William C. Harris and John Hegarty
Innovation Advisory Partners
Dublin, Ireland

R&D Infrastructure Tool for Policy Makers

A Robust and Replicable Model: Science Foundation Ireland

Abstract: To remain economically competitive, countries need continuous innovation, strategic investment in R&D, and an effective means to realize economic value from discoveries and technological advances. A model developed in Ireland – Science Foundation Ireland (SFI) – has proved to be instrumental in transforming the scale and quality of research underpinning existing industries and emerging technologies, the nature of partnership between universities and industry, and the performance culture of universities. The model is now sufficiently mature that other countries may want to study and adapt it to their local economic priorities. SFI can be viewed as a policy implementation or execution tool to make sure a modern competitive system emerges. It represents a 21st Century partnership between government, academia and industry that is replicable and transformational as evidenced by establishing Science Foundation Arizona in the USA.

We describe the rationale for the establishment of SFI at the end of the 1990's, the challenges of implementation, the context in which it was able to be successful and the lessons learned that may be of benefit to other countries seeking to follow a similar transformational path. The authors were deeply involved in the initiation and first implementation of SFI. Notwithstanding the downturn in the Irish economy and the need for a financial bailout, the impact of SFI-stimulated innovation remains a strong and positive element of the Irish economy.

Introduction

It is generally agreed that all countries must innovate continuously to be competitive and that universities and advanced institutes can be a strong force for innovation if they develop effective partnerships with the world of enterprise. To be successful, innovation programmes require strong strategic incentives to drive the necessary transformation involved.

A 21st Century research university will be expected to be far more responsible and accountable for the development and use of knowledge for the benefit of the society in which it exists and which supports it. Conversely, to attract – and afford – the very best faculty, students and facilities, world leading academic centers will most likely be located in the most successful economies. While universities must retain a commitment to their strong and vital values, the engineering, applied sciences, medicine and related business disciplines will advance *and* benefit greatly from a strong connection with industries and enterprises of all types. An appropriate and effective partnership will create a unique competitive advantage for the country and offers the best basis for a robust, sustainable economy that can adapt continuously. Most countries, however, fail to establish the policy structures essential to benefit from the investments made in their universities. In this paper, we focus on strategic investments in partnerships as an essential and effective means for realizing the greatest value[1] from discoveries and technological advances, and describe one model which has been successful.

We recognize that research and economic performance varies across countries for historical and cultural reasons. In order for countries to successfully create more robust and competitive economies, policy objectives must be linked to an implementation plan. Successful policy makers will increasingly establish research and innovation strategies that link investment in the university system with the competiveness of its economy and will measure the added value of the investment on that basis. Such strategies in turn improve the support for the university across broad disciplines as the tax base of the country is enhanced. We suggest that determined policy makers will benefit from the experience of success elsewhere – particularly from a country like Ireland, which was near the bottom of the economic ladder in the EU as recently as 1990. Ireland now has a strong and robust high- tech economy that is increasingly recognized for being entrepreneurial.[2]

In this paper we put forward Science Foundation Ireland (SFI) as a "value for money" construct that can be used by policy makers as a tool to help transform economies by making strategic R&D investments with measurable goals. SFI was an innovation step based on a bold policy decision by the Irish Government beginning in 1998.[3] SFI transformed the Irish research landscape and continues as the government's main mechanism for research investment in strategic areas to drive innovation.[4] The success of Ireland's high tech or knowledge-based ecosystems will be of interest to any country that faces economic challenges.

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[1] Robert M. Solow, Nobel Prize in Economics, 1987 (http://www.nobelprize.org/nobel_prizes/economics/laureates/1987/solow-lecture.html)

[2] A former Deputy Prime Minister of Ireland noted on April 11, 2012; "Notwithstanding the downturn in the Irish economy and the need for a bail-out, the impact of SFI stimulated innovation remains a strong and positive element of the Irish economy"

[3] www.sfi.ie

[4] SFI's current Director General outlines an ambitious agenda "2020 Science Foundation Ireland: Excellence and Impact" (http://www.sfi.ie/news-events/publications/)

One of the authors of this paper (Harris) was the first Director General of SFI and the other (Hegarty) was President of Trinity College Dublin during the implementation of the new research policies. The first has gone on to implement a similar initiative in the USA and both have been involved since 2012 in the formation of the new Skolkovo Institute of Science and Technology (Skoltech) in Russia.[5] While our experience in the USA and Russia have enriched our understanding of the challenges facing policy makers, we focus on Ireland given the importance of its success and the fact that this model is replicable in any country determined to create a robust and 21st C ecosystem – a system that must constantly adapt and evolve.

The Irish Context

The SFI initiative was a significant step in a line of strategic policy decisions dating back to 1960. At that time, Government policy changed from being protectionist and isolationist to one which allowed foreign direct investment (FDI) and the ownership of companies based in Ireland by non-Irish mother companies with low corporation tax rates.[6] From that seminal change followed a steady build-up of FDI and the creation of new jobs requiring increasing skills over time. Until 2000 most FDI was in manufacturing and services, and the knowledge base underlying the companies was elsewhere.

In 1967, another milestone development in policy took place in the form of free second-level education for all. This led to greater student enrollment and completion. It also signaled the beginning of a massive expansion of higher education from the 1970's onwards. Thirteen new institutes of technology were created to focus on apprentice, diploma and baccalaureate courses. Two new special institutes were also formed which eventually became fully-fledged universities to add to the five already existing.[7]

In the 1980's, the government instituted a new Skills Initiative to educate more people in ICT. That model was used later in life sciences to satisfy the growing needs of the FDI companies based in Ireland. This led to a large expansion both of computer science departments and the number of graduates ready for employment. All higher education institutions responded quickly and enthusiastically to the needs of expansion and to the specific skills needs.

In parallel with these developments, Ireland joined the EU in 1973. This led to two very significant developments for higher education during the 1980s and 1990s. First, Ireland availed effectively of the EU Structural Funds, part of which were used to support the Skills initiatives and part to begin putting in place some infrastructure for research. Secondly, Irish scientists participated heavily in the EU Framework programmes, including one of the authors (Hegarty); this helped to create a base of research in the absence of any significant local funding. At that time, projects involving economically challenged countries, like Ireland, were looked on with some favour by the EU.

In the 1990's it was realized that a focus on manufacturing jobs dependent on a knowledge base generated elsewhere, was unsustainable. Low cost manufacturing jobs were anticipated to move to other economies with cheaper labour prices. The economic development agencies successfully refocused on creating on attracting knowledge-intensive jobs – indigenous and by FDI. However as the

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[5] There are two different entities both with the name Skolkovo: (1) The Skolkovo Foundation and (2) Skolkovo Institute of Technology (SkolTech). The first is about development of a very large suburban area about 20 km from Moscow. SkolTech is the university in this area but is a separate legal entity and is a partnership with MIT.

[6] Sean Dorgan, *How Ireland Became the Celtic Tiger:* Backgrounder #1945; The Heritage Foundation; http://www.heritage.org/research/worldwidefreedom/bg1945.cfm

[7] Ireland has a population of approximately 4 million people and 70 million in its diaspora: http://www.ft.com/intl/cms/s/2/d845313c-8718-11e2-9dd7-00144feabdc0.html - slide0

decade progressed, it became clear that to attract and grow knowledge intensive industries, including advanced manufacturing, it was essential to have access to the highest levels of skilled people and the outputs of a vibrant world-class research community. Thus, a critically important government policy initiative emerged to support university research in a strategic way and at an unprecedented scale *for the first time* in its history. Two complementary initiatives were instituted during this period:

- A philanthropic initiative to challenge the country to build research capacity and physical infrastructure in its higher education institutions through a 50/50 financial partnership with the government.[8] This required institutions to define strategic priorities for the first time. All areas across the sciences and humanities were included.
- The establishment of SFI to invest strategically and with a very high quality bar in use-inspired research[9] across areas of science and technology to underpin and sustain existing and emerging industry sectors. SFI was itself a "policy tool" designed to create greater value for the economy by incentivizing partnerships between academia and industry and designing and managing performance incentives for the academic institutions.

The rest of this paper will focus on SFI as it inspired and enabled the establishment of a recognized innovation ecosystem and is regarded as successful and replicable.

Science Foundation Ireland

Origin: To set the stage for this new policy "tool", in 1999, the then Minister for Science and Technology requested ICSTI (Irish Council for Science, Technology and Innovation) to conduct a Foresight exercise to determine areas of strategic research and emerging technologies for economic benefit. The process was an engagement between all players. The report[10] identified ICT and biotechnology as the priorities because of the strong multinational manufacturing presence in both. It recommended the creation of a significant fund, the Technology Foresight Fund, to underpin both areas strategically.

The Minister for Industry and Employment and Deputy Prime Minister[11] at that time became the champion of this new initiative and stewarded the formation of SFI to operate the fund. SFI was first established as a branch of a government agency but was established on a legally statutory basis in 2003.

The key lessons from the Foresight exercise leading to establishing SFI are:

1. Focus on areas of strength and opportunity in the Irish context: priority-setting is an essential first step for every country seeking to improve its economic competitiveness. Trying to do *everything* will prevent the changes essential for progress. We encourage policy makers who are

[8] The Programme of Research for Third Level Institutions (PRTLI) was supported by Atlantic Philanthropies, led by a member of the Irish diaspora, Chuck Feeney: http://www.atlanticphilanthropies.org

[9] The term 'use-inspired' research is holistic and broad and we choose not to use tired categories such as basic and applied since distinctions of this type are not appropriate for the 21st century. The significant challenges to society and industry draw on the whole spectrum of research in a holistic way.

[10] http://www.forfas.ie/media/icsti990430_technology_foresight_overview.pdf

[11] Mary Harney, Deputy Prime Minister and Minister for Enterprise and Employment

attempting to establish such a framework and infrastructure essential for a modern, knowledge-based economy, to consider an appropriate version of a Foresight exercise.[12]
2. Ensure participation in priority setting by key leaders from each of the three sectors: industry, academia and government. This will lead to a common understanding of the 21st century economy and the need to converge on a shared set of priorities.
3. Establish essential political support across parties so that government will become a champion of the strategy: it has the power and responsibility to deploy resources for investment.
4. Commit to a 10-year strategy: Time is needed to achieve the structural/cultural changes essential to a competitive and diverse modern economy.

Formation of SFI: After the decision to establish SFI, the more important challenge was defining the strategy to achieve the goals laid out and the implementation of the strategy. Without a serious implementation plan, both policy and strategy are limited. In Ireland's case, there were two questions that had to be addressed before establishing SFI:

1. Should new institutions be formed, independent of *existing* university/research centers or was the existing system capable of changing and adapting to deliver?
2. What programmes could best provide competitive advantage to the prevailing and emerging industry sectors and how might partnership between the research community and industry be established and measured?

The answers to these questions proved to be contentious at times for all parties – government, academia and industry – as they challenged accepted patterns and modes of behavior. The existing institutions were naturally proud of their long history and achievements and were wary of any hint that their research quality was not up to international standards or that new competitor institutions might be formed. We learned that addressing these challenges benefits greatly from an "outside" agent engaging constructively and respectfully with the culture, but strong enough to help forge the changes essential to progress – in this case, the agent was a Director General of SFI recruited from abroad with no bias or obligation to any one institution or political interest.

During this period industry was wary of significant resources going into the early stage of the innovation cycle – research – rather than into development, even if one of the thrusts of SFI was to incentivize more effective support for industry through new performance driven partnerships with university faculty and students. The existing "incentives" at that time for industry reinforced such wariness. Existing Government agencies were wary of a new entity being formed with wide-ranging responsibilities. Government itself had an expectation that investment could yield a return within a short timeframe.

In the following, we summarize briefly how Ireland handled the cultural and structural challenges of implementation.

1. *Should new institutions be established, independent of existing university/research centers or was the existing university system capable of adapting and changing to deliver?*

There was considerable debate on whether to establish new R&D institutes to work with industry or to take advantage of the existing higher education institutions.[13] The SFI Director General argued

[12] For EU countries drawing down Structural Funds, the Foresight exercise could be included in the preparation or review of their 'Research and Innovation Strategies for Smart Specialisation'.

that incentivizing change in the universities would be the most effective way forward for Ireland because:

- The university leadership at the time was ambitious to develop and change to meet the research challenge;
- Universities had a small number of highly respected researchers who were creating intellectual property largely from EU Framework funding and the DG argued they could help transform the institutions from within.
- The universities had very bright students who could insure innovation was continuous and directly transferable to industry as they completed their graduate work, which is in line with the argument that led to the founding of the US National Science Foundation.[14]

This was a wise decision in retrospect.

The State of Arizona chose to adopt[15] the Irish model in 2006 for its approach to innovation, even though there were significant cultural differences between it and Ireland. The Arizona goals were to diversify the economy and to ensure a more competitive education system at all levels.

By contrast, in 2011 the Russian Federation -- as part of its focus on its R&D infrastructure – elected to start a new entity, known as the Skolkovo Institute of Science and Technology (Skoltech).[16] The Russian approach concluded that the existing system might not be able to change quickly enough to meet the new challenges for innovation and the needs of a diversified economy.

Our experiences in Ireland, Arizona and with the Russian Federation give us confidence that the path to a knowledge-based economy is available for any country, provided the factors and challenges specific to it are identified so that entrenched cultures/practices can be addressed. We recommend that careful consideration is given to transforming the existing system in the first instance – if this is not feasible, then a new institution can make sense. For either approach – transformation of existing institutions or the creation of a new transforming institution – we recommend metrics be established at the beginning as accountability is key to becoming truly competitive.

2. ***What programmes could best provide competitive advantage to the prevailing and emerging industry sectors and how might partnership between the research community and industry be forged?***

SFI adopted two specific programmes which in retrospect turned out to be important from the point of view of timing and content. These focused on developing outstanding faculty and creating exceptional interdisciplinary research teams in strategic areas, respectively, as follows.

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[13] Ireland had very few research institutes unlike many countries that have Academies carrying out research.

[14] "*Science – the Endless Frontier*"; A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945.

[15] www.sfaz.org

[16] www.skoltech.ru

- SFI attracted new, world-class talent to Ireland by using the well-established peer review process of the US National Science Foundation.[17] SFI used reviewers external to Ireland in order to ensure that decisions were overtly merit-based.[18] SFI focused on individuals and talent, rather than on institutions. SFI offered these world-class researchers large grants, which were renewable contingent on achievement as determined by external experts.[19] The manner in which the SFI technical team[20] managed this process starting in late 2001 was described as a "game changer".[21]
- Recruitment of exceptional talent required the universities to modify their recruitment and promotion processes, to prioritise recruitment, and to transform their research service operations. This was a challenge to the university leaders and governance but the incentives put in place by SFI were sufficiently robust to induce rapid and effective responses. The initial SFI focus on recruiting talent created a "buzz" world-wide about Ireland.
- SFI incentivized partnerships between universities and Irish-based companies by creating Centres for Science, Engineering and Technology (CSET) which were modelled after a US National Science Foundation programme.[22] These focused on complex, use-inspired projects drawing academic and industry researchers together. To maximize impact, SFI worked closely with other government organizations, such as the Industrial Development Authority (IDA Ireland) responsible for attracting new companies to Ireland, Enterprise Ireland (EI), responsible for the development of indigenous companies, and the Higher Education Authority, responsible for education policy and funding.

For the second of these programmes, SFI worked hard to make clear to industry that such a research partnership was a good business proposition. At the same time, the government's Industrial Development Authority (IDA Ireland) used this value proposition to convince multinational companies to place some of their R&D operations in Ireland in association with SFI and the universities. Industry leaders became chief advocates for the value of SFI in helping to make Ireland a great place for modern, high technology enterprises and encouraging government to sustain the investment. The SFI-IDA working partnership played a significant role in the success of IDA ramping up the number of R&D based FDI projects in Ireland[23] and saw the annual new R&D investment commitments grow enormously. Similarly, Enterprise Ireland[24] extracted significant value from the SFI focus on innovation in its drive to build indigenous companies. The benefit that came from this effort was soon owned "intellectually" by the EI. Universities, including their leaders

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[17] www.nsf.gov

[18] Irish university funding was up to this time largely driven by formula funding and was Institutional based; thus, the SFI was a radical departure from the status quo.

[19] Principal Investigator Awards for 5 years and €1M/year and were renewable.

[20] SFI was guided by a small internal team led by Drs. Alastair Glass (ICT) and John Atkins (BIO) and complemented by Drs. Eoin O'Sullivan and Niamh O'Dowd, Caroline Ang and Richard Hirsh. Mr. Brian Sweeney served as Chairman of the Board. Overall, the board had 1/3 of its members recruited from the international community.

[21] Dick Ahlstrom, The Irish Times, Summer 2006 COMPLETE

[22] www.nsf.gov

[23] The successful focus on innovation – knowledge-based companies is reflected in the IDA annual report: http://www.idaireland.com/news-media/publications/annual-reports/accesible-versions/2011/pdf/IDA-Annual_Report_2011.pdf

[24] http://www.enterprise-ireland.com/en/

and faculty, were proud of the dramatic and broad impact that they were able to make: innovation was copper fastened as the third arm of the university's role along with education and research.

In short, SFI was a catalyst that helped the government agencies and the Irish institutions add even greater economic value to Ireland[25].

Results and Achievements

This paper has focused on the birth and early development of SFI as a new model for transformation. This section will mention two success factors measured later which provide evidence for the robustness of the model.

After 5 years of operation, the performance of SFI was independently reviewed and its findings published.[26] It was found that even within five years, the performance of the research had leaped ahead by international benchmarks based on the quality of publications as measured by citation rates.[27] In 2013 the CWTS Leiden Ranking placed one of the Irish universities(Trinity College) at 48th place worldwide and 9th in Europe based on bibliometric indicators.[28] Achieving internationally recognized quality is an important indicator of progress.

One clear indicator of the economic impact of SFI and its partnership with the industry agencies was a comparison of the nature of FDI in 2000 and 2010. Up to 2000, foreign companies investing in Ireland showed very little interest in establishing R&D operations there. In 2010 this had changed dramatically: 40% of all new investment projects spearheaded by the IDA were R&D-based. Some might argue that any focused effort by the IDA would produce a similar result or that the numbers of jobs created were modest by comparison with manufacturing. However, the dramatic result following investment in research was along a sustainable trajectory and the jobs created were high-end and with widespread knock-on effects across the whole economy. Policy makers will understand the critical value of research to an international company's road map and its future products and economic ambition. Being part of the most critical path to a company's future helps to imbed and secure the company for many, many years in the country – there is nothing more critical. SFI served as the catalyst for this impact and insured added value by working in close partnership with other economic driven entities in Ireland.

As SFI has moved from the birth and growth phase described in this paper to a more steady state operation in recent years, it has placed greater importance on defining and being able to measure the impact of the research carried out. This is to be expected given economic challenges worldwide and the desire by government to see clear return on investment after a decade of investment. Provided the metrics defined to measure impact address the all-important intangible outcomes as well as the more tangible ones, the impact factor can be a central rallying point for good engagement between government, academia, and industry. An SFI-like entity may be the most effective pathway to diversify and strengthen a country's economy since it leverages enormous value from its universities – the source of the talent and innovation essential for the development of an entrepreneurial culture.

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[25] http://www.forfas.ie/media/BERD%202009-2010.pdf

[26] Sir Richard Brook, Chair of the panel to review Science Foundation Ireland; *http://s3.amazonaws.com/hoth.bizango/assets/10612/External_SFI_Review_Sir_Richard_Brook.pdf*

[27] Scientific indicators for research performance

[28] http://www.leidenranking.com/

Conclusion

SFI was a game changer for one small emerging country – as it became the policy maker's tool for accountability. We are confident that SFI is a replicable and adaptable tool in countries where policy makers are determined to establish the appropriate infrastructure and incentives to improve prosperity. We have seen that the SFI model can be adopted and adjusted in a very different culture or eco-system in Arizona.[29] The lessons and experience outlined in this paper could be of value to help short-circuit some of the challenges and risks that inevitably arise. A commitment of 10 years is normally required for the systemic/cultural changes essential to develop the needed, robust 21st C economic ecosystem. Measureable progress, however, should be evident in 3-5 years.

Innovation Advisory Partners[30] was formed to work with a small number of countries that are determined to develop more diverse economies that perform at world-class levels.

Acknowledgment: We would like to acknowledge helpful discussions with a number of people who were instrumental in making SFI a success at the early stages: Mary Harney was Deputy Prime Minister and Minister for Enterprise, Trade and Employment and championed the new policy but also served as a mentor and colleague to the DG; the Minister for Science, Noel Tracey, was always helpful and focused on advancing Ireland's prosperity. Alistair Glass was the SFI Director of ICT and the leader of the university partnerships with industry; Sean Dorgan was the Chief Executive of IDA and Enda Connolly was the IDA Director of Research and they were the key strategic partners with SFI; Feargal O'Morain was the Enterprise Ireland executive who worked closely with and helped SFI; Edward Walsh, the founding president of the University of Limerick, led ICSTI and the Foresight study; John Travers was the Chief Executive of Forfas that was the original home of SFI before legislation. Brian Sweeney (initial Board Chair) and Frank McCabe were the Board members who spent greatly helped the DG and others build the new organization and were critical in the start-up years. Finally, we appreciate the thoughtful reviews by Professors Mark Ferguson (SFI) and John Boland (TCD).

[29] www.sfaz.org

[30] http://www.innovationadvisorypartners.com