick, K. (2013) 'Beyond Industrial Policy: Emerging Issues and New Trends', OECD Science, Technology and Industry Policy Papers, No. 2. Available at: 10.1787/5k4869clw0xp-en

tasks flow from the policy priorities established for enterprise and innovation policy and reflect a 'linear' perspective on the different stages of the innovation process.

Such a focus is also found in other countries. For example, they include strategic tasks in support of early stage research and knowledge generation, through to more applied R&D in business, and its commercial exploitation.

In addition, a third strategy task, namely 'meeting global and national societal challenges' can also be discerned from policies such as the Research Prioritisation Report, as well as in non-DJEI Departments and agencies remits.

The current strategic tasks for enterprise RD&I in Ireland can therefore be summarised as shown in Figure 3:

Figure 3. Strategic tasks for enterprise RD&I in Ireland

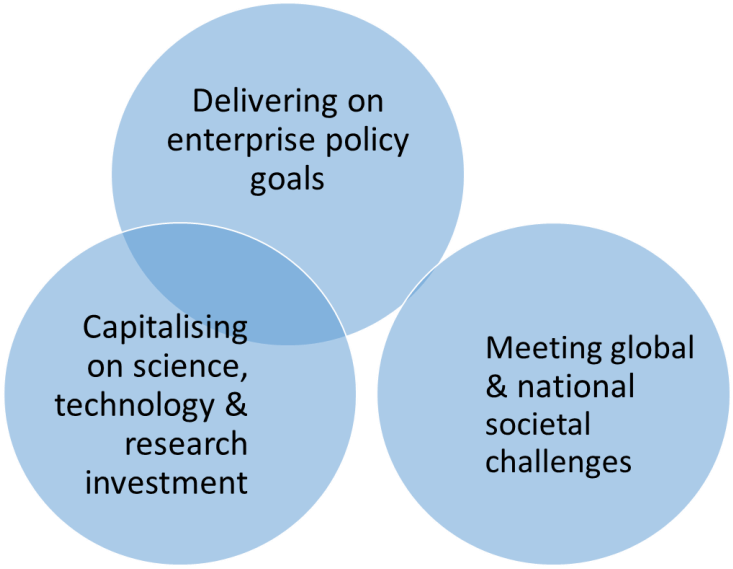


Figure 3 describes the current situation where there is a conjunction between the strategic tasks for enterprise RD&I in Ireland in respect of two of the policy areas while there remains a gap between these and the third strategic task identified, that of 'meeting global and national societal challenges'.

By contrast, the potential for RD&I policy measures to produce economic and social benefits is becoming increasingly evident across the EU member states. Indeed, EU programmes such as Horizon 2020 seek to address each of the three strategic tasks described in the figure above.

Policy measures:

Ireland's principal enterprise RD&I policy instruments are outlined in the OECD Science, Technology and Industry Outlook 2014[14].

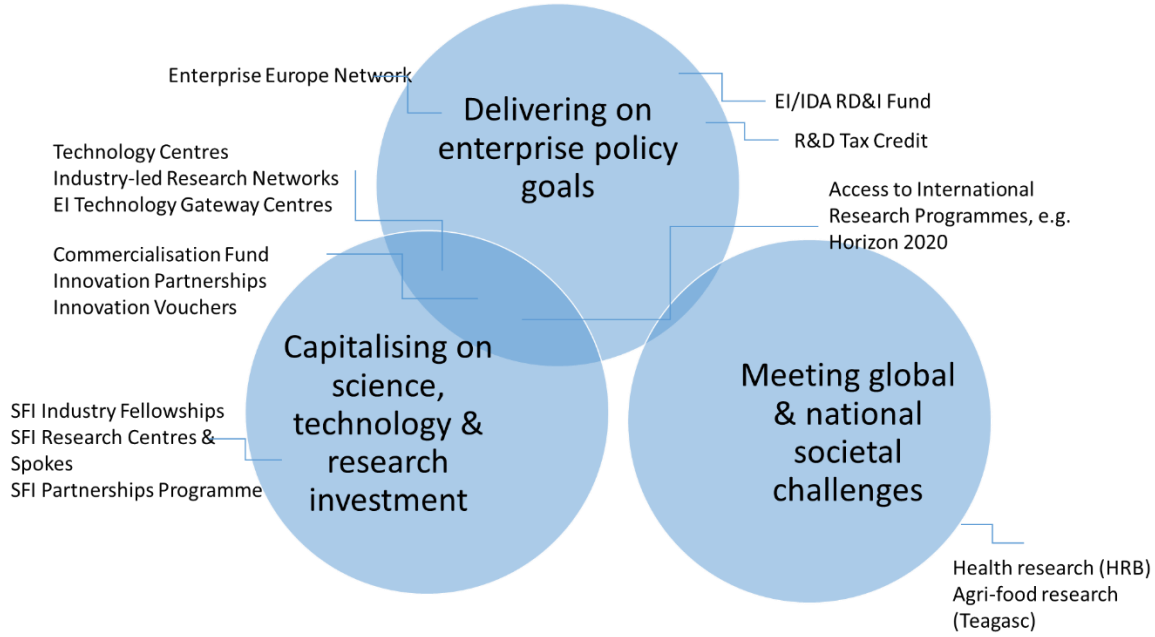
[14] OECD (2014) 'OECD Policy Questionnaire on the Science, Technology and Industry (STI) Outlook 2014 – Ireland Response'.

Figure 4 provides an indicative snapshot, based on the data in the OECD Outlook, categorised according to the three strategic tasks, described above.[15]

While there are often multifaceted objectives established for programmes, a keyword search of the measures suggests that the major RD&I measures are aimed at two areas of strategic task: 'Delivering on enterprise policy goals', and 'Capitalising on science, technology and research investment'.

The interfaces between these strategic tasks is also well populated with measures to encourage interaction, collaborative R&D and commercial exploitation. This includes measures targeting enterprises directly, as well as supporting researchers to produce economically valuable research and capacity for knowledge transfer, and suggests a comprehensive and balanced approach to these strategic tasks.

Figure 4. RD&I policy measures by strategic tasks



By contrast, relatively few specific RD&I measures address the strategic task of 'Meeting global and national societal challenges'.

The measures that do exist in this broad area of policy and strategic task are ones that largely reflect societal and national issues associated with health, environment, energy, and agri-food including Smart ageing, Healthy Ireland, Climate change, Bio Energy and Big Data for societal benefit. In these areas, the action groups convened around the Research Prioritisation Exercise areas play an important role.

Ireland's Enterprise Innovation Challenges

Based on our analysis, three overarching policy challenges for enterprise RD&I policy can be identified:

Challenge 1: Increasing the number of innovation performers in the multinational company sector

15 This categorisation/allocation of measures is based on key word analysis of the respective programme descriptions.

The multinational sector in Ireland accounts for the largest proportion of overall BERD in Ireland and has one of the largest proportions of BERD arising from multinational companies amongst all OECD countries. This is testament to the success of IDA and other agencies in securing innovation-focused inward investment.

While the contribution of multinationals that undertake RD&I activities in Ireland to overall BERD levels is significant there are some caveats.

As shown in Chapter 3, the majority of multinationals do not undertake RD&I activities in Ireland.

As highlighted by ACSTI, for example, the pharmaceutical, computer and electronic hardware and computer software sectors all have a strong multinational presence in Ireland, and are highly innovative industries. However, there is evidence that Ireland is not getting a large share of the global investment in R&D in these sectors (ACSTI, 2010). [CLARIFY REPORT]

One reason commonly given for non-RD&I activity amongst multinationals is that their Ireland-based managers do not hold decision-making powers with respect to RD&I which are, for the most part, controlled outside of Ireland. As a consequence such multinationals are likely to have pre-existing/incumbent R&D sites, and other sites acting as internal 'competitors' for future investment.

Ireland needs to continue to increase the number of multinationals, that are RD&I performers, and across a broader range of sectors and thereby increase overall innovation activity.

A challenge that is specific to the Irish operations of MNCs is the need to be competitive against group subsidiaries elsewhere in the world on R&D cost and attracting R&D talent from within the company.

Challenge 2: Broadening and deepening the RD&I activity in the indigenous sector and building absorptive capacity

As reflected in Ireland's BERD performance, significant number of indigenous companies do not undertake any RD&I activities or make only low levels of investment when undertaking innovation.

The specific challenges faced by indigenous firms can be found in other countries[16] – namely the lack of capacity to innovate and to absorb innovations. Typically, this stems from the difficulties that such companies face in absorbing the results of RD&I activity.

Where indigenous firms do undertake RD&I activity, the OECD found that an associated challenge that they typically face is that their innovation activities and strategies may have relatively low economic impact.[17] According to this research, it looks like one explanation may be that for many firms the primary approach taken to innovate is based on 'wider innovation' in which firms engage 'mainly in innovation aimed at improved management and

[16] See OECD (2014) Policy Questionnaires on Science, Technology and Industry Outlook 2014, various country responses.

[17] Haugh, D. (2013) 'From Bricks to Brains: Increasing the contribution of knowledge-based capital to growth in Ireland', OECD Economics Department Working Papers No. 1094. Available at: http://www.oecd-ilibrary.org/docserver/download/5k3wd358lj8r.pdf?expires=1411462770&id=id&accname=guest&checksum=4D2F0721209880DDE15E07233B51F119

business strategy changes'.[18] It is also likely that many indigenous firms will be innovating in ways that are 'new to the firm' rather than 'new to the market'. This can be contrasted with RD&I based 'modes' of innovation typically associated with traditional technological innovation and the development of new goods and services including new sales and distribution methods.

Given the relatively low levels of RD&I activity in the indigenous economy in relation to leading small innovative economies, the broadening of RD&I will help to boost innovation in new, products, processes and services. The indigenous firm base will also benefit substantially from new and renewed products, processes and services, with evidence pointing towards such firms benefiting from increased relative added value relative to their (non-innovating) peers.

Similarly, since R&D jobs are typically highly skilled and well paid, in the indigenous sector these jobs will be particularly important in helping to provide R&D capability, as well as helping to secure greater 'absorptive capacity'.

Further challenges faced by the indigenous sector include the lack of access to finance for RD&I and other activities. This challenge has been particularly acute in recent years and has been identified as a barrier in recent surveys. It is also clearly reflected in the EU Innovation Union Scoreboard results which show this to be a dimension of the assessment where Ireland performs rather poorly compared with the EU average and against comparator countries.[19, 20] In this respect Ireland's performance is at around 70% against the EU 27 average in both public expenditure in R&D and Venture capital investments although R&D expenditures by the business sector are closer to the EU 27 average at 92%, implying that while there is an appetite from firms for making investments, the availability of appropriate risk and innovation funding is less positive.

Challenge 3: Strengthening firm-firm collaboration and collaboration between firms and the public research base

Strengthening collaborative links between firms and between firms and the HE sector is a key challenge for Ireland in support of enterprise innovation, involving both multinationals and indigenous firms.

The specific challenge for indigenous firms is linked to the issue of absorptive capacity and available finance (discussed above). In indigenous firms limited pre-existing R&D activity and capability may result in a lack of awareness of who to collaborate with (so-called 'know-who'), as well as a lack of confidence and expertise to undertake and make sense of RD&I results (so-called 'know-how'). This challenge is potentially more acute for smaller indigenous companies who lack financial resources to employ specialist staff.

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[18] Haugh, D. (2013) 'From Bricks to Brains: Increasing the contribution of knowledge-based capital to growth in Ireland', OECD Economics Department Working Papers No. 1094. Available at: http://www.oecd-ilibrary.org/docserver/download/5k3wd358lj8r.pdf?expires=1411462770&id=id&accname=guest&checksum=4D2F0721209880DDE15E07233B51F119

[19] EU Innovation Union Scoreboard 2014

[20] CSO (2012) 'The Community Innovation Survey 2008-2010. Available at: http://www.forfas.ie/media/300412-Community_Innovation_Survey_2008-2010-Publication.pdf

The evidence also shows relatively low levels of multinationals reporting links to the higher education sector[21]. For multinational firms the collaborative RD&I challenges relate to a number of factors such as the locus of control of their RD&I activities and the potential lack of a local remit to conduct such activities and the company's ability to access RD&I expertise from within their wider group of companies rather than seek external collaborators.

The supply side in Ireland also presents challenges for the strengthening of RD&I collaborations and knowledge transfer. Here, as illustrated by HERD performance, the capacity of the universities and, to a lesser extent, the Institutes of Technology have developed substantially over the past decades. However, the existence and capacity of research centres with an industry focus is less developed.

Moreover, unlike leading OECD countries, Ireland does not benefit from industry-focused Research and Technology Organisations (RTOs). Such centres would typically help to bridge the divide between business and companies of all sizes and tend to support RD&I activity that is more applied in focus.

Conclusion

The analysis in this chapter suggests that Ireland needs to take action to address some specific challenges that have an impact on enterprise RD&I. In addition, while maintaining a focus on the strategic tasks of 'delivering enterprise policy goals' and capitalising on science and technology research investment', Ireland should also seek to explore opportunities for enterprise by increasing its focus on the strategic task 'meeting global and national societal challenges'.

The following chapter explores specific ways in which Ireland can do this, by looking at innovation practices in leading comparator countries.

[21] Haugh, D. (2013) 'From Bricks to Brains: Increasing the contribution of knowledge-based capital to growth in Ireland', OECD Economics Department Working Papers No. 1094. Available at: http://www.oecd-ilibrary.org/docserver/download/5k3wd358lj8r.pdf?expires=1411462770&id=id&accname=guest&checksum=4D2F0721209880DDE15E07233B51F119

Chapter 5: Lessons from International Comparators

This Chapter considers how other countries are addressing the enterprise innovation challenges facing Ireland, and builds on those measures available in selected comparator countries.

The evidence presented below draws on the OECD Policy Questionnaires completed by the following countries for inclusion in the Science, Technology and Industry (STI) Outlook 2014:

- Sweden
- Denmark
- Finland
- Netherlands
- Belgium
- Israel
- New Zealand

This analysis is not intended to be exhaustive but rather to give an indication of some of the main policy instruments recently introduced by comparator countries to increase RD&I in enterprise.

Countries are adopting a Systems Approach to Innovation

Countries across the OECD are increasingly adopting a systems approach to innovation.

The essence of a systems approach to innovation is that it encourages a focus on the whole innovation eco-system rather than simply the individual elements of the policy domains. In a systems approach, while the individual elements of the policy domains and strategic tasks are important, it is the interrelationship between the individual parts and the way in which they interact and reinforce each other that is the most important aspect and reflects the joint fulfilment of the objectives and the purpose of the whole eco-system.

As highlighted in Chapter 2, firms in countries that are innovation leaders benefit from operating within a balanced innovation ecosystem where a range of framework conditions and a full spectrum of supports are available.

The adoption of a systems approach is evident in the approach being taken by competitor countries in the following areas:

Innovation policy as a 'whole of Government' issue

The first point to emerge from the approach of the comparator countries is that innovation policy measures and strategy development are increasingly recognised as a cross-government issue.

In Sweden, for example, the recent national innovation strategy (2012) was based on a cross-ministerial process and was intended to provide an overarching framework for the further development of specific policy measures, both by Government and by different public agencies.

Finland's strategy similarly recognises the inter-linkages and responsibilities of all the public organisations involved in innovation policymaking and implementation.

Focusing RD&I activities around public and societal challenges

Addressing national strategic and societal issues is currently one of the most active policy areas amongst comparator countries

In addressing so-called 'challenge-led innovation' a number of approaches are evident in the comparator countries.

Denmark, for example, has worked with public and private actors to develop Inno+ covering 21 concrete areas for research and innovation that are geared towards finding solutions to the grand societal challenges.

Sweden has launched the SIA (Strategic Innovation Areas) project whose results are available to so-called 'problem-owners' in industry and the public sector with the primary selection criteria being the potential for innovation projects to generate important impacts.

The UK's Innovation Platform model brings together stakeholders with a range of programme resources around strategic issues and challenges.

In the *Netherlands*, the Top Sectors programme supports collaboration between entrepreneurs and knowledge institutes, in leading sector areas, with the potential to provide input in solving societal challenges.

Within the broad area of challenge-led innovation, procurement is a growing area of importance. Here, public policy has focused on promoting and favouring RD&I in public purchasing decisions and the potential to support and encourage new innovative goods and services.

A common approach here is the Small Business Innovation and Research (SBIR) model, initially transferred from the USA. The SBIR approach is gaining rapid popularity in a number of countries, such as the *Netherlands* where the scheme aims to use public procurement to stimulate SMEs to undertake R&D activities and provide results that address social challenges.

Elsewhere, *Finland* and *Denmark* address societal issues and challenges through the development of a series of demand driven innovation framework policies with the potential for societal and national needs to be addressed.

The *Finnish* Demand and User Driven policy framework sets out a broad action plan to raise awareness, empower citizens to choose services that better meet health needs. The concept includes a number of approaches to involve the end user in open forms of innovation, including the establishment of a living lab network, prioritising user centred research, and focusing TEKES research programmes towards 'demand driven business opportunities emerging from societal challenges'. These initiatives involve the end user in RD&I activities through opportunities to contribute towards co-creation activities and contribute ideas and 'needs' for researchers to develop solutions.

Innovation in Services and Business Processes

Innovation in Services and Business Processes (ISBP) is one of fourteen national priorities identified in the National Research Prioritisation Exercise.

The type of research relevant to ISBP differs in a number of important respects from research typically carried out in higher education institutions. These differences include the fact that the timescale for research is much shorter, end users are typically centrally engaged, and the research is multidisciplinary in nature.

The report 'Assessment of Publicly Funded RD&I Supports for Innovation in Services and Business Processes', adopted by the Research Prioritisation Action Group (PAG) in March 2014,

contains an overview of ISBP initiatives in comparator countries, including Finland, Norway, UK, Austria, France and Germany.

These international comparisons that policy for ISBP is still very much an evolving area, and the PAG report revealed a wide variety of government approaches and initiatives in terms of scope, policy priorities, available resources, the stakeholders engaged, as well as the mechanisms and instruments that are being used.

The Report stated that the enabling and transformative capacity of services innovation is an important challenge for Irish policy and that the enabling role of ISBP points to the potential for innovation in services and business processes to contribute to other policy priorities within the Research Prioritisation exercise helping to maximise the impact of the overall Prioritisation initiative.

It also stated that developing policy and supports for innovation in services and business processes will require the creation of a common understanding of the economic and social benefits to be gained from greater innovation in services and business processes amongst key stakeholders.

The implementation of the recommendations of the Report is being facilitated by an Advisory Group reporting to PAG. The Advisory Group is drawing on the experience in a number of comparator countries where the focus is on addressing important economic and societal challenges. In this respect policy towards innovation in services is based on its role as 'a means to an end'.

Individual RD&I instruments still matter

Our analysis of comparator country's practices shows that, within a systems innovation approach, individual RD&I instruments still matter.

Further, a comparison of instruments in use in competitor countries shows that Ireland, for the most part, has most of these RD&I instruments in place. This echoes a recent review of enterprise RD&I supports conducted by Forfás / DJEI. The suite of evaluations that were carried out concluded that the policy instruments in Ireland are broadly in line with those currently in place in leading innovative economies.

The evaluation also noted, however, that these supports may not always necessarily be working in one accord, and made recommendations as to how the coherence of the system of RD&I supports for enterprise could be improved.

Our comparison of Ireland's policy system with that of competitor countries shows that Ireland's policy instruments are broadly in line with other countries, but highlights a small number of instruments where Ireland could take additional action.

Strengthening the number of innovation performers in the multinational company sector

The objective of strengthening the RD&I focus of the multinational sector is shared by a number of the international comparators. This reflects the small size and international nature of the comparator economies and the important of the multinational sector to their overall economic performance. This is the case, for example, for Sweden, Denmark, Israel and New Zealand, where associated concerns are identified that a downturn in RD&I activity in the multinational sector could have a substantial 'knock on' effect with respect to their demand

for innovation-related services from knowledge-intensive SMEs, research institutes and universities[22].

Policy approaches to these challenges and concerns are beginning to emerge, and these fall into a number of areas.

The main area, in this respect, relates to the treatment of R&D for tax purposes. Comparators approaches in this area include:

- R&D tax credits – RD&I activity measures (common across OECD countries)
- R&D researcher tax credit – RD&I human resource measure (Sweden, Denmark, Belgium)
- Patent box tax credits – an RD&I output measure (Belgium, Netherlands, UK)

These measures are found in most of the comparators and seek to provide taxation incentives for different elements of the innovation process. Of these, the Patent box concept is an area of strong recent growth, although the details of the concept are still being worked out.

While tax credits are not always tailored specifically to multinationals directly, countries such as Belgium identify them as being particularly attractive to multinational investment, reducing labour costs for conducting R&D and maximising the benefits of successful RD&I.

Direct supports for RD&I activity are also evident, however, primarily these represent adaptions of mainstream RD&I supports, for example, efforts to encourage multinational participation in strategic R&D projects.

Israel, for example, has designed the Global Enterprise R&D Cooperation Framework (GIRDF) to promote the transfer of R&D from multinational technology companies to their Israeli subsidiaries.[23] This provides funding via its main R&D funding programmes, with the target of increasing the technology focus of Israeli plants.

Sweden has adopted a broader, more strategic approach which aims to increase the international attractiveness and competitiveness of its RD&I base. The Vinnova Global Links for Strong Research and Innovation Milieus programme, for example, includes financial support for research organisations and business to develop an international dimension to their RD&I activities, and attracting R&D-performing firms from abroad.

Broadening the RD&I activity in the indigenous sector and building absorptive capacity

Building innovation capacity in the SME population is central to the long-term success of RD&I innovation support in most comparator countries.

In most cases support is shaped around a funding incentive to encourage firms to conduct RD&I and reducing the risks of conducting RD&I, which is noted as a barrier for SMEs. Other common supports provide collaboration opportunities for those companies looking for partners or expertise.

A key part of the challenge for Ireland is one of encouraging greater numbers of indigenous SMEs to conduct RD&I activities while also broadening the range of sectors that are represented.

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[22] OECD (2013) 'OECD Policy Questionnaire: Sweden'

[23] http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/il/supportmeasure/support_mig_0010?searchType=advanced&tab=template&avan_typo=all&reverse=true&subtab=&avan_fecha_fin=&avan_fecha_ini=&num=20&country=&orden=LastUpdate&query=multinationals

For the comparator countries reviewed both RD&I funding and non-funding supports are the key mechanisms available to SMEs. In Europe such supports are governed by the State Aids Framework for RD&I, and the comparator countries illustrate a range of different approaches.

Sweden, for example, has recognised that some 80% of private R&D is performed by large companies while 98% of all Swedish companies are SMEs. In response it has developed a number of mechanisms including R&D grant and loan funding targeted at those small companies that have yet to undertake any RD&I activity ('Product Development in Small Companies'). It has also developed a 'Research and Grow' funding for RD&I which explicitly includes the objective of '*creating a better balance between RD&I activity and supporting SME needs-driven projects*'.

Innovation advisory services can be particularly useful in helping to build innovation capacity. Such supports typically include an audit of innovation capacity and plans for product, process and service development. *Denmark* is a good example of such an approach with its Innovation Agents scheme. These Innovation Agents are typically R&D and technology experts and are able to provide advice, and signposting for companies in the early stages of innovation.

In Denmark, the Development and Demonstrations programme (GUDP) aims to create better links between research, development and demonstration of knowledge in the specific areas of the economy, for example, in food, agriculture, fisheries and aquaculture. The programme funds research, development and demonstration projects that have the greatest potential and contribute most to a competitive and sustainable food and non-food production.

Strengthening firm-firm collaboration and collaboration between firms and the public research base

Collaborative linkages between firms and between firms and higher education institutions, is a core policy measure for most of the comparator countries.

Such measures typically address the opportunity to better exploit investments that are being or have been made in public and academic research. They also provide the basis for companies to gain expertise and access to partners for their RD&I activities.

The majority of comparator programmes in this area are focused on enabling access of SMEs to academic research and building collaborative R&D projects. This includes examples ranging from informal networks, to strategic projects.

Collaborative knowledge exchange networks include the *Flanders* Cooperative Innovation Networks scheme. Such schemes focus on providing the context for SMEs and researchers to meet and exchange knowledge and conduct joint R&D.[24]

The *Danish* Strategic Platforms for Innovation and Research (SPIR) are another example, of a mechanism to which targets cooperation in strategic research areas, as is the *Israeli* Magnet programme, targeting support for consortia to develop new generic technologies.

Physical centres focusing on collaborative RD&I are also well developed in many comparator countries. The Research and Technology Organisation (RTO) model, for example, is well developed.

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24 http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/be/supportmeasure/support_mig_0052?matchesPerPage=20&orden=LastUpdate&avan_prios=19e97f58-84f9-11df-a2e2-53862385bcfa&searchType=advanced&intergov=all&tab=template&index=Erawatch+Online+EN&sort=&avan_other_prios=false&searchPage=3&subtab=&avan_country=at&reverse=true&displayPages=10&query=innovation+capacitybuilding&action=search

In *Finland*, for example, its SHOK programme (Strategic Centres for Science, Technology and Innovation) represents a collaborative public-private partnership approach to RD&I, with an emphasis on renewing industry clusters and creating radical innovations which address industry and social needs.

Finland has also recently developed this concept further with its creation of city innovation hubs, promoting cooperation in large city regions. The INKA scheme emphasises the role of cities in driving innovation and providing an environment for innovative interactions between firms and higher education, public officials and so on, supporting lead markets, and encouraging national and international collaboration for innovation.

International centres or 'hubs' is a further area of activity in addressing collaborative links. This approach seeks to internationalise RD&I links, and can be seen in models such as *Denmark*'s Innovation Centres (ICDK) in Shanghai, Silicon Valley, München, São Paulo, New Delhi and Seoul. The Innovation Centres Denmark (ICDK) are designed to create international links for innovating companies and research institutions, to access new knowledge, networks, technology, capital and markets.

While most policy measures support business and higher education collaborations, programmes developing knowledge transfer professionals are also evident amongst the comparators. In *Sweden*, for example, VINNOVA's Key Actors programme provides support to help the professionalization of this sector, with a view to improving collaboration in the knowledge transfer and commercialisation process.

Additional instruments for Policy Action

This review of comparator countries' innovation policies shows that the policy instruments in Ireland are broadly in line with those currently in place in leading innovative economies. However, the following small number of initiatives are identified as being of potential promise for Ireland:

1. The Global Enterprise R&D Cooperation Framework (GIRDF) in Israel
2. Vinnova's Research and Grow Programme in Sweden
3. Vinnova's Key Actors Programme in Sweden
4. The Development and Demonstrations Programme in Denmark

1. The Global Enterprise R&D Cooperation Framework (GIRDF) in Israel

Objectives	The Global Enterprise R&D cooperation framework (GIRDF) aims to attract prominent multinational corporations (MNC) to forge investment cooperation deals with Israeli SMEs and start-ups. The Framework's main purpose is to provide a friendly, favourable approach and supportive work environment ("one-stop-shop") for Israeli SMEs and start-ups looking to collaborate with the MNC.
Activities	Israel's Office of the Chief Scientist (OCS) in the Ministry of Industry, Trade & Labour signs joint venture agreements which aim to encourage creation of industrial technological R&D cooperation between the relevant MNC and Israeli companies to work together to develop innovative technologies and products, within the MNC's technology and innovation roadmap.

	Both the Office of the Chief Scientist and the multinational corporations commit to invest in pre-selected R&D projects, conducted jointly by the MNC and Israeli companies. The MNC may not be required to invest money, it may also provide the SME with facilities and support. The OCS shares the risks and costs of the technology development with the partnering companies and enables Israeli companies, cooperating with the MNC, a funding grant of up to 50% of the approved expenses from the OCS and in-kind supports from the MNC to prove the technology. The in-kind support may include: Technological guidance, Equipment and Lab facilities, Software licenses and, Business mentoring, etc The IP created from the joint project may be owned jointly by the Israeli SME and the MNC. Each project must lead to a technology Proof of Concept (POC) and/or a development of a new technology product/process. The MNC provides a named dedicated programme manager who ensures that the progress of the projects and the results are integrated into the MNC.
Results	OCS operates several MNC R&D cooperation agreements with Alcatel, Intel, IBM, HP, Oracle, Merck, Coca Cola, Deutsche-Telecom, GE, Microsoft and BT

Potential 'fit' of GIRDF with Ireland's policy and programme landscape

Programmes in Ireland identified as potentially having somewhat similar or complimentary policy objectives and/or programme activities:

The SFI Strategic Partnership Programme has somewhat similar or complementary policy objectives and is aimed at funding *"compelling research opportunities, on a flexible basis, that are not otherwise served by other national funding programmes and which represent research opportunities in Ireland in collaboration with multinational companies and/or international organisations"*[25].

There was an estimated budget of EUR 2.6 million available for 2014[26].

This Programme is targeted mostly at collaborations between MNCs and Irish researchers. However, in this programme there is no specific focus on the SME collaborator.

Potential added value of GIRDF for Ireland

An adapted GIRDF could strengthen the number of multinationals performing RD&I in Ireland by building collaborations in RD&I between MNCs, Irish SMEs and Irish researchers.

The GIRDF approach provides direct support to the indigenous SME, rather than the MNC. Indirectly however, the Framework also allows the MNCs to create a supported long-term relationship with leading edge indigenous SMEs. This should allow the MNC to leverage additional research resources and competencies into delivering their global RD&I objectives and strategies.

The MNC provides 'soft' inputs and, crucially, also brings its objectives, ambitions and ideas for the technology area and market sector to the cooperation with the indigenous SME. This

[25] SFI web site (March 2015)
[26] Ireland's STI Outlook Questionnaire 2014, OECD

benefits the SME by allowing them to focus their RD&I with a commercialisation route already apparent rather than speculatively posed.

Conclusion

The introduction in Ireland of an instrument similar to the Global Enterprise R&D Cooperation Framework (GIRDF) in Israel could enhance MNC-SME collaboration and potentially increase the attractiveness of Ireland as a destination for MNC RD&I investments.

2. Vinnova's Research and Grow Programme in Sweden

Objectives	The programme aims at stimulating greater R&D investment in R&D performing firms and also attracting R&D-performing firms from abroad.
Activities	The "Research & Grow" programme was introduced in 2006 and is inspired by Small Business Innovation Research (SBIR) / Innovation voucher type of schemes. The programme is highly competitive and only 10-12% of the applicants are successful. 80% of private R&D in Sweden is performed by large companies while 98% of all Swedish companies are SMEs. This calls for policies to specifically target the stimulation of innovation and R&D activity in SMEs and allow Swedish SMEs the opportunity to build their capacity to conduct RD&I. The programme therefore targets SMEs and aims at funding their needs-driven R&D projects and providing support for feasibility studies. The company applies for the grant, together with its collaborators, these may include universities or research institutes or companies – but the company decides who to collaborate with and how. (The collaborators can receive a part of the grant but cannot apply for it.) Grants are given for feasibility studies and R&D projects at three different levels: • Up to €10k (SEK 100k) for a needs analysis; • Up to €55k (SEK 500k) for a feasibility study; • Up to €550k (SEK 5m to a max 50% of the total project) for an R&D project. SMEs need to demonstrate how the R&D investment can lead to a substantial improvement to their international competitiveness. The criteria used is that the support "***shall strengthen the company's capacity to compete on the global market and thereby contribute to the generation of economic growth and new jobs in Sweden***." Proposals are evaluated by external experts as well as internal experts at VINNOVA . Feasibility studies and R&D project grants can be applied for twice per year. Support for a needs analysis (€10k) can be continuously applied for making this a more voucher like instrument. This mainly attracts SMEs who have not previously engaged in R&D activities.

	The programme distributes approximately €13 million on an annual basis.
Results	The initial 2005 phase saw 33 R&D-projects funded from 316 applications (10%) with 300,000 € per project. • In 2006, 213 companies received funding (out of 1166 who applied) • In 2007, 49 companies received funding (out of 366 applicants). • In 2008, 109 companies received funding (out of 707 applicants). • In 2009, 64 SMEs received funding (out of 287 proposals). • In 2010, 87 companies received funding • In 2011, 100 companies received funding • In 2012, 98 companies received funding.

Potential 'fit' with Ireland's policy and programme landscape

Programmes in Ireland identified as potentially having somewhat similar or complimentary policy objectives and/or programme activities include:

- The **R&D Fund** provides support for RD&I at all stages of company development and supports companies to progress from undertaking an initial research project to high level innovation and R&D activity.

  The R&D fund is open to application by existing and potential clients of Enterprise Ireland, Údarás na Gaeltachta and City and County Enterprise Board clients. Only manufacturing and/or internationally traded service companies located in Ireland can apply for funding, although partners can be in other EU countries.

  A budget of €26,330,897 was available in 2011 and €39,072,985 in 2010.

- An **Innovation Voucher Scheme** is available to build links between Ireland's public knowledge providers and small businesses and create a cultural shift among SMEs regarding innovation..

  Innovation Vouchers with a face value of up to €5k are available to assist a company or companies to explore a business opportunity or problem with a registered knowledge provider. Each voucher can be redeemed against consultancy or knowledge services by one of Ireland's higher education institutions.

  Voucher recipients can join with other small businesses also in receipt of an Innovation Voucher to work with a knowledge provider in solving an issue of common concern, up to a maximum number of ten companies.

  To 2013, 5,021 vouchers have been awarded to Irish Industry of which 2,803 resulted in completed research projects. A total budget of €4 million was available in 2013.

Potential added value for Ireland

Research & Grow explicitly ties the support to a global market perspective being adopted by the SME rather than allowing a local market need perspective determined by the SME. The focus therefore is on building the SMEs capacity to be able to compete in a global market by its innovation activities.

Research & Grow is highly competitive ensuring that only good quality projects are supported – this is assisted by an internal **and** an external expert evaluation of project applications. The

'voucher' element within the Research & Grow programme is, partly as a result, aimed at a somewhat higher level of support (€10k compared to €5k).

Finally, with Research & Grow, the choice of a collaborator (or collaborators) is made by the SME as part of the application process rather than limited, or proscribed, to an in-country set of institutions.

Conclusion

The introduction in Ireland of an instrument similar to Vinnova's Research and Grow Programme in Sweden could increase the focus of Enterprise Ireland's R&D Fund on building RD&I activities in SMEs that are likely to result in products, processes and services that can compete in global markets.

3. Vinnova's Key Actors Programme in Sweden

Objectives	The long-term goal of the Key Actors Programme is to develop competence, methods, processes and structures to enhance the professionalism of key actors in the Swedish innovation system. VINNOVA launched the Key Actors Programme as a means to increase the effectiveness of investments made by VINNOVA and other research-funding actors, and to strengthen the role of universities and university colleges in the Swedish industry It focuses on increasing the amount and efficiency of co-operation between research performers, industry and other actors in the surrounding society, as well as knowledge transfer and commercialisation of research results.
Activities	The Key Actors programme provides support to help the professionalisation of this sector, with a view to improving collaboration in the knowledge transfer and commercialisation process. One part of the Key Actors Programme is targeted exclusively at universities and university colleges. Universities and university colleges specialised in technology, medicine or science are offered funding to carry out strategies for knowledge transfer and commercialisation. The programme is aimed at individual universities/university colleges selected using a peer-review process according to four criteria: • relevance • quality • implementation • commercialisation potential The programme has a programme council and three peer-review groups with representatives from academia/industry/research institutes and other stakeholders. The peer-review groups play an active role in the selection process and in programme evaluations. The first call of proposal in 2006 targeted universities and university colleges although the programme's long term objective is to involve and fund research institutes and industry.

	The activities of the KAP could be seen in two ways: 1. Shorter-term activities to boost innovation capability (e.g. Student/SME/activities, improving spin-out support, 2. Longer-term activities to build innovation capacity (e.g. changing structures, building staff competence, creating networks) The KAP does not restrict itself to the development of new products through spin-out of research, but instead takes a broad view of innovation, which encompasses service and process innovation, entrepreneurship amongst students, engagement with large companies and SMEs. The Key Actors programme is co-financed by foundations and charities – as is common in the Swedish context - and the overall budget, agreed initially in 2006 was €22.6million. *(More recent budgets and results are not published)*
Results	A mid-term evaluation of KAP (2011) noted that: Almost all universities noted that the flexibility and adaptability of the programme has allowed them to write project plans and to plan activities which are adapted to their own circumstances, and to the economic needs of the region. KAP has also helped to strengthen the role of the university as one of the key players in regional innovation support.

Potential 'fit' with Ireland's policy and programme landscape

Programmes in Ireland identified as potentially having somewhat similar or complimentary policy objectives and/or programme activities include:

- **Knowledge Transfer Ireland (KTI)** was established in late 2013 as a partnership between Enterprise Ireland and the Irish Universities Association, arising from a recommendation from a Government-led task force that reviewed the state of business-research base engagement in 2012.

  KTI takes a national perspective on the knowledge transfer system in Ireland, and aims to enable business to leverage the commercial potential of Irish research and innovation through connecting businesses with cutting-edge research, expertise and opportunities in Ireland's higher education sector.

  KTI directly supports the development of Ireland's knowledge transfer infrastructure through engagement with business, investors and technology transfer offices to shape practice; and through allocating and managing funding to support knowledge transfer offices within Ireland's HEIs and State funded research organisations.

- The **Programme for Research in Third Level Institutions** (PRTLI) launched in 1998, provides financial support for higher educational institutional strategies, programmes and infrastructure to ensure that Irish higher education institutions have the capacity and incentives to formulate and implement research strategies that will give them critical mass and world level capacity in key areas of research.

  The PRTLI has a number of objectives:

- To fund research capacity and infrastructure relevant to society and the economy;
- To encourage greater focus by institutes on their strengths and on existing, new and emerging potential areas of interest in the regions and nationally;
- To drive effective collaboration between higher-education institutions in the national interest.

The PRTLI programme supports research in humanities, science, technology and the social sciences, and provides support both for talented individual researchers and teams within institutions, as well as the encouragement of co-operation between researchers both within and between institutions, within Ireland, the EU and internationally.

Funding of €347 million is allocated under Cycle 5 covering the period 2010-2015 – with just under €100m allocated to research programmes and people with the balance allocated to buildings and equipment.

Potential added value for Ireland

The Key Actors programme provides support that is targeted at individuals and institutions by seeking to professionalise individual researchers and academics to be able to interact and collaborate more effectively with enterprises through RD&I activity.

KAP therefore seeks to develop the skills, cultural attributes and appreciation of individual researchers to more effectively work with businesses rather than to solely fund specific research projects or collaborations.

KAP is competitive ensuring that only good quality proposals from a limited number of institutions are supported – this is assisted by an internal and an external expert evaluation of applications.

Conclusion

The suite of commercialisation supports in Ireland available to researchers in Universities and Institutes of Technology has been evolving towards the broad spectrum of supports available under the Key Actors Programme in Sweden. The establishment of the Central Technology Transfer Office is the culmination of this evolution of policy in Ireland. The Key Actors Programme in Sweden could act as a benchmark for the further development of commercialisation supports for researchers in HEIs in Ireland.

4. The Development and Demonstrations Programme in Denmark

Objectives	Development and Demonstrations programme (GUDP) aims to create better links between research, development and demonstration of knowledge in the specific areas of the economy – in this specific case the food, agricultural, fishery and aquaculture sector.
Activities	The programme targets funding at R&D projects that address the most central challenges in the food sector. For example, in food, agriculture, fisheries and aquaculture, the programme helps to ensure that there will be funds for the research, development and demonstration projects that have the greatest potentials and contribute most to a competitive and sustainable food and non-food production. GUDP gives funding to the development of new technologies, instruments, production systems, processes, products and management and logistic solutions.

	Every project application to GUDP must present a business plan documenting how the desired outcomes and impacts will be achieved - in the form of innovative and concrete products, novel processes, or new knowledge, which are commercially viable and may subsequently be marketed and sold to consumers or enterprises. Funding goes to small and medium sized enterprises, not to public organisations. GUDP has a board which is responsible for all funding decisions. The programme publishes calls for projects, normally twice a year. Project proposals are evaluated by external reviewers, among others by experts in the Danish Council for Strategic Research. The GUDP programme was allocated approx. 200 million DKK annually in the period 2010-12. • 2010: €5 369 128 • 2011: €5 369 128 • 2012: €5 369 128 Funding from GUDP is granted according to actual costs incurred in the project, including personnel effort, overhead, subcontracting, and materials. Companies typically receive 50% reimbursement. For Development and Demonstration projects, GUDP typically funds projects having total budgets between €65k (DKK 500,000) and €2.5 million (DKK 20 million). Project duration is a maximum of 4 years. A similar programme (MUDP) provides grants for business development, test and demonstration of innovative environmental technology solutions. The programme was allocated DKK 77 million (10m €) in 2012. This element was overseen by the Danish Environmental Protection Agency under the Ministry of the Environment.
Results	A 2011 evaluation of 46 projects (€26m) found that an overall economic impact of circa €200 million (DKK 1,500million) had been achieved - with additional investment by both businesses and research institutes of €13.9m (DKK 104 million) being made.

Potential 'fit' with Ireland's policy and programme landscape

- The **Food Institutional Research Measure (FIRM)** is the main Department of Agriculture and Food programme in Ireland for the funding of food research in public research institutions in Ireland. The aim of FIRM is to develop public good technologies that will underpin a competitive, innovative and sustainable food manufacturing and marketing sector.

  FIRM is the primary funding mechanism in Ireland for food research in third level colleges and Teagasc food research centres. The type of research funded by the FIRM runs from basic or fundamental research through to more applied type research with a key output being young researchers, trained to MSC, PhD and postdoctoral level, with specialist scientific skills that benefit the Irish food sector.

  The majority of research is conducted by research teams from a number of institutions, who share their individual expertise to address complex research topics. Some projects are linked with food manufacturers.

Since 1994, the FIRM programme has awarded €150 million to fund food research throughout Ireland, through open competition.

- The **Science, Technology, Research and Innovation for the Environment *(STRIVE)*** 2007-2013 support measure aims to protect and improve the natural environment by addressing key environmental management issues through the provision of world-class scientific knowledge generated through a vibrant, competitive programme of research developed supported and co-ordinated by the Environmental Protection Agency.

  Funding provided by the STRIVE programme supports both project and researcher-based awards. Applications for funding under the STRIVE programme are be assessed in terms of:

  - Scientific and technical quality, innovation and research content of the proposal;
  - Justification for the research in relation to national and International research objectives;
  - Familiarity with relevant issues and current related R&D;
  - Experience and capability of the R&D team;
  - Management of the project;
  - Costing and value for money.

  The final selection of project proposals is made by the Environmental Protection Agency with the assistance of a National Advisory Panel (drawn from relevant government departments and agencies).

  Results from the 2007 – 2013 STRIVE programme include €74m in funding for Irish environmental research; Over 100 reports published since 2007; 800 researchers funded, including 100 post-doctorates and 150 scholarships; 500% increase in peer-reviewed publications by Irish environmental researchers.

  There has been no published results of the Science, Technology, Research and Innovation for the Environment support measure although it is understood that its performance is being /has been reviewed with a view of continuing the STRIVE programme post 2014.

Potential added value for Ireland

The specific sectoral targeting at the core of the GUDP is interesting in the context of low RD&I performing sectors such as food, fisheries and agri-food in Ireland.

In addition, the focus on specific societal and national challenges to achieve R&D results that are commercially viable provides a sharp focus for long term investment by businesses working in the sector. This is in direct contract to the funding of universities, research institutions and other bodies to undertake the research and rely on them to transfer results to the indigenous business sector.

Conclusion

A number of RD&I instruments in Ireland have rationales and objectives similar to those of the Development and Demonstrations Programme in Denmark. Further funding for this type of funding programme aimed at the commercialisation of technologies and solutions focused on societal objectives could form part of a strategy to increase applied RD&I activities in Ireland.

Conclusion

The following general lessons emerge from the analysis of international comparator practices:

- Innovation policy measures and strategy development are increasingly being recognised as a whole-of-government issue.

- Addressing national strategic and societal issues is an active policy area amongst comparator countries, and one in which there are untapped opportunities for enterprise in Ireland.
- Innovation in Services and Business Processes remains an area of high potential in Ireland. If harnessed effectively, it could play an important role in maximising the returns from investment in R&D in the priority areas identified by Ireland.
- The review of comparator countries' innovation policies shows that the policy instruments in Ireland are broadly in line with those currently in place in leading innovative economies.
- The following small number of additional initiatives are identified as being of potential promise for Ireland:
    - The Global Enterprise R&D Cooperation Framework (GIRDF) in Israel
    - Vinnova's Research and Grow Programme in Sweden
    - Vinnova's Key Actors Programme in Sweden
    - The Development and Demonstrations Programme in Denmark

Chapter 6: Recommendations

The importance of investment in science, technology and innovation (STI) to Ireland's on-going and future economic and social development has been well recognised by Government.

After a number of years of severe recession, the Irish economy is once again experiencing significant growth. It is imperative that innovation and in particular, business enterprise investment in innovation be at the forefront of improved economic performance.

Government can play a major role in stimulating and directing innovation for economic and societal benefit.

The focus of this report is on identifying actions that Ireland can take to support and more effectively optimise the impacts of enterprise RD&I investment, given the enterprise structure in Ireland and knowledge of other national innovation systems and policy mixes.

The study draws conclusions on Ireland's existing enterprise RDI policy and makes recommendations for strengthening the policy mix in support of enterprise RDI covering both short-term and medium-term practical actions.

In summary, while maintaining:

- funding for research excellence and human capital in the science base, and
- a focus on direct and indirect supports for RDI in firms

Ireland also needs to:

- increase focus on commercialisation and translation of research,
- widen our view of innovation beyond R&D,
- further exploit opportunities for enterprises in societal challenge areas,
- develop new ways to create linkages between the science base and enterprises, and
- double the number of researchers in the enterprise base.

While a number of interventions are possible at the level of individual RD&I instruments, actions at the level of policy systems and the policy framework are also required.

Policy System Recommendations

At the policy system level 4 main actions are identified. These are:

Policy System Action 1

Ireland must significantly increase both public and private investment in RD&I if the returns from public investment in RD&I are to be maximised and the overall aim of building a strong economy and a better society is to be achieved.

Policy System Action 2

Ireland should follow international best practice by adopting appropriate 'whole-of-government' structures for the governance of its national innovation system.

Policy System Action 3

Ireland's funding agencies and Departments should adopt a wider view of innovation embracing innovation in services and business processes as a central component of Ireland's enterprise RD&I funding landscape.

Policy System Action 4

Ireland's funding agencies and Departments should place a greater emphasis on policies and funding for the testing and deployment of new technologies in real-life problem-solving settings, going beyond the current PAG focus on input funding.

Framework Recommendations

The following specific policy framework recommendations and actions arise from the analysis in this report, and are aimed at helping to achieve the policy system level actions set out above.

Framework Recommendation 1

In allocating future funding for RDI, Ireland should aim for an appropriate balance of funding across policy instruments that maximises the returns of public and private investment in RDI.

While maintaining a focus on funding for mission oriented research, Ireland should direct additional funding towards instruments that facilitate the development and deployment of emerging technologies.

Action: *Ireland should increase funding for partnerships for applied research and technology activities, such as Technology Centres*

DJEI, EI, SFI

Action: *Ireland should commit to the establishment of one or more research technology organisations (RTOs)*

DJEI, SFI, EI, IDA

Action: *Ireland should commit to further investment in infrastructures for test-bedding and deployment to enable the development of emerging technologies in real life settings*

DJEI, DCENR, DAF, DoH, HSE, DECLG, SFI

Framework Recommendation 2

Innovation in Services and Business Processes remains an area of high growth potential in Ireland. Increased investment in ISBP must be a key priority, given the increasing contribution of internationally traded services and global business processes to Ireland's economy.

Action: *Increase funding for the recently introduced 'Business Innovation Initiative' which supports firms in business model and services innovation. Ensure that this funding is available to both Irish and foreign-owned firms.*

EI, IDA

Action: *Increase ISBP capacity in the higher education sector by appointing a number of 'star performer' researchers with proven track records of 'solutions-driven' ISBP research in collaboration with global leaders in enterprise.*

DES, SFI, HEA

Action: *Increase funding for existing SBIR pilot activities that makes effective use of the purchasing power of the public sector to reward innovative solutions developed by small and medium sized enterprises.*

DCENR, DAFM, DoH, HSE, DECLG

Framework Recommendation 3

Ireland should explore additional opportunities for enterprise RD&I by increasing its focus on synergies between enterprise goals and the strategic objectives being pursued by other government Departments in 'meeting global and national societal challenges'.

Action: *Ireland should consider establishing RTOs and Research/Technology Centres of scale focused on providing solutions to specific global and societal challenges*

All government Departments

Action: *Ireland should establish a competitive funding mechanism for developing infrastructures of scale for test-bedding, scaling and deployment of existing and emerging technologies focused on areas of global and societal challenges*

All government Departments

Action: *Ireland should establish a competitive funding mechanism aimed at stimulating solutions-driven collaborations, which will bring together interdisciplinary consortia, comprising enterprises, higher education institutions, and public service delivery bodies, to overcome identified bottlenecks in transitions towards stated government goals in societal challenge areas. ISBP will form a central focus of this funding.*

All government Departments

Framework Recommendation 4

Innovation policy measures and strategy development are increasingly being recognised internationally as a whole-of-government issue. Ireland follow international best practice by devising and adopting appropriate whole-of-government governance structures for implementing the successor to SSTI.

Action: *A Cabinet Committee on Science, Technology and Innovation should be established, chaired by an Taoiseach*

Action: *An enlarged Secretariat, under the auspices of the Office of Science, Technology and Innovation, with a cross-government remit for STI policy*

Action: *An advisory group, akin to the Technology Strategy Board in the UK, tasked with advising on the allocation of funding across government based on government's prioritised goals for STI investment.*

All government Departments

Framework Recommendation 5

Ireland should adopt the goal of achieving a more balanced performance across the EU Innovation Scoreboard indicators as a guide in making future public investments in RD&I.

This means that increased public investment in RD&I should be made in such a way as to leverage greater investment by firms, based on investing in areas of excellence and global opportunity, which in turn should aim to increase intellectual property outputs from the enterprise base.

Action: *Further investment in RDI should be aimed as much as possible at leveraging private funding for enterprise RD&I, either directly or by putting in place infrastructures and enabling environments for increased enterprise RDI activities.*

Department of Jobs, Enterprise and Innovation; SFI, EI, IDA; Higher Education Authority

Operational Recommendations

The following specific operational recommendations and actions are aimed at underpinning the achievement of the policy system and framework actions set out above. They relate to the important role of human resources in RD&I and to the need to continually seek innovative approaches and interventions that will challenge and may further optimise the RD&I programmes in place in Ireland.

Operational Recommendation 1

Successful implementation of the approach outlined above - widening Ireland's definition of innovation to include ISBP, placing a greater emphasis on policies and funding for testing and deployment of new technologies in real-life problem-solving settings, and devising and implementing a whole-of-government approach to governance of innovation – will require training and deploying the requisite human capital.

It is recommended that Ireland adopt the necessary policies to ensure the skills required to implement this new approach are in place.

Action: *Increase the competences and capabilities in the public sector by establishing the governance structures outlined in Recommendation 8 and increasing staffing on the basis of competitive competition based on expertise in STI policy.*

Department of An Taoiseach; Department of Jobs, Enterprise and Innovation; all other government Departments

Action: *Continue to increase competences and capabilities in the enterprise sector through increased funding for EI and IDA programmes in this area*

Department of Jobs, Enterprise and Innovation; EI; IDA

Action: *Continue to increase competences and capabilities in the Higher Education sector*

HEA; SFI; IRC

Action: *Continue to ensure the competences and capabilities of graduates from the Higher Education sector*

HEA; IRC

Operational Recommendation 2

A review of comparator countries' innovation policies has identified a number of additional initiatives as being of potential promise for Ireland:

The Global Enterprise R&D Cooperation Framework (GIRDF) in Israel

Vinnova's Research and Grow Programme in Sweden

Vinnova's Key Actors Programme in Sweden

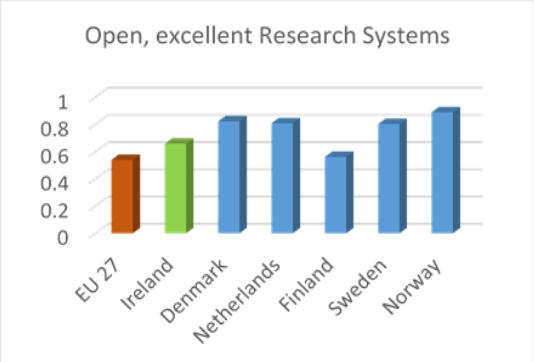
The Development and Demonstrations Programme in Denmark

Action: *These programmes should be adapted and adopted in Ireland, within the context of the new SSTI.*

DJEI, SFI, EI, IDA

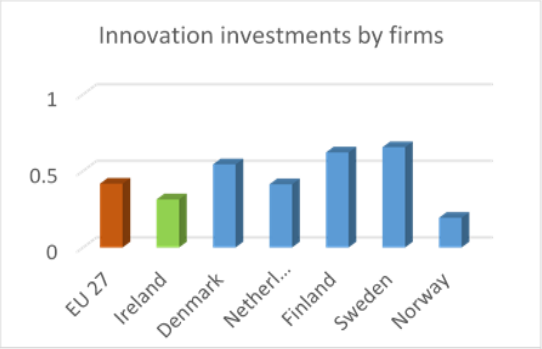
Annexes

Annex 1: Ireland's Innovation Union performance

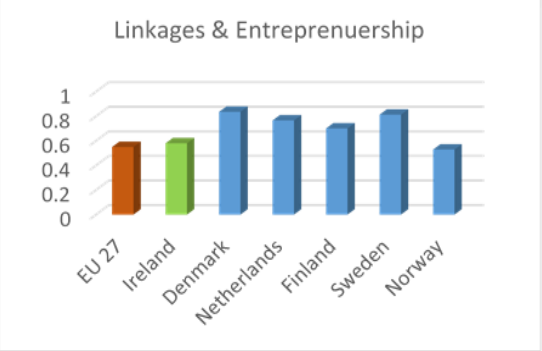


Countries exhibiting a high score in the 'Open, excellent and effective research systems' dimension, suggest that the innovation systems in these countries are open to cooperation with partners from abroad, researchers are well networked at international level and the quality of research output is very high.

In the measurement of 'Finance and support enablers', strongly performing countries are characterised by a public sector which is well endowed to perform R&D activities and by the availability of risk capital for private firms to develop new technologies.



In the dimension, 'Innovation investments by firms', high scoring countries have a large body of companies that typically invest in innovation activities, both for science-based R&D activities and non-R&D innovation activities including investments in advanced equipment and machinery.



The 'Linkages & entrepreneurship' dimension considers the extent to which SMEs combine in-house innovation activities with joint innovation activities with other companies or public sector organisations. The research systems in high scoring countries are also geared towards meeting demand for innovation from companies.

Source: Adapted from the Innovation Union Scoreboard 2014

Annex 2: Summary of Findings of Forfás Data Review of RD&I in Ireland

Draft Top Level Messages

The following analysis was conducted in 2013 and was intended to give a snapshot of the performance of Ireland's national innovation system at that time.

While more recent data has become available since then, the following is still useful in giving an overview of Ireland's performance across a wide range of metrics, particularly with respect to Ireland's performance in relation to our key competitors.

Note on Comparator Countries

A number of countries have been selected as comparator countries in this analysis and data is presented on these or subsets of these based on availability of data. These countries are Belgium, Denmark, The Netherlands, Finland, Sweden, Israel, New Zealand and Singapore.

Countries were chosen based on size, GDP per capita and innovation performance. Most have innovation systems that are more mature than Ireland's innovation system, and some are innovation leaders. Nevertheless, they give an indication of what it is possible for a small country of a similar level of development to achieve.

1: High Level International Benchmarking of National Innovation Performance.

Spending is low by international comparison and is falling…

While Ireland's GBAORD increased over the last decade, GBAORD is low by comparison with selected comparator countries, and is now falling. As a % of GNP, GBAORD has fallen from 0.71% in 2009 to an estimated 0.65% in 2011.

The Strategy for Science, Technology and Innovation 2006-2013 (SSTI) set a target for GERD intensity of 2.5% of GNP by 2013. This target has been revised to 2.5% GNP (i.e. 2.0% GDP) by 2020. In 2011, Ireland's GERD intensity was 1.72, below other comparator countries.

BERD in Ireland has also increased, but remains low in comparison with selected countries. When normalised for GDP, Ireland's BERD increased from 0.77 in 2001 to 1.17 in 2011, but still lags comparator countries.

While HERD in Ireland has increased, it too remains low in comparison with selected countries. When normalised for GDP, Ireland's HERD increased from 0.24 in 2001 to 0.47 in 2011, but still lags comparator countries. Business funding of R&D in higher education in Ireland is low by international comparison (3.9% compared with an EU-27 Average of 6.4% and total OECD of 6.3%).

GOVERD is low by international comparison, and is falling. As a percentage of GNP, the level of GOVERD has dropped from 0.11 per cent in 2003 to 0.07 per cent in 2012.

The total stock of research personnel has increased but remains low by international comparison…

Total R&D personnel more than doubled from 10,826 in 1997 to 21,817 in 2011. However, when normalised per thousand employees, Ireland's R&D workforce is still low in comparison with selected comparator countries, 10.7/1000 employees compared with a range of 11.0/1000 employees (New Zealand) to 22.5/1000 employees (Finland) in 2010.

The proportion of firms that are innovation active is ahead of, or on par with, comparator countries, but we seem to get relatively lower returns on innovation…

The proportion of innovative firms in the manufacturing sector is ahead of many comparator countries. The proportion of innovative firms in the services sector is comparable to that in comparator countries. Turnover from innovation for all firms in Ireland however is slightly below the EU average.

Ireland's output of scientific publications is low by international comparison, but is of leading international quality in a number of areas, including materials science, immunology and genetics...

Ireland's manufacturing sector appears to be performing below international norms in terms of patenting, with most patents coming from the services sector. Ireland lies ahead of many comparator countries in terms of trademarks per capita…

In general terms, Ireland is towards the bottom of the range of comparator countries in terms of both scientific publications (as measured by papers per thousand population) and impact (citations per thousand population). Ireland is however in the top 20 countries ranked by citations per thousand population. Ireland's relatively small output is of leading international quality in a number of areas, such as immunology, and molecular genetics and genomics, as measured by citations per paper.

The number of triadic patents per capita registered in Ireland rose over the last decade, but still lags comparator countries. Ireland is unusual in that firms in high- and medium-high-technology manufacturing sectors play a much smaller role in patenting than in comparator countries. Around 70% of patents in Ireland come from firms in the business services sector. Of firms that patent, Ireland has the highest share of young firms of all comparator countries.

Ireland lies ahead of, or on a par with, comparator countries in terms of trademarks per capita.

While collaboration between scientists and inventors in Ireland and international counterparts is high, collaboration between firms in Ireland and firms abroad is lower than in comparator countries…

Ireland leads many comparator countries in terms of co-authorship of scientific publications and co-invention on PCT patent applications, with collaborators abroad.

Irish firms collaborate with other Irish firms at rates similar to or slightly higher than comparator countries, as measured by CIS. However collaboration between firms in Ireland with firms abroad is slightly lower than most other comparator countries.

Rates of collaboration between firms and HEIs are lower in Ireland than in many comparator countries.

Government procurement as a % GDP in Ireland is around the OECD median and has the potential to be better harnessed for encouraging innovation, especially from SMEs…

While the quality of outputs is high, the overall impact of R&D and innovation in Ireland remains low. The decline in the number of R&D intensive sectors poses a threat to innovation-driven growth…

Ireland's Technology Balance of Payments (TBP) has remained negative over the last decade. This is contrast to Sweden, for example, which shows a strong net positive TBP.

Of four R&D intensive industries, Ireland's share of total OECD exports has held up in 'Pharma' and 'Instruments industry'. It has declined in 'Electronics' and declined sharply in 'Office machinery and computer industry'.

Patent quality in Ireland is highest among the comparator countries.

2: RDI Performance in the Enterprise Sector

Numbers of R&D performing firms in Ireland and the scale of their R&D effort are growing. BERD is increasing in absolute terms but BERD intensity has remained fairly static since 2009. Ireland's BERD intensity is below the OECD average and many selected comparator countries.

80% RD&I active firms are Irish owned yet foreign owned firms account for over two thirds of RD&I expenditure. Medium/Large Firms accounted for 75% of BERD at €1.4 billion in 2011. However, small firms play a larger role in R&D in Ireland than in selected comparator countries. R&D investment by medium/large firms was less affected by the crisis than small firms.

Between 2003 and 2011 expenditure on R&D has shifted from being manufacturing dominated to being services dominated.27 However, an overall increase in large scale R&D activity since 2003 is still evident in the manufacturing sector.

The vast majority of funding for R&D performed in the business sector comes from company funds. Ireland has one of the highest shares of total innovation support resources going directly to assisting business R&D in the OECD and is also among the highest in OECD countries and comparator countries in terms of indirect government support for R&D. IDA grants have increased 5 fold in absolute terms in the period 2002 – 2010. The number of firms using the EI Innovation Voucher scheme increased from 428 vouchers redeemed in 2007 to 856 in 2010 to value of €4.2m.

The period 2003 - 2011 has seen an overall shift towards closer to market research. The majority of research spending in Irish and foreign owned companies is in experimental development and has been shifting further away from basic and applied research over the period 2003 to 2011. The share of total expenditure accounted for by basic and applied research projects in Irish owned firms is still higher than non-Irish firms.

Over a third of R&D active companies in Ireland are engaged in collaborative research projects as reported in the latest BERD survey. While the overall % of firms involved in collaborative research efforts remained fairly static from 2005, collaboration rates with HEIs have risen steadily over the period 2004 to 2010. Firms are more likely to collaborate with other firms outside Ireland rather than Irish based firms.

RD&I performers are gaining an increasing share of sales, export sales and accounting for increasing shares of employment. In addition RD&I performing firms demonstrated better employment retention during the recent challenging economic period. Researchers and research personnel engaged in the enterprise sector have increased over the last decade, with PhD qualified researchers increasing by a factor of 3. Two-thirds of PhDs are in the services sector and 55% are in foreign owned firms.

Numbers of firms that are actively innovating increased over the 2006 to 2010 period. Ireland had the 7th highest technological innovation rate of all countries for whom data has been published in the 2006-2008 CIS, ahead of a number of comparator countries. Turnover attributable to innovation as a % of total turnover in Ireland is lower than the EU average, but mid-range in comparison to comparator countries. Turnover attributed to 'new to firm' and 'new to market' product innovation declined between 2006 and 2010 although new to firm turnover remained steady from 2008-2010.

27 (Note however: Caveats in data raise questions as to extent of this observation).

Venture capital funding in Ireland has increased both in absolute terms and in numbers of companies funded, however with overall levels of funding are at less than half the EU-27 average, and below all comparator countries, 2010.

3: RD&I Performance in the Higher Education Sector

In absolute terms HERD has increased by a factor of three from €238m in 2000 to €708m in 2010. HERD has decreased in more recent years from a high of €750m in 2008 as a result of the economic crisis. HERD as a percentage of GDP is now at EU and OECD Average but still lags behind comparator countries. 83% HERD is financed by Government, almost 10% from foreign sources, 3.8% from industry, 2% from Irish business. The SSTI set a target of 20% of HERD to be funded from foreign sources by 2013. The percentage of HERD financed by industry is well below both the EU-27 and OECD averages, and lags other comparator countries.

The top 5 Universities account for almost three quarters of total research spending in the higher education sector.

Total researchers in the higher education sector almost trebled from 2,148 FTEs in 2000 to 5,729 FTEs in 2010. However Ireland still lags all comparator countries, apart from the Netherlands, in terms of higher education researchers per 1,000 labour force.

Ireland's total scientific publications more than doubled from 3178 in 2000 to 7799 in 2008. This is an average annual growth rate of 11.9%. This is double the EU average and ahead of the growth rates in comparator countries. Highly cited publications for Ireland increased at an average annual growth rate between 2000 and 2007 of 14.8%. This is ahead of growth rates in comparator countries. High growth rates on this indicator are indicative of catch-up. Ireland ranks 20th on the Thompson Reuters national citation ranking.

Ireland's ratio of highly cited publications out of the total number of publications in 2007 was 0.11. On average a country is expected to have 10% of its publications in the top 10% most cited papers worldwide. The European countries with the highest ratio of highly cited publications out of the total number of publications in 2007 are Switzerland (0.16), Denmark (0.15), the Netherlands (0.15) and Belgium (0.13).

Four Irish universities have made it into the top 100 on at least one international ranking system. Three of these are in league tables for universities under 50 years old. None of Ireland's universities appear in the top 28 ranking of European universities hosting ERC grantees. Selected comparator countries dominate this list.

SSTI established a target of €400 million to be secured by Irish participants under Framework Programme 7 during the period 2007-2013. This target was subsequently revised upwards to 1.25% of the available fund, which is approximately €600 million. By 2012, researchers from Ireland had been awarded €430m. Based on the proportion of available funding secured by Irish researchers to date, Ireland is on track to approach the revised target of ~€600 million by 2013.

The number of patents applied for by public research organisations increased from 83 in 2005 to 202 in 2008. In 2010, the number of applications had decreased to 101.

Inventions disclosures from public research organisations increased from 135 in 2005 to 425 in 2010. Licence agreements increased from 12 in 2005 to 93 in 2010.

4: RDI Performance in the Public Sector

Ireland allocates a low proportion of GBAORD to GOVERD by international standards. Ireland's GOVERD as percentage of GDP is towards the bottom of the selected comparator countries.

Expenditure on R&D in the State sector has fallen from a high in 2004 of €138m to an allocation of €96m in 2012. As a percentage of GNP, the level of GOVERD has dropped from 0.11 per cent in 2003-04 to 0.07 per cent in 2012. Ireland's relatively small amount of funding for GOVERD is distributed across a relatively large number of bodies. Teagasc is responsible for more than half of R&D funding in the state sector. The remaining funding is distributed among 8 other main state sector bodies, and a number of other minor actors.

The total number of publications from government sector organisations over a ten year period was around 2,660. Teagasc was responsible for around half of these. This volume output is of the same order as, for example, the publication output of a university like NUIG over the same period.

Research organisations in the government sector play a range of important roles, aside from their roles in innovation and enterprise development. However, research in the government sector is critical to many of the 14 national research priority areas, including Food for Health and Sustainable Food Production and Processing, Diagnostics, Medical Devices, Connected Health and Independent Living, Marine Renewable Energy and Smart Grids and Smart Cities and sectoral public sector research funders and performers have a critical role to play in realisation of the opportunity in a number of these areas.

5: Human Capital for ST&I

By international standards, Ireland has a well-educated population, and Ireland's universities are more focused on science, technology and maths than many comparator countries…

The percentage of the 25-34 year old population in Ireland that has attained tertiary education is highest of all the selected comparator countries. Ireland also ranks highly on the number of graduates in science-related fields (science and engineering, manufacturing and construction), per 100 000 25-34 year-olds in employment among the selected comparator countries. While the proportion of graduates in science, mathematics and computing is high in comparison with other countries, the proportion of engineering graduates is lower.

Between 2000 and 2013, first choice applications for Level 6/7 and Level 8 science/applied science courses rose, while first preferences for Level 6/7 and Level 8 engineering and technology courses fell.

Total spending per tertiary student is becoming a concern…

In 2009 Ireland's total spending per tertiary student was around the OECD average and lagged that in selected comparator countries. Since then a reduction in government funding of HEIs has been only partially offset by rising student contributions, and recurrent funding per student has fallen.

Graduation rates at doctoral level increased substantially between 2000 and 2009 but still remains below the OECD average, and lags those in most of the selected comparator countries. However, Ireland's science and engineering graduates at doctoral level as a proportion of all new doctorates in Ireland is among the highest in the OECD, and is ahead of all selected comparator countries. The share of engineering graduates is lower than in many of the selected comparator countries.

Between 2005 and 2010, the number of SET primary degree graduates from the university sector remained relatively constant. The number of HSS primary degree graduates from the university

sector rose from 10,313 to 11,014. SET University Masters graduates increased from 1,695 in 2005 to 2,180 in 2010, while HSS University Masters graduates rose from 4,498 to 6,534 in the same period. There were also an additional 1,705 Master graduates from the IoT sector in 2010.

The SSTI set the following targets for PhD numbers: SET to nearly double annual output from 543 in 2005 to 997 in 2013; HSS to increase from 187 in 2005 to 315 annually by 2013. PhD graduates from the university sector increased from 774 in 2005 to 1,153 in 2010. SET PhDs graduates from the university sector increased in line with the target in the SSTI from 576 in 2005 to 776 in 2010, with an additional 56 SET PhD graduates from the IoT sector.

In HSS disciplines, PhD graduates from the university sector increased from 198 in 2005 to 377 in 2010, with an additional 13 HSS PhD graduates from the IoT sector, an increase of over 90% on 2005 and ahead of SSTI target of 282.

Most PhD graduates find employment in Ireland. In 2009, around 90% were in employment or further training.

Inward migration has contributed substantially to Ireland's human capital…

As an integral part of the SSTI, Ireland's immigration policy aims to attract some of the world's best researchers. Census figures show that almost 22,000 people who had completed their education held a Doctorate (PhD) level qualification in 2011. This represented a significant increase of over 52 per cent on 2006. The Census in 2011 shows that around 36% of PhDs in the country were born outside Ireland.

But Ireland could do more to attract leading international researchers to Irish universities…

ERC grants may be used as a proxy for the attractiveness of a country to top international researchers. Ireland lags comparator countries in terms of winning ERC awards.

22 ERC Starter Grant awards were taken up at institutions in Ireland in total for the years 2007 and 2009-2012 (the years in which data is available). This is low in comparison with the Netherlands (169), Switzerland (126), Belgium (86), Sweden (73), Denmark (39), and Finland (36).

Ireland won 8 ERC Advanced Grant awards in total for the years 2008-2012. This too is low in comparison with Switzerland (126), The Netherlands (108), Sweden (56), Denmark (29), Belgium (27), and Finland (19).

Ireland lies around mid-range among comparator countries in terms of female researchers as a percentage of total researchers in the higher education, government, and business sectors…

The percentage of doctorates awarded to women, at 46% of total doctorates awarded, is at the OECD average. Female PhD researchers in the enterprise sector increased their share of the total cohort from 19 per cent in 2003 to 28 per cent in 2011.

Ireland lies mid-range in comparison with comparator countries as regards female researchers as a percentage of total researchers in the business sector although based on 2011 Irish data in comparison to 2010 data for comparator countries but was ahead of comparator countries in 2009.

Annex 3: SSTI Targets and Indicators, 2013 Review

Progress in attaining the targets set in SSTI, as assessed in 2013, is summarised below.

GERD

SSTI Target	Current Performance
The Strategy for Science, Technology and Innovation 2006-2013 (SSTI) set a target for GERD intensity of 2.5% of GNP by 2013. Developments over recent years however have caused an interruption in this trajectory. The Government target, as reported to EU Commission in relation to the implementation of the National Reform Programme, is for GERD intensity indicator for 2020 of 2.5% GNP (i.e. 2.0% GDP).	GERD intensity in 2011 was 2.1% of GNP
The Lisbon Strategy includes the target that the business sector should account for two thirds of total R&D investment.	Ireland has maintained this ratio over the period.

People

SSTI Target	Current Performance
Number of new doctorates in science, engineering and technology earned annually to nearly double from 543 in 2005 to 997 in 2013 and in humanities and social sciences to increase from 187 in 2005 to 315 annually by 2013.	SET PhDs graduates from the university sector increased from 576 in 2005 to 776 in 2010 (SSTI target of 801), with an additional 56 SET PhD graduates from the IoT sector. In HSS disciplines, PhD graduates from the university sector increased from 198 in 2005 to 377 in 2010, (ahead of SSTI target of 282). There were also 13 HSS PhD graduates from the IoT sector in 2010.

Publications

SSTI Target	Current Performance
Ireland will aim to significantly advance its performance in terms of the European Commission publications league table from 12th in 2005. (number of scientific publications per million population)	Ireland was in 14th place in the OECD league table of publications per 1,000 population in 2009. Of EU countries, Ireland ranks in 9th position.

Citations

SSTI Target	Current Performance
Ireland ranked 12th (out of 45) with a score of 0.76. In a number of fields the Irish performance was even better (in Clinical Medicine ranked 10th and in Engineering and Technology ranked 4th with a score of 0.92). Indicator: Ireland will aim to significantly advance its performance on the citations index.	Ireland ranks 20th on the Thompson Reuters national citation ranking. Ireland ranked 10th on the innovation Union Scoreboard in 2012.

Internationalisation

SSTI Target	Current Performance
Share of HERD funded from foreign sources to return to 20% by 2013.	In 2010, 9% of HERD was funded by EU public and foreign business. This figure in 2000 was 15% in 2000.
Target significant levels of participation in FP7 and other international research programmes, (2007-2013); SSTI established a target of €400 million to be secured by Irish participants under Framework Programme 7 during the period 2007-2013. This target was subsequently revised upwards to 1.25% of the available fund, which is approximately €600 million.	By 2012, researchers from Ireland had been awarded €430m. Based on the proportion of available funding secured by Irish researchers to date, Ireland is on track to approach the revised target of ~€600 million by 2013.

Support for Research Commercialisation

SSTI Target	Current Performance
Number of invention disclosures reported	Invention disclosures rose from around 140 in 2005 to around 400 in 2011
Number of patents applied for and granted	Patent applications rose from around 150 in 2005 to around 400 in 2011
Number of patents generating revenue	
Number of licence agreements with companies	Increased from 12 in 2005 to 121 in 2011, 87 in 2012
Total revenues from licencing and fees from royalties	

Number of actively trading spin-off firms established and their survival rates	117 companies emerged from HEIs from 2007 to year end 2011
Private sector investments in public research spin-offs	
Number and size of industry-commissioned projects	

Source: Inventions and Innovations, Enterprise Ireland, 2012

Enterprise R&D - Targets

SSTI Target	2003	Current Performance
Number of indigenous companies with minimum scale R&D activity (in excess of €100,000) to reach 1,050 by 2013;	462	732 (2011)
Number of indigenous enterprises performing significant R&D (in excess of €2 million) to reach 100 by 2013;	21	40 (2011)
Number of foreign affiliates companies with minimum scale R&D activity (in excess of €100,000) 520 by 2010;	213	338 (2011)
Number of foreign affiliates performing significant levels of R&D (in excess of €2 million) to reach 150 by 2010;	60	114 (2011)
Business Expenditure on R&D in foreign-owned companies to grow to €1.675bn by 2013		€1.323bn (2011)
Business Expenditure on R&D in indigenous companies to grow to €0.825bn by 2013;		€0.537bn (2011)
Total BERD to grow to €2.5billion by 2013 - constant prices	€1.076bn	€1.962 bn (est 2012)
Proportion of sales in indigenous enterprises from innovative products & processes introduced in the last 2 years to double by 2013.		