Life Science Innovation Strategies in Sweden, Ireland and Ontario: Lessons Learned for Scotland

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Executive Summary

Background and Purpose of the Report

This report was commissioned by Scottish Enterprise in order to help put Scottish life science policy efforts in context with other countries and regions around the world. For the past two decades, R&D efforts and the ability to bring innovative products or services to the market have been seen as key to an economy's competitiveness, and the life science sector in particular has been seen as a source of high value for those regions able to create critical mass.

The importance of the life science has been highlighted most recently in the UK's "Strength and Opportunity: Building Britain's Future", and in Scottish Enterprise's most recent business plan. The life science sector was pursued in Scotland from the region's strength in public and university research, with long-term commercialisation and growth potential. However, since the 1990s, Scotland has encountered many challenges to benefit from the full economic potential of the life sciences. For this reason, three different economies are presented here to highlight some successful policies used outside of Scotland. The comparison has led to a set of lessons for Scotland detailed at the end of the report.

The cases selected for this report are the countries of Sweden and Ireland, and the province of Ontario in Canada. The cases were selected because they shared a similar size to Scotland, and have been recognised as having some success in developing their life science industry. The differences between the cases are also interesting as they focus on different strengths, weaknesses, and stages of development so comparison may be useful for Scottish policy. The comparison was conducted by surveying secondary sources such as government documents, assessments, industry reports, news releases, and academic journals outlining the policies, programs and progress in innovation, R&D and life science across the three cases. This research was supplemented by a series of interviews with public sector and industry representatives from each case.

Sweden

Sweden has the strongest industrial history of the three cases presented here, and its life sciences are characterised by high level of Business R&D expenditure (BERD) dominated by large multinational companies. The main challenges faced by Sweden are increasing the level of commercialisation of the research conducted in universities – solving the Swedish "paradox" of high R&D and little commercialisation, and ensuring that the economy is less dependent on the potentially mobile multinational firms which are such a large part of its economy.

The Swedish policies and programs highlighted in this report revolve around the leadership and foresighting of Vinnova, the Swedish Agency for Innovation Systems, and Innovationsbron. The National Incubator Program, professionalisation of the technology transfer system, and the Fokus Analysis method of policy analysis are argued to hold particular significance for Scotland. These programs target the development of an indigenous life science industry, leveraging the high quality research conducted in Swedish universities. Other key points noted from the Swedish case are the horizontal nature of its policy, with no direct focus on the life sciences in terms of building the innovation system; the

importance of clinical trials; investor views towards drug development and therapeutics; and business and management skills development – all points which emphasise a systemic approach over straightforward corrections of market failures.

Ireland

While Sweden has a long industrial history and high levels of BERD, Ireland has a relatively young industry characterised by its "Celtic Tiger" ascendancy and dominance by foreign firms. The main challenge facing Ireland, and which is reflected in its innovation policy is to raise Ireland's R&D profile to keep foreign R&D, but also to increase home-grown knowledge production and commercialisation.

Irish policy is mostly horizontal, like that of Sweden, and driven by Science Foundation Ireland in terms of R&D and skills; IDA Ireland in terms of FDI; and EI in terms of indigenous firm growth and development. Among the programs highlighted in this report are the Centres for Science, Engineering and Technology funded by SFI but promoted by the IDA to attract further R&D, and used by EI as a source of indigenous innovation that can be commercialised. Other important programs are EI's commercialisation funding, technology transfer professionalisation, and Seed and Venture Capital Programme. Key points to keep in mind are Ireland's use of program evaluations and economic assessments as both a source for evidence-based policymaking, as well as material to attract further investment and open markets for local enterprises; the coordination of Irish policy; and the public sector's long-term commitment to policy targets and initiatives.

Ontario

Ontario is perhaps the most similar to Scotland amongst the three cases as it is a sub-national economy with its own regional parliament, but also influenced by a larger political economy. Ontario is characterised by a strong, long standing university-based R&D system, and similar challenges to Sweden in terms of transforming locally created knowledge into successful commercial enterprises. Of the three cases, Ontario has the most life science focused policies, but can still be characterised as having a generally horizontal approach to improving its innovation system.

Most notable within the Ontario system is its continuing investment in university-based R&D, building and expanding its strengths, and its continuing efforts to garner international recognition for its achievements in these areas. It also differs from the other two cases in that it is weak in terms of program evaluations and economic assessments that can provide investors and the public with information regarding its strengths and weaknesses in life science and innovation in general – this weakness also raises the issue of how well it can carry out evidence-based policymaking. In view of its lack of program evaluations, based on other evidence, it would seem that its current state of publicly provided commercialisation support needs improvement in contrast to its strong R&D structure. Ontario's Regional Innovation Networks, and coordination efforts among university tech transfer offices and arm's length agencies, shows interesting activity in helping Ontario grow its local enterprise base beyond the Ministry of Research and Innovation's program suite. Other key points to keep in mind regarding Ontario are the importance of procurement policy to the life sciences; clinical trials; and R&D tax policy.

Discussion Points from Sweden	Discussion Points from Ireland	Discussion Points from Ontario
The Swedish innovation system is coordinated by a strategic body, Vinnova, but independent units manage the innovation programs.	Ireland's innovation strategy is well coordinated through Forfas, with EI, IDA and SFI executing program delivery.	Ontario's innovation policy is driven by the Ministry of Research and Innovation, but overall coordination with key stakeholders is a challenge.
Sweden's innovation policy is horizontal, with programs applied the innovation system, though the life sciences are seen as an important part of the technology landscape. The Innovation strategy is characterised by qualitative goals and measures.	Irish strategy is horizontal, characterised by specific quantitative targets, with each agency defining its targets. Some specific life science programs, and life science specialist teams are notable.	Ontario's innovation strategy is horizontal, with vague overall objectives. It does have some specific life science programs, and a new forthcoming life science strategy.
Sweden has strong BERD performance, but is attempting to grow its local firm population from Swedish IP sources. It does not have an R&D tax credit, which is different compared with other jurisdictions considering its goals.	Ireland's main innovation objective is to increase the value added activity, and its R&D capacity in order to keep FDI while strengthening indigenous firms' innovative capacity. Part of its program for increasing high value activity is the use of R&D tax credits.	Ontario is characterised by a strong R&D environment, but a struggle to commercialise relative the amount of knowledge created. It has introduced tax credits favouring local IP developed by new local firms.
There has been a strong emphasis on incubators in the Swedish system, and professionalisation of TTOs.	Ireland has invested in professionalising the tech transfer system and using it to increase R&D commercialisation.	Universities and research hospitals play a major role in Ontario's life science industry, with most local companies made up of university spin-offs. TTOs are independently adjusting their practices and using RIN program for commercialisation.
Innovationsbron, ALMI and Industrifonden programs fill gaps and challenges along a company's life cycle.	SFI and EI's programs, beginning with CSETs and then commercialisation funding, help fill gaps and challenges along a company's life cycle.	MRI's academic funding helps progress university research through various career stages – new programs have been added to address commercialisation gaps.
Sweden has strength in clinical trials and research. Therapeutics and drug discovery suffer from funding shortages, particularly if performed within SMEs, but institutional investors are recalculating their long-term benefit.	One explicitly stated goal is to try to encourage more convergence technologies, and their commercialisation. Also looking to develop niche markets such as nutraceuticals, building on Irish strengths.	Ontario has an advantage in clinical trials which is interesting, and many firms are characterised by hybrid business plans. Ontario's procurement strategy seems to have had an effect on the life sciences industry.
Program evaluation, specifically Sweden's Fokus Analysis tool, is seen as an important component to a well-functioning, evidence-based system for innovation policy.	Ireland's program evaluations and system assessments are used both to promote the Irish system to investors, outline policy progress and next steps, and to demonstrate evidence based policy making.	Ontario does not have publicly available program or policy evaluations. This is mostly a matter of the material not having been gathered, either by government or industry organisations.

Key Lessons

The final section of the report outlines key lessons for Scotland stemming from observations and comparisons based on the three case studies. These lessons are important because they address some current concerns held by Scottish policymakers and industrial representatives. The lessons indicate possible approaches to deal with particular challenges shared between the cases and Scotland.

The lessons can be summarised as follows:

1) *Across the cases, R&D policy is the backbone to growing a successful sectoral system of innovation (i.e. helping to grow GERD, BERD or a combination of the two, depending on the structural features and needs of the local economy), with an emphasis on a broad systemic correction, rather than a standard market failure approach which would likely be narrower in its impact.*

For example, rather than simply looking to correct low performance in BERD, effective policy could seek to improve the overall R&D system beginning with basic research in the public and university sector, the network links between industry and academia, as well as ways to transform both local and foreign industrial R&D. Simply focusing on one problematic area, while possibly correcting the specific market failures, will likely lead to more bottlenecks down the line which would need attention.

a. The need to focus on creating platforms to link basic R&D with industrial R&D and technology use.
b. Ideas on how to improve the translational platform.
c. The utility of incubator programs.

2) *Funding gaps and investor preferences – some food for thought on different investor preferences, and the long-term value of drug discovery and therapeutics investment.*

Discussions regarding the value of therapeutics and drug discovery have been noted in this report. One discussion in particular, from a Swedish public VC, challenges the common wisdom that diagnostic devices and med tech are lower risk products for investors to support because of lower capital requirements, shorter routes to market, and a higher probability of bringing a product to market after trials. Instead, based on calculations using global market size and product turnover projections, the investor re-calculated the economic risk associated with med tech and concluded that there are higher than previously claimed risks for long-term returns, and these are enough to justify maintaining and perhaps increasing investments in drug discovery and therapeutics.

3) *The importance of Evidence-based policies and evaluation processes.*

Evaluation processes are necessary to accumulate data in order to highlight how well programs are functioning and where limitations may be arising. But they are also useful to highlight to potential investors and enterprises the efforts being put in place in an economy to develop a life science industry, presenting a R&D and industry friendly environment. The report highlights Sweden and Ireland's use of

evaluation and how it has aided their strategy development, and Ontario's lack of evaluation procedures which may be hindering its own strategy development and coordination.

The report also highlights the importance of long-term commitment to programs, which creates a tension between reacting to short-term policy evaluations and allowing a program to continue. The most successful programs noted in the three cases featured long-term government and agency commitment, with at most slight tweaks and adjustments to increase efficiency.

4) *Ideas on effective program design – a cascade of programs.*

The report discusses how, along with long-term commitment to programs, effective program development should have different mechanisms to support different phases of the innovation process and/or life cycle. For example, this may mean a set of programs that help develop R&D projects over a long-term, or develop researchers' careers, such as in Ontario; or provide incubation and funding support for enterprises through the various stages of their life cycle such as demonstrated to different degrees by all three cases. This point is related to the first lesson (above) regarding strategies focusing on system change and corrections rather than standard market error corrections.

5) *Improving knowledge exploitation capacity.*

With regard to getting the most out of local knowledge and technology strengths, the report focuses on the following topics:

d. The growing interest in convergence technologies and how to commercialise them.
e. The impact of procurement strategies on local supply capacity.
f. Clinical trials, markets and market effects.

All three of the cases studied showed efforts to try to develop niche markets where regions possessed some strength – in Ontario and Sweden clinical trials were identified as a strength and a source of positive spill-over for the rest of the life science industry. In Ireland, nutraceuticals has been identified as a sub-sector to be pursued based on the country's strength in the food industry. Procurement has also been discussed as an important element to include in innovation strategy, particularly as related to drugs, medical devices, and services.

Introduction

Over the past decades, the use of cellular and molecular processes to develop new technologies, products and services has resulted in applications in a number of industrial sectors. While the structure of these sectors is changing, expectations for economic growth remain strong, with major implications for regional and innovation policy (R&IP).

In this context, the competitiveness of countries and/or regions seems increasingly related to their capability to generate new knowledge and use that knowledge to innovate. In a globalised and competitive world capability endowments have to be continuously renewed, raising demands for the endorsement of interactive learning, networking, foresighting, and the mobilisation of complementary skills to respond to new challenges and opportunities. The debate around innovation systems suggests that the emergence, deployment and transformation over time of such knowledge is often the result of an historic, complex and context-dependent process. Innovation systems encompass private firms, public authorities, research organisations and socio-economic structures (such as social, industrial and professional networks) that can promote interaction and innovative thinking. Accordingly, R&IP is frequently assigned the mandate to deal with failures in the optimal functioning of the system and improve systemic interaction.

As a consequence, understanding the 'traditional' scientific, technological, and economic factors driving the emergence and growth of new sectors can be a necessary but insufficient condition to develop appropriate and effective policies. The nature and effects of such driving factors need to be understood in relation to context-specific processes. It follows that different policy strategies are needed to promote and/or support the emergence and growth of life sciences sectors (and sub-sectors) in different locations and at different points in time or phases of the industry life cycle.

Bearing this in mind, comparing diverse experiences with the implementation of R&IP can help to reflect on existing frameworks and develop more effective policy models. This involves not only the identification of bottlenecks that hinder the functioning of regional/national systems, but also foreseeing future scenarios and planning policies that deal with a variety of cross-cutting issues. That includes understanding and acting upon potential challenges and opportunities such as new patterns of technological convergence, multi-purpose technologies, micro-macro economic shocks and indispensable changes to extant institutional settings.

The UK and comparable jurisdictions

In the UK context, the importance of both innovation and the biotech industry has been reiterated in the recently released "Strength and Opportunity: Building Britain's Future" (December 2009), and by the Life Sciences Blue Print (July 2009), both by HM Government. In the foreword for "Strength and Opportunity" they state: "The life science industry is of vital importance to the UK and is one of a number of high-tech industries that will play a leading role in building a stronger UK. A flourishing UK life science industry will give economic growth and play a key role in meeting future healthcare challenges." The same emphasis on biotech innovation is made in Scottish Enterprise's Business Plan 2009/12, which

commits to further developing Scottish innovation from its strong research base, with particular attention to its BioQuarter. It can further be argued that, in terms of policy, Scotland led the way in Britain by first crafting and then implementing the Framework for Action in the 1990s, a cluster-based approach to building a competitive life sciences industry.

The life sciences industry/cluster was identified as a strategic sector in Scotland because of Scotland's strength in public and university research, with long-term commercialisation and growth potential. However, since the sector in the early 1990s could be described as nascent, economic development policies had to be implemented to overcome a number of challenges.

Certain factors, or pre-conditions, were identified as necessary for a successful life science industry: a strong R&D base that would facilitate innovation; the presence of working networks and collaborative partnerships; the existence of a strong skills base; adequate physical infrastructure and communications; large firms that could act as anchors for the sector; a strong entrepreneurial culture; and access to sources of finance. While Scotland did not possess all of these factors in optimal quantities, there has been sufficient capacity in the system which, thanks to policy support and its strengths in life science research, allowed Scotland to become "one of the most sizeable and vibrant life sciences communities in Europe, with over 650 organisations employing in excess of 31,000 people," and contributing over £3billion to the Scottish economy. Regardless, SE's focus remains achieving critical mass of companies of scale by:

Creating the supportive business environment that will support the accelerated growth of companies, anchor current companies of scale, and embed more activity in Scotland.

Attracting more companies to locate in Scotland as well as supporting the international business growth aspirations of groups located in Scotland.

The Scottish industry is now constructed around a core of health care applications and two primary value chains, medical devices and therapeutics. In Scotland, the economic promise of life sciences remains the same as it was in the 1990s, if it is not further heightened.

The measures of success for Scotland's Life Science strategies have evolved from targets of employees and number of firms, to measures regarding contribution to the economy, with particular emphasis on GVA (Frontline Consultants, 2009). The benefits and short-comings of SE's current approach must be measured. Proper measurement leads to proper understanding of existing policies (In Scotland and elsewhere), and allows for more efficient and effective policies to be developed. Past policy, and the industry's pre-conditions must be considered in order to better understand what has been successful, what has been difficult to implement, and any trends that may affect current efforts. However, while past Scottish policy and pre-conditions are important to consider, it is also useful to consider best-practices and policy development in other jurisdictions.

For this reason, the project's main deliverable is a description of other regions' programs, and an evaluation of what has been successful, what may need adjustment, and whether a new approach to solving a particular problem has been be useful. In particular, we aim to (a) define the state of

development and structure of the regional/national life sciences sector, (b) highlight similarities and differences as regards R&IP design and implementation and (c) provide some evidence-based insights in relation to planning and/or implementation of R&IP (including specific initiatives) in different contexts. Most of the policies and programs discussed in this report are regional or fall within the remit of Scottish Enterprise, other Scottish Agencies, or the Scottish Executive's activity. However, some policies discussed (e.g. R&D tax credits or tax policy) may fall beyond the powers of the Scottish Executive, but we include them in order to provide context for the cases discussed, provide information which may be useful for lobby efforts or negotiations for Scotland's benefit, or to spark some idea of alternative policies which may help attain the same goals.

This report focuses on Sweden, Ireland and Ontario. These regions/countries are similar to Scotland in terms of population, stage of economic development and policy framework. Both Ontario and Sweden have a very strong bioscientific base, as demonstrated by the fact that they score high in international publication and citation tables (OECD, 2009) and occupy nodal positions in global co-publication networks (Cooke, 2007). Ireland is trying to catch up, for example by trying to double the number of PhDs by2013 as defined in their Strategy for Science Technology and Innovation, and setting targets regarding the expected academic outputs produced by researchers funded by the Science Foundation Ireland.

The three countries are in the process of developing and growing a life sciences sector. They all have fairly comprehensive policy strategies to support and stimulate the emergence and growth of the life sciences sector, ranging from schemes that support direct technology transfer from the research base into industry, financial and non-financial support for new technology-based firms, stimuli to encourage private-public partnerships in applied research projects, to skills development schemes, to investments in both the physical and the 'intangible' infrastructure.

Another commonality is that life sciences applications tend to focus prevalently (although not uniquely) on patient healthcare, that is, the wide range of activities that characterise the discovery, development, production and commercialisation of new therapies, lab equipment, diagnostic tools, and other types of applied medical technologies (e.g. anaesthetic, respiratory, dental, imaging equipment etc). Following discussions with Scottish Enterprise officials, it was agreed that this report would predominantly concentrate on healthcare-related policies.

There are, however, important differences. First, the stage of emergence of the local innovation systems and the composition of the local industries are different. Sweden both enjoys the benefits and limitations of an industrial history structured around large-scale firms and manufacturing, and the presence of Swedish multinationals that are global players (e.g. Astra Zeneca, ABB, Ericsson). While the economy benefits from a tradition of cooperation and collaboration between the public and private sector, one of Sweden's main limitations is its lack of entrepreneurial history and the need to alter the system in a way that facilitates SME creation and growth in key technological sectors.

In contrast, Ireland's industrial history is limited, only beginning for the most part in the 1970s when it began attracting foreign direct investment (FDI) and the creation of a critical mass of high-tech

manufacturing. Currently, Ireland's main challenge is to move its economy up along the value-chain and encourage both more indigenous innovation and firm creation, as well as encourage more R&D to be conducted on its soil.

Ontario sits mid-way between the two former examples, and to some extent resembles Scotland in terms of its governance structure and the endowments of its innovation system. Ontario is a sub-national region which is influenced both by national level efforts to enhance the Canadian system of innovation, and the provincial government's efforts to make Ontario stronger among the provinces and a global centre of innovation. It benefits from a long and deep history of academic and public sector R&D in the Life Sciences which has resulted in world recognition, and a large number of foreign firms interacting with Ontario institutions in exploiting the IP produced. The challenge is therefore maintaining and growing the science base, but also facilitating indigenous firm creation and IP exploitation in order to try to keep the benefits of commercialisation in Ontario.

The three cases' Regional Innovation Policy (R&IP) differs as well. From a government-sponsored agency point of view, Ireland is the most coordinated example, with all programs and initiatives driven through the Department of Enterprise, Trade and Employment (DETE). Forfas is the Irish agency in charge of foresighting and coordinating innovation and technology policy, with programs and initiatives executed by Enterprise Ireland (EI), Industrial Development Agency Ireland (IDA), and Science Foundation Ireland (SFI). Sweden's Innovation policy is mostly driven by Vinnova in terms of foresighting and developing the R&IP strategy, but programs and initiatives are run by a host of organisations fairly independently once the R&IP direction is set. Ontario's innovation policy is mostly coordinated by the Ministry of Research and Innovation (MRI), and many programs are run directly by them, however, there is a myriad of influential centres and organisations that are arm's length from the ministry, which raises questions regarding the level of coordination in practice.

Case Selection

Ontario-Sweden-Ireland presented an opportunity for good data availability and time-effective access to both primary and secondary sources, and a good mix of industrial dynamics and policy perspectives from which to draw lessons. Alongside Sweden, Ireland and Ontario, we originally discussed the possibility of including Israel, Denmark and Singapore (IDS) in the study. Our decision to focus on the first set of countries and not include IDS was based on (i) time limits to complete the report (which limited the choice to 3 countries), (ii) access to info/data, and (iii) personal contacts (with potential interviewees). IDS remain interesting case studies and constitute an interesting mix of countries with evolving biopharmaceutical sectors and sectorial systems of innovations characterised by differing industrial structures, institutional settings, financial institutions and (strong) bio-scientific bases.

Methodology

The evidence and data used in this study have been extracted from public documents, supplemented by recent studies concerning the state of development and the performance of biotechnology innovation systems in the selected countries. Each case study is introduced by a descriptive section defining the general characteristics of the national and/or regional economy, its system of governance (especially in

relation to innovation and regional policy) and the stage of development and structure of the local life sciences industry.

In addition, semi-structured interviews have been conducted with 11 individuals. The Semi-structured interviews were used to investigate policy-issues and their impacts on the themes driving this study. However, while the interviews were structured to meet the same goals, the questions asked varied depending on (a) region, (b) organisation and (C) role of he interviewee. The questions focused on the following matters:

- Role and responsibilities covered by the interviewees;
- Rationale behind the planning of specific initiatives;
- Scope and role of specific initiatives within the general innovation (and possibly science and economic) policy framework and institutional framework;
- Interaction with other components of the regional/national system of innovation at both an organisational and an operative level;
- Impact on targets;
- The process of policy impact assessment and appraisal: methods and indicators used;
- Modifications to R&IP across time.

Criteria used to select interviewees:

- Currently employed by one of the key public organisations or industry bodies involved in the process of planning and implementation of RiIP in one of the selected countries;
- Covering a strategic role within the organisation;
- Directly involved in policy planning and/or implementation

Policy Areas of Interest

Regarding the areas of policy intervention, we took into consideration both policies that operate horizontally across technological areas/industrial sectors but have an important relevance for the life sciences sector (e.g. a significant proportion of the resources made available is invested to support this sector), and policies that target life sciences directly.

Five themes that underpin the strategy to grow a sustainable life sciences sector in Scotland (Frontline Consultants, 2007), and which are the main areas of intervention the report focuses on, are:

- Capital;
- Infrastructure;

- Skills;
- Technology;
- Collaboration.

The report also considers the importance of global links and networks, scientific and technological investment and trajectories, and how the behaviour of various agents is affected by the characteristics of regional institutions and policy frameworks. The results of policy programs implemented in a number of regions are compared and lessons are learned as to the effectiveness of both specific measures and wider strategic approaches. The ultimate objective is to learn useful lessons to inform the process of policy planning in Scotland.

SWEDEN

System of Innovation and Context

Beginning with the case of Sweden, we see an economy with a long industrial history, and large indigenous multinational firms which developed during the 20th century and were favoured by the historic Social Democratic institutional structures which characterised Sweden before the 1990s. In terms of its general system of innovation, Sweden demonstrates an interesting set of highs and lows, performing strongly in research, but weaker in exploiting its new knowledge. To begin with, R&D intensity was at 3.6% of GDP in 2007; second only to Israel within OECD countries. The business sector contributes approximately 65% of the total R&D investment, which is equivalent to 4.45% of total added-value in 2007 (OECD average is 2.4% and an EU average is 1.8%). Public R&D expenditure as a share of GDP is high (over 0.8%) and around 25% of total R&D, a slightly lower proportion than the OECD (28%) and EU (31%) average.

R&D intensity (GERD/GDP), 2007
OECD, Main Science and Technology Indicators database, June 2009.

	R&D intensity	Share of total OECD R&D expenditure
EU27	1.8	**29.7**
United Kingdom	1.8	4.4
Belgium	1.9	0.8
Canada	1.9	2.7
Australia (2006)	2.0	1.7
France	2.1	4.9
OECD	2.3	**100**
Germany	2.5	8.1
Denmark	2.6	0.6
Austria	2.6	0.9
United States	2.7	41.6
Iceland	2.8	0.0
Switzerland (2004)	2.9	0.8
Japan	3.4	16.7
Finland	3.5	0.7
Korea	3.5	4.7
Sweden	3.6	1.4
Israel	4.7	1.0

Source OECD (2009)

R&D human capital is very high, with 7.6 researchers per 100 total employments, second only to Finland and one of the highest graduation rates in post-graduate programs (e.g. PhDs) among OECD countries. Scientific publications went up since 1990 to achieve 95 articles per million inhabitants in 2007, second only to Switzerland.

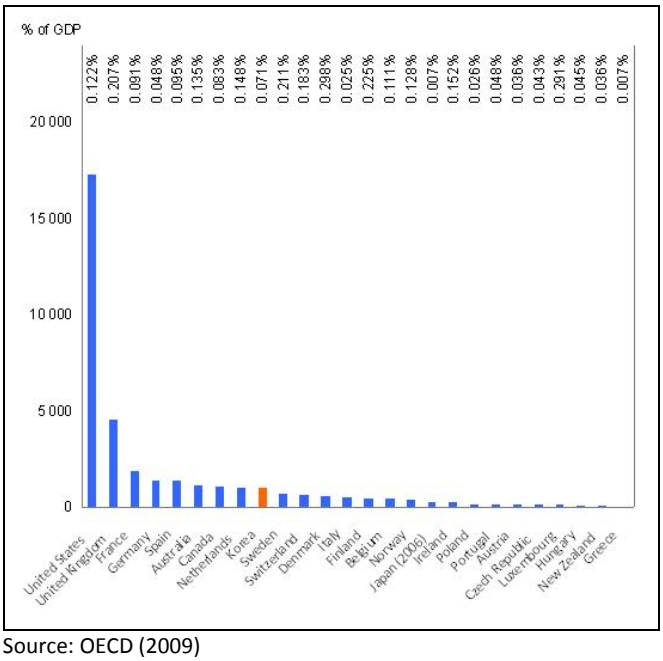
Public sector R&D is dominated by higher education institutions (HEIs), and collaboration between HEIs and the private sector is strong and frequent. Collaborative research is characterised by interaction between higher education institutions (HEIs) and multinational corporations (MNCs).

Despite its high R&D, Sweden has not been performing as well as desired in relation to patent intensity/R&D investment, particularly as a ratio of industry-financed GERD. Also, dependence for

private R&D on MNCs - around 40% of total GERD - is perceived as a matter for concern by policymakers, together with a low propensity to export-oriented entrepreneurship.

The Swedish economy has a high proportion of firms bringing new products to the market. However, Swedish small and medium-sized firms (SMEs) account for a small proportion of Gross R&D (GERD). The proportion of high tech manufacturing over total export is just above the OECD average but SMEs' contribution to exports is limited (no progress has been made in the 1998-2008 period). Official statistics show that over the past 15 years Sweden has consistently performed above the European average rate of patent applications per million capita between 1995-2000, but well below OECD' (p. 9). Some of these problems were related to shortages in the capital supply for early stage ventures and the tax system's inadequacy to give incentives for private investment and inflows of skilled labour (SwedenBio, 2004). Indeed, in turbulent economic conditions these factors may hinder Sweden's capacity to exploit market opportunities in emerging (but also in traditional) sectors. An interesting point to note is that, unlike the majority of OECD countries, Sweden has no direct tax subsidy for private R&D investment.

Despite a relatively weak entrepreneurial culture, Swedish firms attract significant flows of private equity investment. In 2008, Sweden scored tenth among the most venture capital (VC) intensive countries in the world.[1] The most significant increase of total private equity investments (including VC and buy-outs) seems to have taken place between 1995 and 2004, when it grew from EUR 1.3 billion to almost EUR 24 billion. Such growth coincided with the establishment of an increasing number of foreign and indigenous VC firms (VCs) - managing EUR 12 billion in 2004 (ISA, 2004).



Source: OECD (2009)

[1] It should be noted that the Swedish definition of venture capital incorporates innovation R&D, seed capital, start-up capital, expansion and development capital, as well as "turnaround" and restructuring capital.

In the period 2005-2007, however, access to venture capital for medical technology and biotechnology sectors increased. VC investment in biopharma and med-tech reached a total of $300M (OECD, 2009) in 2007. In the same year, Sweden recorded the highest VC investment as a percentage of GDP - 0.089% - as well as the highest share of all national VC investments - 36.9% of these investments went to the life sciences (OECD, 2009). However, Ernst & Young (2009) signals that in 2008 such investment went down around 20%, following a bad performance particularly in the last quarter - a similar trend was expected for 2009.

Regions outside Stockholm-Uppsala have recently captured the interest of investors and particularly the Swedish part of the Öresund region. Investment has also shifted towards seed, start-up and expansion, although buyout activity remains strong. To date, more than 210 venture capital organisations and registered business angels operating in Medicon Valley. They have approximately EUR 1,350 million under management on the life science sector. On the contrary, the business angel market is small in Sweden compared to the venture capital-based systems in the Anglo-Saxon countries (Vinnova, 2008).

Overall, despite some progress, this picture reflects the one depicted by Rosiello's report *Comparing Biotechnology Innovation Systems: the cases of Scotland, Sweden and Denmark* (2005) - also commissioned by Scottish Enterprise, which highlights that the situation was raising concerns in terms of the low percentage of population engaged in entrepreneurial activities, low productivity levels and the limited knowledge exploitation capacity of indigenous (mostly SMEs) firms. Among the remedies suggested by various authorities, the report highlighted (i) stimuli for entrepreneurship, innovation and the growth of SMEs in knowledge intensive sectors; (ii) changes in the demand for innovation by the large Swedish public sector; and (iii) the strengthening of mission-oriented research and exploitation capacity.

While similar concerns are still held, the debate about innovation policy in Sweden has recently moved forward, and among the issues currently under discussion we find granting universities more autonomy; government support for basic research of strategic importance to industry; and support to innovative start-ups and small and medium-sized firms (OECD, 2009). A recent report published by Vinnova (2007) has also stressed the potential advantages of implementing new public procurement procedures to finance and stimulate innovation. The report highlights the critical role that could be played by local authorities, the need for greater coordination among different layers of government, and identifies the UK as country where best practice has been achieved in this regard. Both this report and Action Medtech (2007) suggest that public procurement (key component of a strong local market) can be especially effective in relation to the medical devices (Vinnova, 2007).

The Swedish Life Sciences System

According to Vinnova (2008b), the total number of companies active in R&D, product development, consulting or manufacturing in biotechnology, pharmaceuticals and medical technology in Sweden is roughly 620 with a total of about 34,500 employees. Companies that work on marketing and/or sales employ over 7,200 people, bringing the total to 830 companies and 41,700 employees. If companies

producing lab equipment were also included, the total number of employees and number of companies would be around 42,400 and 850 respectively. Research-intensive and/or manufacturing companies represent 80% of the total.

The regional hotspots for life sciences are in Stockholm-Uppsala, accounting for roughly 50% of all biotech companies in Sweden; Gothenburg (15%); and Malmo-Lund, part of the Oresund region that includes the Danish capital Copenhagen (15%). In these regions we find clusters of HEIs, private and public research consortia, medical schools and private R&D investment (Vinnova, 2008).

Foreign-owned companies represent a significant share of the Swedish pharmaceutical sector, which includes a large contingent of long-established pharmaceutical companies. Firms are prevalently US, Swiss or British corporations, though there is also a significant presence of Dutch-owned and Danish-owned ones. For example, Astra Zeneca is responsible 30% of the total employment within the life sciences industry, and 50% within the pharmaceutical sector (Vinnova, 2008a).[2]

According to SwedenBio (2009), together the biopharmaceutical sector contribute €3,5 billion in exports to the Swedish economy, accounting for about 20% of all exports. In 2009, the drug development pipeline included some 147 new therapies (a total of 33 firms are in the process of developing them), AstraZeneca being responsible for about 50% of them. Most projects target neurological disorders and cancer. Sixty-five percent of Swedish biopharmaceutical companies have at least one therapy in development - 55 % of the projects in phase I-III are chemical molecules, 42 % are protein-based molecules and 3 % were not disclosed in a survey conducted by Vinnova (2009). Roughly 57% of these therapies are small molecules.

Sweden has the highest share per capita of biotechnology firms in the world and ranks fourth in Europe for total number of firms (SwedenBio, 2009). OECD (2009) reports the existence of 143 dedicated biotech companies[3], roughly 40% of them are classified as SMEs (less than 50 employees) - SwedenBio (it adopts a wider definition) suggests that they can be as many as 80%. Their total R&D expenditure was $486M in 2007, the second highest level per firm ($4.64M) worldwide.

A significant share of the biopharmaceutical companies is start-ups from HEIs or spin-offs from other private companies with less than 50 employees. In the 1997-2007 period the Swedish industry was characterised by an increasing number of new companies. Although the survival and growth rates were low, the period showed positive results in terms of employment (except for non-R&D intensive companies), productivity and added-value to GDP. R&D-intensive companies and MNCs were mostly

[2] It should be noted that Astra Zeneca, which is now headquartered in the UK, is made up of what was previously Astra AB, a Swedish company, and Zeneca from the UK.

[3] OECD (2009) defines a dedicated biotechnology firm: a biotechnology firm whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or to perform biotechnology R&D. These firms are captured by biotechnology firm surveys. That excludes firms that supply biotechnology tools and equipment, biotechnology medical technology, food-related biotechnology and Contract Research Organisations (CROs).

responsible for this trend across the biotech, pharmaceutical and med-tech sectors. Med-tech displayed a steadier pattern of growth.

Medical devices and diagnostics are also a critical component of the Swedish economy and innovation system. They represent 0.4% of GDP (pharmaceuticals around 1.4%), with a growth of 9.7% in terms of added-value in the 1999-2005 period (Action Medtech, 2007). They employ roughly 10,000 people (pharmaceuticals 15,000) with a growth of 3.5% in the period 1999-2005. Aggregated revenues in 2006 were up by 6% at over €500 M (Action Medtech, 2007). Pharmaceuticals and medtech produced the biggest progress in terms of productivity (added-value/time) in the Swedish economy in the period 2000-2005 - with respective increments of 11.1% and 10.3%.

Despite high R&D intensity - the contribution of SMEs being negligible - the sectoral system of innovation is characterised by low output in terms of triadic[4] patents/GERD and export/import balance (OECD, 2009). A recent comparison with the Danish sectoral innovation system highlights a higher mortality rate and slower growth (during the shift from SME to medium-sized), which can be partly explained by less experienced management teams and directors' boards, smaller amounts of risk capital invested in each round, a lower propensity towards entrepreneurial activities and higher administrative burden (Valentin et al. 2008; Gestrelius 2008).

Triadic Patent Families and industry-financed R&D
Average for 2005-07 or closest available years
OECD, Patent Database, June 2009.

	Industry-financed GERD	Triadic patent families	triadic patent/GERD
Australia	6637	339	0.051
Austria	2816	388	0.138
Belgium	3345	408	0.122
Canada	9962	699	0.070
Denmark	2399	298	0.124
Finland	3538	313	0.088
France	18220	2435	0.134
Germany	37300	6083	0.163
Ireland	1054	71	0.067
Italy	6848	761	0.111
Japan	86946	14258	0.164
Korea	22016	2524	0.115
Luxembourg	341	24	0.069
Netherlands	4287	1050	0.245
New Zealand	458	51	0.111
Norway	1377	126	0.091
Spain	5373	227	0.042
Sweden	6462	733	0.113
Switzerland	4790	890	0.186
Turkey	1772	20	0.011
United Kingdom	13100	1643	0.125
United States	184475	15805	0.086
EU27	110438	14592	0.132
OECD	430378	49289	0.115

Source: OECD (2009)

[4] Sweden, Europe and USA

Across all industrial sectors, SMEs have felt the effect of the recent financial squeeze, which has reduced access to most sources of financing (bank lending, private equity and public markets). This is expected to have a significant effect on R&D investments, survival rates and growth (Vinnova 2009; OECD 2009).

Assessment of Sweden's Strategic Context

Historically, despite a weak entrepreneurial culture, Sweden has had a strong tradition in the life sciences. About 40% of all research currently undertaken at Swedish universities is within biosciences and biotechnology, with a focus on areas such as functional genomics, proteomics, regenerative medicine, stem cells and technological platform development.

One particular area of Swedish expertise that may be of interest in relation to the Scottish perspective is that of clinical trials. According to a report compiled in 1009 by the Delegation for Competitiveness in Clinical Research (DCCR, 2009), Sweden consistently offers the following advantages which make it attractive for life science companies to conduct clinical trials, particularly in phases 1 and 2. The reasons are listed and summarised here:

- Strong life science tradition (roots in the early 1990s)
- Expertise in clinical research – it is the world's 12th largest producer of research results and placed 6th in the analysis of the most cited publications.
- Strong skills in performing clinical trials
- Outstanding regulatory advice – Sweden's Medical Products Agency is one of the EU's most frequently consulted authorities
- Unique assets for biomedical research (e.g. electronic electronic patient records, biobanks and health care databases)
- High data quality – resulting from strong know-how
- Patients willing to participate in studies
- High quality health care system
- Long-term use of personal identity numbers
- Insurance system adapted to industry needs
- Tradition of co-operation between industry and the health care system

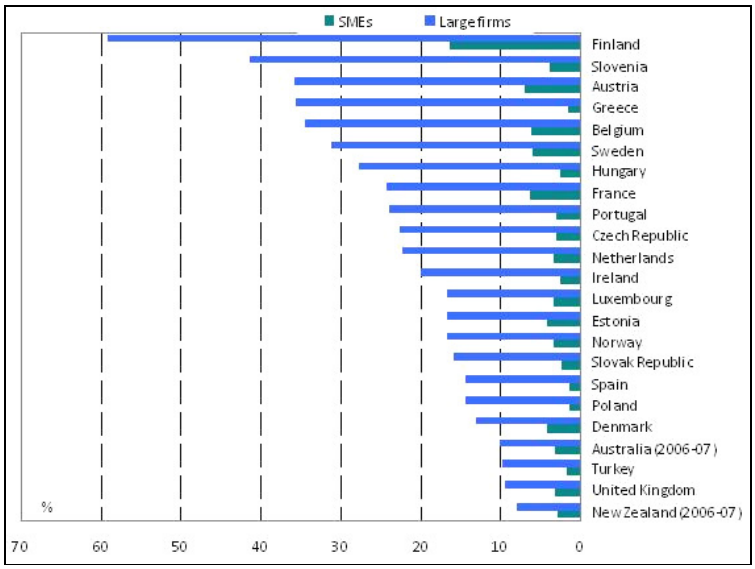
To emphasise the strength of Sweden's clinical trials capability, the report highlights three statistics, reproduced here:

100 %	No. 4	No. 6
Share of the world's ten best-selling medicines that have undergone clinical development in Sweden	Sweden's Medical Products Agency is one Europe's most preferred investigative authorities, measured as its share of investigations under the EU centralized procedure.	Sweden's ranking in a comparison of the world's most cited research publications in clinical medicine

(DCCR, 2009)

Private sources constitute a significant proportion of the total funding. Regarding bio-medical research, the Karolinska Institute attracts over €400M, followed by the Universities of Gothenburg and Lund with €100-150M worth of funding. Private sector funding (from industry and private donors) represent the bigger share of such investment. Public funding is mostly provided by research councils and public foundations but Vinnova (either directly or via the Swedish Foundation for Strategic Research) also plays an important role. Over the past few years there has been a moderate but constant increase in funding for needs-driven research. Expenditure within the biotech business sector reached €400M in 2007 (OECD, 2009), which represents 5.4% of total private R&D investment.

Proportion of firms collaborating in R&D with HEIs



Source: OECD 2009

At the same time, there are several research fields in which Sweden used to have a strong technological knowledge base but is now struggling (Vinnova, 2008). For example, according to Vinnova (2008): '…GlaxoSmithKline (GSK) declined to locate a specific establishment in Sweden due to a lack of a specific kind of competence they needed, cell culturing. This competence is required by most biotech companies but it is too expensive for individual SMEs to build a large scale production unit' (p. 52). As a result, the skills requirements of local/foreign firms may not always be satisfied by the existing competence base.

Life science companies demand personnel highly specialised in directly applicable bio-scientific fields. They are also demanding personnel who combine specialist competence with skills in marketing, economics etc. It has been claimed that there is a lack of competence in international business development in Sweden, particularly concerning competence in business development in smaller companies. Rosiello (2005) pointed out that the restructuring of big pharmaceutical corporations has helped some SMEs recruit executives (a phenomenon we also observed in the Cambridge area).

The different issues discussed in the description of Sweden's industrial background, it's post-crisis experience, the technical base and market base of endowments all influence the policy framework that has been put in place to deal with innovation and the life sciences.

The Policy Framework

Within this context, the Swedish *Science, Technology* and *Innovation* policy framework contains key organisations.

Since 2000, the national system for research-based innovation has been headed by the Swedish Agency for Innovation Systems (Vinnova), with a budget of roughly 200M EUR per year to co-finance needs-driven research and regional economic development in cooperation with industry. The creation of Vinnova signalled a radical change in the way regional and industrial policy was conducted compared to the mid-nineties. Because of the re-structuring of some MNCs, increased international competition in manufacturing and low levels of productivity in R&D, substantial cuts in public spending were implemented, marking the end of policies based on the Social Democratic principles of compensation and redistribution. The new goal was to revitalise the national economy and solve the 'Swedish dilemma' (high R&D investment and low output). Vinnova's mission can be characterised by the following points:

- Link basic and applied research and reinforce (regional) innovation systems;
- Invest in speculative applied research which suits national priorities in areas of strength;
- Create excellence and a critical mass of skills/knowledge in a number of very specific and selected areas;
- Create regional systems within which R&D activities are strongly anchored (ideal locations for commercial and industrial exploitation, which involves having MNCs on-board), and are strongly linked to Swedish regions and HEIs;
- Support proof of concept and early-stage innovative activities within start-ups;
- Support a sustained flow of ideas, create new companies, jobs and varied sources of revenues – in short, to address the Swedish dilemma and the separation between basic and applied research.

Most of Vinnova's initiatives apply *horizontally*, to all industrial sectors, including the 18 growth areas in which Swedish regions are believed to be able to win competitive advantage because of their skill and

resource endowments. Among these sectors, biosciences, biotechnology and clinical research are considered fields in which Sweden plays a leading role thanks to its strong research base, health system and industrial tradition in pharmaceuticals, diagnostics, biomedical engineering and bio-food.

A summary of Sweden's programs is included in appendix 1. Briefly, however, programs such as Vinnova's Berzelii Centres and Vinnvaxt have been established to both increase the Swedish R&D profile, specifically the public R&D profile, as well as strengthen innovation systems within Swedish regions. The challenge is ensuring that the programs develop in a way that creates necessary linkages and leadership structures among participants in order to ensure that the knowledge created is properly exploited. For example, while the Berzelii centres are geared towards research, ultimately it is hoped that they will support SME development through the exploitation of the IP produced. In terms of Vinnvaxt, it is hoped that it will create a system that uses market mechanisms to build and exploit regional R&D capacities and their ability to transition IP to market. While Vinnvaxt has performed well in its early evolutions, a continuing challenge for the program is the active cooperation amongst stakeholders – not in terms of lack of will – but in terms of improving the mechanisms of collaboration.

Other programs reflect more direct efforts by Vinnova to correct the Swedish dilemma and increase the level of entrepreneurialism in the country. The range of programs provide proof of concept funding, pre-market competitions for entrepreneurs to build their networks with investors and potential clients, as well as a research base from which new IP may beformed in the life sciences for Swedish SME exploitation.

Nutek and the Competence Centres Programme

Before Vinnova was established, NUTEK was set up in the 1990s to become a national competence centre for entrepreneurship, business and regional development and contribute to the creation of more and stronger new companies. It operated with a regional focus. In 1995 NUTEK launched the Competence Centres Programme that was later taken over by Vinnova, promoting collaboration between HEIs and private companies. By the end of the tenth year, 550M EUR were invested by the Swedish government (30%), HEIs (30%) and industry (40%). Twenty-eight centres were created. Each of them have been granted an average of about 2M EUR to participate in collaborative R&D programs responding to real market opportunities and they are evaluated by expert panels to assess their impact in terms of creating a critical mass of skills and assets. In a 10-year period, 233 private firms had been involved across all growth areas, about 50 of them in more than one project. NUTEK has now been closed and replaced with 'Tillvaxtverket' - an organisation with around 300 employees and 11 regional offices. Although it has been granted funds that are to be used to support economic renewal via innovation, we could not establish whether any of the activities supported by Tillvaxtverket are relevant to the purpose of this report. From Tillvaxtverket's website: 'The aim of the Swedish Agency for Economic and Regional Growth - Tillväxtverket - is to work to achieve more enterprises, growing enterprises and sustainable, competitive business and industry throughout Sweden'.

Tillväxtverket 3 main areas of activities:

- DemoEnvironment is a grant offering support for modern environmental technology solutions in the areas of sustainable urban development and renewable energy.
- Management of EU structural funds assigned to Sweden;
- Support for the tourism industry.

Research Councils

The Research Councils are responsible to fund basic, mainly curiosity-driven research. A distinctive feature of the Swedish system is that scientists maintain property rights over intellectual assets and inventions when employed by Public Research Organisations. As a result, intellectual property (IP) owners can freely choose which way best suits them for technology transfer and commercialisation. Technology Transfer Offices (TTOs) play a big role in helping scientists to protect, transfer and commercialised IP. TTOs are usually composed of an evaluating/counselling unit, a patent and licence office and, at times, a fund to finance early stage ventures. TTOs work alongside incubators and they are present in bioscience-intensive regions such as Medicon Valley and Stockholm-Uppsala. Recently, a lot of emphasis has been placed on the 'professionalisation' of the personnel of the TTOs (Vinnova, 2006).

Innovationsbron

Innovationsbron has been created in order to help scientists, innovators and entrepreneurs translate vision into sustainable ventures. Innovationsbron's is meant to play the role of a small, experienced, well-connected and 'hands-on' investor. Part of the goal is to build the management team, create contacts for firms and help them improve their business plan in order to become investor-ready companies.

Innovationsbron is 84% owned percent by the Swedish Government and 14% by Industrifonden (public VC organisation). It has offices in seven Swedish regions (near HEIs) and makes roughly 50% of its investment in the domain of the life sciences (patient-healthcare). Innovationsbron provides seed funding mostly in very early stage/pre-commercial phase. The basic rationale is well known: investors perceive early-stage ventures as too risky, because of market and technological (perhaps in some cases regulatory) uncertainty; inexperienced management teams which are not investor-ready; and transactional problems due, in particular, to information asymmetries; the possibility of dilution over subsequent rounds of financing. Such a perception is even stronger in bio-healthcare.

The types of Seed funding provided by Innovationsbron are development grants (distributed in collaboration with Vinnova); 'soft' loans, for which companies are not supposed to provide personal guarantees up to €50K; and private equity investments up to a maximum of €250K. Innovationsbron is an evergreen fund run in an arm's-length manner from government. It's expected rate of return is 0%, as its goal is to help and support local ventures rather than make a return on their investments. Innovationsbron aims at supporting 'as many companies as possible' - it does not focus on the most promising ones. However, a representative from Vinnova pointed out that the investment in the 'professionalisation' of support for innovation is meant to reduce the number of companies that are supported and increase the survival and growth rate; this may also explain why there is an increase in

the number of disclosures to TTOs and applications to incubators and a decrease in the number of financed/incubated projects in 2008-09, which has been achieved via tougher 'verification' of emerging ideas.

In terms of what kinds of activities are financed, the life sciences attract around 40-50% of the investment. This is similar to Vinnova's share of investment and public funding for basic research. There also seems to be an unofficial move away from drug-discovery: too risky and expensive (especially because max investment is €250K); a Vinnova representative confirmed this is also the tendency within Vinnova.

Innovationsbron also run the National Incubator Programme (NIP) described in appendix 1. This was launched in 2003, and in 2005 the management of the NIP was transferred to Innovationsbron, and Vinnova allocated 10 years worth of funding to the program. While managed by Innovationsbron, Vinnova remains responsible for the evaluation process. The evaluation plan is to carry out a review every three year as part of the project of the subsequent 3-year phase.

With regards to the NIP's impact on biopharma and medical applications is concerned, Karolinska Innovation is the biggest of all incubator investment funds (Karolinska Holding), with a size of around €50M (private and public money), and a portfolio of around 40 start-up companies (25% of which are in the process of conducting clinical trials).From 2006 to 2008, Swedish incubators appraised an average 3,000 propositions a year.

Over 50% of projects in the NIP originate in the academic sector, but this proportion has declined since 2005. The number of propositions originating from industry, in contrast, has increased. In 2006, the total funding of NIP had reached €15M. In 2007, the incubated companies employed over 3,800 people, had a total turnover of over €200M and 65% were limited companies. A second phase of the program has already been started but we have been unable to gather any information about it.

Interestingly, the program is subject to a periodical review and benchmark process using the 'Fokus Analysis Tool' (Innovationsbron, 2008). The main indicators for assessment are: number of ideas evaluated; origin of the ideas; number of new technology-based companies created; private investment attracted by these companies; returns on the investment made by the incubators, and other measures of progress made by the incubated companies (jobs, products/services in development/market etc). The exercise also involves benchmarking against other countries (Israel, Germany, Austria, Italy).

There has been a lot of emphasis on incubators, either on those which were provided with their own investment funds or those relying on Innovationsbron or other government funds. This is part of a strong emphasis on the professionalisation of the personnel in the TTOs, public agencies and incubators that supports innovators and/or scientists that want to licence out their[5] intellectual property.

[5] It is their IP because in Sweden remains the 'teacher exemption'.

ALMI

ALMI was created in 1994. To date, it has distributed over €1 billion in loans to around 30,000 clients for the purpose of stimulating economic growth. Nearly 15,000 new companies have been launched with the help of finance from ALMI. ALMI's lends money to Swedish SMEs; its mission is to provide liquidity at favourable conditions to companies that are unlikely to receive loans from commercial banks. As their requirements vary depending on their stage of development, ALMI's operations are organised into the following business areas: Innovation, New Enterprises and Established Businesses. A significant proportion the companies that receive support are low-tech SMEs. ALMI helps its clients by offering both loans and support with business development. The ultimate objective is to stimulate economic growth across all industrial sectors. This is to be achieved by increasing the rate of creation of new firms and helping them grow.

ALMI Företagspartner AB is owned by the Swedish Government and owns 51 % of 19 regional subsidiaries. Other owners are county councils, regional authorities and municipal cooperative bodies. Operational tasks are run at a regional level. ALMI Företagspartner AB is in charge of corporate management, coordination, and product/service development. ALMI's lending activity is self-financed.

ALMI Invest is the VC branch of ALMI Företagspartner AB that manages €100M, with the mission to invest it in early-stage companies. Typically, the initial investment is €200-400K. In subsequent rounds, ALMI VC can co-invest up to €1M. Co-investors in the syndicate team can be either Swedish or foreign.

ALMI Invest was created in 2009. Fifty percent of the original capital originated from EU structural funds, which accounts for an investment of 50M EU. The rest has been provided by ALMI's regional partners and ALMI Företagspartner. Investments are automatically returned to the general pool, keeping a constant supply of capital readily available to be invested. In the current fund's portfolio there are no biotech or med-tech companies. However, despite this lack of investment in the life sciences, ALMI has been included in the report to both present a full picture of Sweden's innovation system, but also to emphasise that a large part of the life science support is *de facto* taken up by Innovationsbron; ALMI has focused on supporting small regionally focused firms in lower risk, lower technology businesses.

Industrinfonden

Industrifonden is a public (but independently run) VC firm that provides VC, non-monetary support and a network of contacts to SMEs that aim to grow. Industrifonden was set up by the Swedish Government in 1979. It is entirely funded with public money. The board of directors, which is appointed by the government, is accountable for the fund's operations.

All investments are made on commercial terms alongside company-owners and co-investors. Industrifonden can act as an investor, lender or guarantor. Industrifonden invests directly in companies, as well as via a network of regional venture capital firms. The fund routinely syndicates together with other investors. Industrifonden makes two types of investments in SMEs: development capital for innovative tech start-ups and expansion capital for established companies that want to grow. Returns

from investments are automatically returned to the general pool, with the aim of keeping a constant supply of capital readily available to be invested.

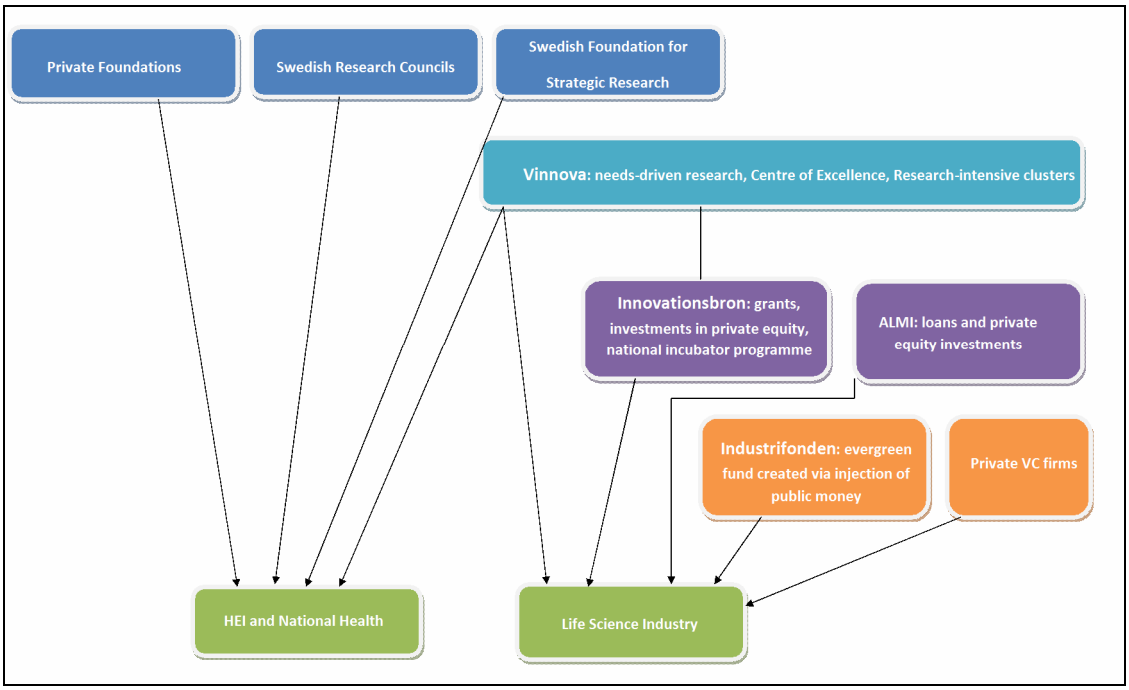
Industrifonden has a dedicated team of experienced investors that focus on the life sciences industry. While we have not been able to find the exact amount invested in the life sciences, an interview with an Industrifonden representative noted that they were biased towards high technology investments which include the life sciences, and use lower risk investments to hedge the risk. In terms of the system flow, Industrifonden picks up opportunities emerging from the incubator system and support structure following on from Innovationsbron and ALMI.

Addressing Skills

As noticed earlier, both Vinnova and some of the regional/industrial players had/have concerns relating to the 'investor-readiness' and managerial capacity of new biotech and med-tech companies, which has the potential to hinder strategic development and growth (both at a firm-level and at a macro-level - Rosiello 2005). While in the past executives from MNCs helped cover this managerial-competence gap, Gestrelius (2008) suggests that this still constitutes one of the explicatory factors regarding the different growth rate of Swedish and Danish companies. As a result, Masters Programs in the management/creation of new firms in the bio-pharmaceutical field have been created at the Karolinska Institute[6], and Uppsala[7]. Also, the Stockolm-Uppsala Life Sciences consortium (SULS) offers coaching services to inexperienced managers of biotech and med-tech start-ups (http://suls.avedas.com/converis/article/30).

Other Initiatives to specifically increase the market-related knowledge have been undertaken. The Knowledge Foundation has allocated €6M over seven years to a program aiming to increase the general competence level in biotech and food SMEs. The program is collaboration between a number of universities and the Swedish Institute for Food and Biotechnology.

[6] www.mastersportal.eu/students/browse/programme/7415/bioentrepreneurship.html
[7] http://www.mastersportal.eu/students/browse/programme/210/applied-biotechnology.html



Reflections On The Swedish Policy Framework/Programs

Sweden has a wide range of public organisations and policy schemes that provide support for R&D activities, entrepreneurship and commercial applications of new science/research outcomes. Unlike Scotland, Sweden's high research-intensity is mostly thanks to private sector R&D investment. Private labs of MNCs (such as AstraZeneca) sit very comfortably among HEIs, medical hospitals and a large national health system.

The Swedish system is characterised by investment in HEIs by research councils, strategic foundations and private R&D investment (especially by MNCs). Sweden does not have many independently run public institutes that conduct research in specific areas. However, public agencies in Sweden enjoy a lot of freedom in regards to how they invest their money. In this sense, some activities have been overlapping, e.g. support and incubation for start-ups and spin-offs coming out of Vinnova's programs and investments. In terms of the flow of information between organisations involved in complementary activities (say Vinnova and ALMI), apart from what's publicly available, this seems a bit problematic. The government has asked for better coordination among difference agencies, for example Innovationsbron is now charge of the incubator program, in cooperation with Vinnova. While not all of these coordination problems have been resolved, the role of the organisations should ideally be one that is sequentially defined in terms of the support and investment that a firm can obtain throughout its life-cycle: Vinnova programs – ALMI (loans) and Innovationsbron programs (private equity and incubators) – Industrifonden investment once they are more mature.

Vinnova's overarching goals, as the organisation that leads Sweden's innovation agenda, do not presuppose the attainment of quantitative targets. Vinnova's final aim is to contribute to economic growth but there are no pre-defined criteria as to how a specific organisation (including Vinnova) would

achieve that goal. Regardless, Vinnova has to report regularly (i.e. annually) to the Government to show how it has contributed and how it intends to continue contributing to the growth of the Swedish economy, i.e. what activities they have funded, how much support they have provided, what results have been achieved. The evaluation focuses on specific deliverables, but it is to a significant extent non-quantitative since most of what Vinnova does, leads to intangible outcomes.

Program Evaluation

In order to comply with this requirement, Vinnova collects qualitative/quantitative evidence about different programs. The mix and nature of the data collected depends on the program. In general, assessing intangible outcomes proves very difficult; e.g. you can measure the number of pre-competitive projects that have taken-off; however when they progress, they tend to be regulated by bilateral contracts and people become very secretive. Then, each program is subject to a mid-term and a final review. Normally, this is conducted by international and independent experts. Again, these reviews tend to have a strong qualitative component. Generally speaking, since different programs work differently, the questions asked and issues tackled in the reports tend to be different.

Below are examples of the main assessment criteria for two programs, the Berzilii Centres and Vinnvaxt.

In regards to the Berzilii centres, the general assessment recently carried out concluded the following: 'Overall, the productivity of the centre is difficult to assess, and any meaningful assessment of this in terms of publications can hardly be expected within just one year. Nevertheless, the productivity of the individual partners, as assessed by the publication list, is excellent (Vinnova, 2009; p. 41)'.

The evaluation criteria used to arrive at this general conclusion reflect the mix of qualitative and quantitative measures (those measures which most reflect a qualitative approach have been emphasised in italics):

- Rigorous science of the highest international quality,
- *A clear and shared intellectual and cultural identity*,
- *A distinctive Berzilii environment for development of young people*,
- *A coherent strategy of basic and applied research aligned with the Centre's vision/mission*,
- Inter-disciplinarity in research and collaboration with industry,
- A growing proportion of projects undergoing translation from science to innovation,

For at least half of the criteria, it would be very difficult to quantify their assessment.

For the Vinnvaxt program, the latest general assessment was concluded as follows: 'It is the evaluation team's firm conviction that the VINNVÄXT programme stands out as a world-class national program' (Vinnova, 2007; p. 5).

The evaluation criteria used to arrive at this general conclusion are:

- A well-known and common vision/strategic idea among key players
- Contribution to developing effective management in the Regional Innovation System
- A sufficient (and growing) quantity of long-term resources allocated to the regional actions
- A research strategy focusing on key areas
- Well-functioning support systems for innovative and newly established business (e.g. Incubators) including access to venture capital
- The collaboration and impact on existing industry
- Creation of knowledge platforms
- Strategies for "branding" the region and the profile
- Creation of new educational profiles, inflow of researchers and international students
- Investments made by national and international companies in the region
- The development of (new) Industry-Academia collaboration
- National and international linkages of strategic importance, (Vinnova, 2007; p. 11).

While many of these criteria may be potentially quantifiable through potentially questionnaires, surveys or investment statistics, the general sense is that there is a large degree of qualitative assessment involved.

Innovationsbron must also undergo regular evaluations, and the analysis is seen as a way for managers to improve their program delivery. The evaluation approach has been labelled Fokus Analysis. The analysis examines the number of ideas evaluated, source of the idea and gender of the "carrier of the idea", number of projects/companies currently in the incubator, the amount of public and private seed capital that each incubator company has attracted turnover of current and alumni companies. It also evaluates the progress of specific companies in the incubators in terms of the VC they have attracted, the number of jobs they have produced, products and services in development and in the market, and their revenues and losses. Finally, the Analysis compares companies in the program with companies outside incubators. A description of Fokus Analysis's benefits from Innovationsbron states the following:

> It is both Innovationsbron and the incubators that specify the demands regarding Fokus Analys. This means that the incubators don't only see Fokus Analys as a tool for reporting to Innovationsbron (who invests 55 million SEK yearly in the sector), but also as a tool for their own management. Each incubator can generate its own customised reports from Fokus Analys. An advantage of the incubators´ using the information is that this leads to a constant quality assessment of the data (email from Innovationsbron, 2010).

As is further mentioned in the email, this approach has been noted by actors in other national systems of innovation and seen as a potential program for emulation.

Some final points regarding the Swedish system of innovation and the life sciences are worth mentioning. Specifically related to Life Sciences support and investment, interviews with an Innovationsbron representative revealed that as an organisation it is facing issues supporting therapeutics. The problem with therapeutics, according to the interview, is that the capital requirement is too high, and Innovationsbron maximum investment capacity is €250 000 per firm. In addition, early stage therapeutic companies are too far from the market or from achieving revenue through licensing, as a result, it is very difficult to convince investors to syndicate on such a project, especially since Innovationsbron's contribution is capped at 250k. The difficulty of supporting therapeutic and drug discovery firms is well known in Scotland, and also reflected in the other cases studied.

Furthermore, Information gathered and interviews conducted with Swedish agency representatives suggest that public authorities/agencies have regular interactions with industrial organisations. As highlighted earlier, Sweden has one of the highest rates of BERD. In spite of that, we understand there have been discussions concerning the introduction of an R&D tax relief. However, no change in this area has so far been introduced. Along with this, another key topic of discussion between policymakers and industry is that of access to highly skilled individual and the preservation of an excellent science base. As a result, the Swedish Government has recently introduced a 25% tax break for scientists that move to Sweden.

During the last decade, another matter of concern has been the perpetuation of the 'teachers' exception' with regard to property rights over innovations and scientific discoveries. Academics have ownership over the intellectual property they produce, rather than it being owned by the academic institution they belong to. As acknowledged by the existing literature, this type of legislation shapes the intensity and frequency of public-private collaborations. Based on the outcome of changes that took place in other countries (especially Denmark) and consultations with various stakeholders, Sweden has decided to preserve the exception. Simultaneously, the policy's focus switched towards the professionalization of TTOs. Finally, the private sector is involved (either as a beneficiary or directly in the managerial process) in initiatives such as the Centres of Excellence and, more distinctively, the regional cluster programme (Vinnvaxt).

Finally, the Swedish system can be described as both an example of evidence-based policy and program building, but also one that is capable of being 'time-effective' in responding to short-term economic situations.

In terms of time-effectiveness, an example of the Swedish system's capacity to respond was recently given through ALMI's creation of ALMI Invest AB in 2009. Though no interview was possible with a representative, it is evident that such a movement was carried out in reaction to the economic crisis which was affecting the amount of investment capital available to SMEs in Sweden.

In terms of evidence-based policy and program building, the Swedish Innovation Strategy reflects a process of identifying both market and system weaknesses and implementing programs that correct

them. This is not simply a reaction to temporary market forces, but rather a thorough evaluation of the structures in place and what must be altered in order to reach their goals. Many examples of this exist: Sweden identified a weakness in funding available to SMEs and therefore set about adjusting public organisations such as Industrifonden, or creating new ones such as Innovationsbron in order to create a venture capital market and encourage private sector investment of this sort. Another example is the recognition that, because of its industrial past, the entrepreneurial culture and skill set was weak – not only were the incubators put in place to offer a setting for mentorship and a strengthening of the nascent business's plan, but educational programs such as Karolinska Institute's Masters in Bioentrepreneurship and Uppsala University's Masters in Applied Biotechnology.[8] This evidence-based strategy building is not unique to Sweden and will be clearly noted in Ireland as well.

Key Points Regarding the Swedish System for Later Discussion

- The Swedish innovation system is characterised by a strategic coordinating body, Vinnova, but independent units which manage the innovation programs.
- Sweden's innovation policy is general, though the life sciences are seen as an important part of the technology landscape.
- Sweden has strong BERD performance, but is attempting to grow its local firm population from Swedish IP sources. It does not have an R&D tax credit, which is an issue of difference compared with other jurisdictions considering its goals.
- There has been a strong emphasis on incubators in the Swedish system, and professionalisation of TTOs.
- Innovationsbron, ALMI and Industrifonden programs fill gaps and challenges along a company's life cycle.
- Sweden has strength in clinical trials and research. Therapeutics and drug discovery suffer from funding shortages, particularly if performed within SMEs, but institutional investors are recalculating their long-term benefit.
- Program evaluation, specifically Sweden's Fokus Analysis tool, is seen as an important component to a well-functioning, evidence-based system for innovation policy.

[8] There is also an MSc in Business Creation and Entrepreneurship in Biomedicine at the University of Gothenburg, Entrepreneurship and Innovation Management at KTH University, amongst others.

IRELAND

System of Innovation and Context

Ireland had one of the most celebrated high-tech economies of the late 1990s and early millennium, resulting in the label "the Celtic Tiger". In the 1990s the Irish economy "experienced an upgrading of investment, R&D, skills, and productivity," (O'Riain, 2004; pg. 48). The Irish economy showed very strong rates of economic growth, with Irish GNP as a percentage of the EU-15 average going from 75% in 1993 to 101% in 2003. The typical explanation of how this came about includes the use of a low corporate tax regime to attract investment, social partnership to keep wages down for foreign manufacturing, skill development through the educational system, a fortunate demographic make-up of available young, skilled labour, combined with the effective use of EU funds (Mastroeni, 2007). The Irish manufacturing industry saw increases in investment, R&D, employment and productivity in most sectors of the economy, but what was most notable was the emergence of a "knowledge economy" cluster (O'Riain, 2004, pg. 49).Yet according to many analyses, the *entrepôt* nature of foreign firm activity in Ireland meant that, while its production and export of high technology was strong, it remained weak in the indigenous production of innovation (Mastroeni, 2007).

In the Irish case, the role of the state in pursuing the creation of a high-tech sector has grown and changed incrementally as a result of socio-economic reports and realisations. In the 1960s and 1970s, Irish industrial policy was geared towards attracting foreign multinationals in industries such as chemicals, electronics and "other" sectors with high export-potential (Mastroeni, 2007). According to Cogan and McDevitt, this targeting of Foreign Direct Investment was not so much a set of policies focusing on technology acquisition as it was a focus on job creation and a strategy of utilising Ireland's asset of a well-educated workforce compared to other "newly industrialising countries," (Cogan and McDevitt, 2000; pg. 3).

Following a fall in FDI and jobs associated with the high-tech sector in the late 1970s and early 1980s, the Boston-based Telesis Consulting Group carried out a review (1982), which the government followed up with a "White Paper on Industrial Development" in 1984 (O'Connor, 2001; pg. 12). The Telesis Report criticised the over-emphasis on foreign-owned industry as a tool of industrial policy and argued that this should only be a short-term solution for industrial development. The main critique in the report was that there was no strong attempt to encourage foreign-owned firms to become embedded in the Irish economy and have their technology and know-how diffuse through indigenous industry (Cogan and McDevitt, 2000; pg. 4). The White Paper's response included recommendations for the state to promote the development of indigenous industry through the following mechanisms: the selective application of state-incentives to internationally-traded industries, the shift to technology acquisition and export development rather than fixed asset investment, the prioritisation of foreign projects that perform key business functions in Irish locations, the creation of a risk-capital market for internationally traded industries through tax incentives, and an overall improvement to the business environment in order to increase competitiveness and profitability of industry (O'Connor, 2001; pg. 12). However, most of the recommendations were not put in place until the 1990s (Cogan and McDevitt, 2000; pg. 5).

In 1992, a further review of Irish policy emerged in the Culliton Report, or "A Time to Change – Industrial Policy in the 1990s," by the Industrial Policy Review Group (Fitzpatrick, 2001; 2). The Report concluded that Irish-owned industry was underperforming and most growth was foreign; there was also an under-supply of seed and equity capital and industrial agencies had a tendency to duplicate delivery of their services (Fitzpatrick, 2001; pg. 2). The Culliton Report put Science and Technology policy up-front in Ireland (Cogan and McDevitt, 2000; pg. 8), and stressed the importance of establishing "clusters" around sources of national competitive advantage (Hayward, 1998; pg. 5). It was as a result of the Culliton report that three of the main agencies that currently characterise Ireland's innovation system were created: Forfas, Industrial Development Agency Ireland (IDA) and Enterprise Ireland (EI).

The Irish Life Sciences System

The *Health Life Sciences in Ireland* report summarises Irish ambitions, efforts and state of the life sciences industry in 2009. The report describes that by 2008, 52 000 people were employed in the general Health and Life Sciences, in 350 enterprises. The industry is responsible for 44.4 billion in exports, or 30% of Ireland's exports.

According to the report, the areas of expertise recognised in Ireland lie in immunology, oncology, neuroscience and gastroenterology.

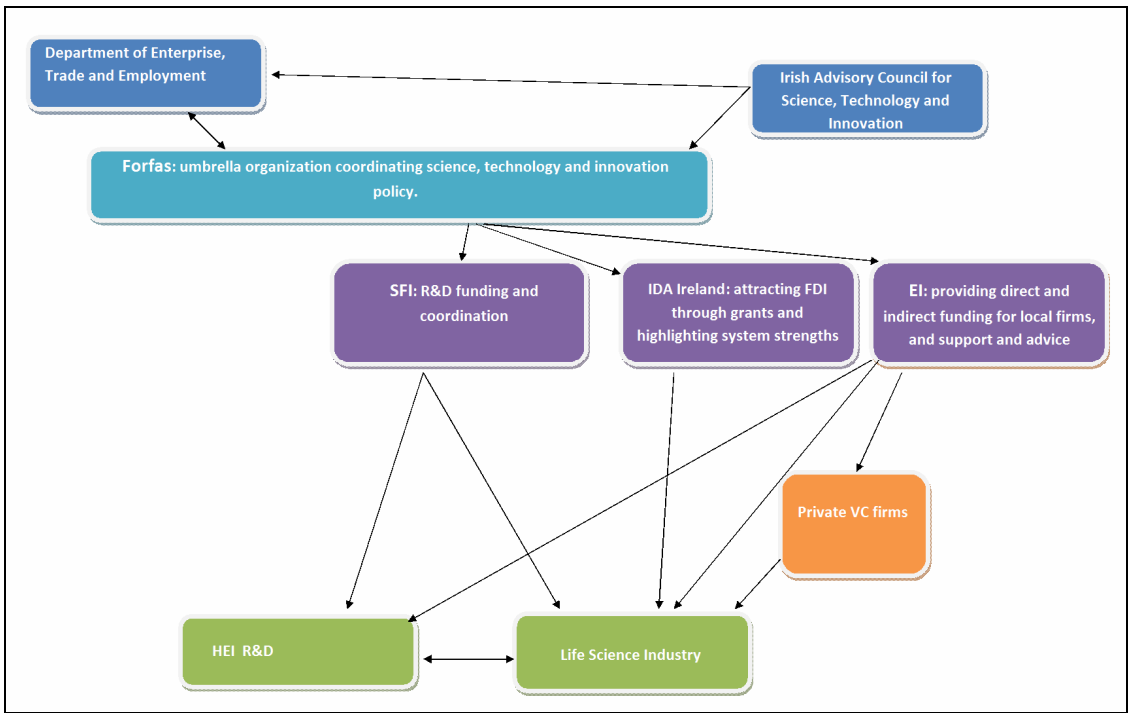
The official goals summarised in the report are for Ireland to have a highly collaborative, innovative and internationally networked environment for the life sciences, achieved by harnessing technology and multidisciplinary skills to provide creative solutions for next generation products and services.

According to the report, Ireland is positioned to take advantage of trends in the life sciences industry as a result of being in position of critical enablers. Among other things, it lists Ireland's quality and reliability in pharmaceutical manufacturing as an advantage in its future development of process R&D facilities, and maintaining advanced manufacturing facilities in country; local expertise in ICT, pharma, and other tech industries due to its FDI, and indigenous industries, also position Ireland to potentially take advantage of new convergent products based on multiple technologies, as well as the potential to move into new areas of remote healthcare and diagnostics. Finally, Ireland's well-established food companies have been moving into the area of nutraceuticals.

Most of Ireland's success has been due to the country's ability to attract, maintain, and enhance FDI. Around this investment, local SMEs have been growing both to service multinational firms but also as a result of spin-offs from companies, established centres of excellence and university research.

Ireland's Life Science sector initiatives are fairly centrally concentrated, as are all of Ireland's innovation policies and programs. Forfas serves as the umbrella organisation for Ireland, coordinating policy and releasing white papers and reports regarding the state of the industry. Foreign Direct Investment, the backbone of Irish industrial success, is managed by the Industrial Development Agency Ireland (IDA), which includes use of R&D tax credits for foreign firms, grants, and the promotion of local assets such as research centres to attract foreign R&D to Ireland. Local industry is supported by Enterprise Ireland with a full suite of programs including business plan evaluation, network building, R&D collaborations,

innovation support, financing, etc. A third key organisation is Science Foundation Ireland, responsible for helping grow and fund Ireland's R&D capacity.



History of Irish Life Sciences

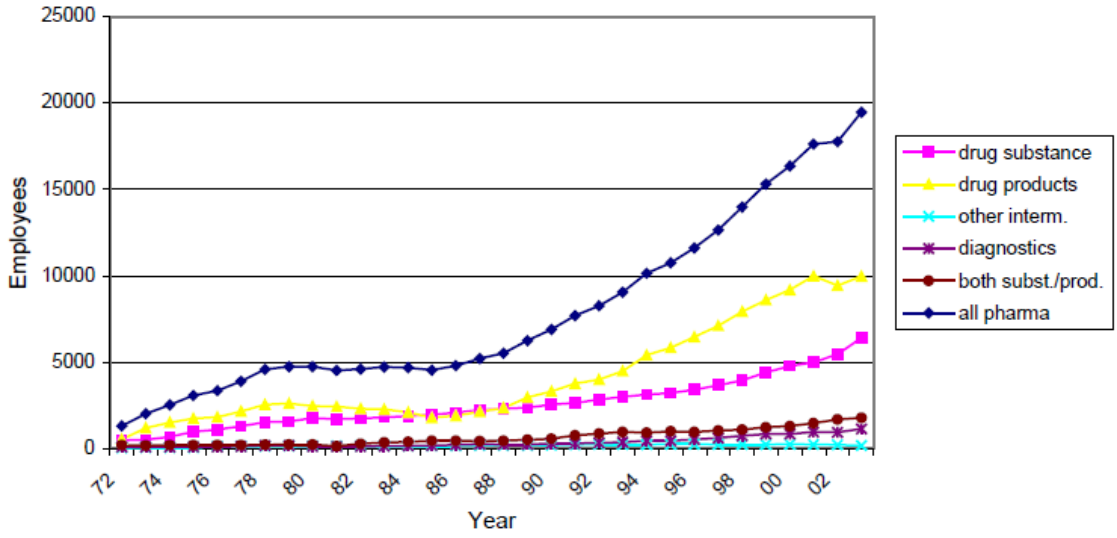
The Irish Life Sciences industry is relatively young, beginning with the attraction of pharmaceutical FDI. Until the 1960s there was no pharmaceutical industry to speak of, their was no incentive for foreign companies to manufacture in Ireland and local production was not possible, reflecting Ireland's generally weak industrial infrastructure (Egeraat and Barry, 2008). However, pharmaceutical investment began, and accelerated, when Ireland joined the European Economic Community and Industrial Development Agency Ireland (IDA) began targeting foreign investment from pharmaceutical companies. IDA targeted FDI aggressively in what were deemed as industries with high future value, and the pharmaceutical sector and IT sector were seen as particularly desirable (Egeraat and Breathnach, 2008). Through the use of employment grants, capital grants, green field sites, zero export tax rates and leveraging the low corporate tax rates in Ireland, employment in the pharmaceutical sector rose rapidly from less than 5000 in 1985 to 19,500 in 2003 (Egeraat and Breathnach, 2008; IPHA, 2005).

Number of operations and Employees in Pharma, 2003

	Foreign		Indigenous		Total	
	Operations	Employees	Operations	Employees	Operations	Employees
Drug substance	30	6379	1	26	31	6405
Drug product	32	9082	13	886	45	9968
Both substance and product.	5	1772	1	20	6	1792
Other Interm.	2	109	2	58	4	167
Diagnostics	5	732	4	411	9	1143
Total	74	18074	21	1401	95	19475

(Table from van Egeraat, 2006)

Employment in Pharma sub-sectors, 1972-2003



(Graph taken from van Egeraat, 2006)

According to the Irish Pharmaceutical Healthcare Association, the momentum towards building a pharmaceuticals sector in Ireland really began once they had attracted Bristol-Myers Squibb in 1964, followed by Pfizer, Eli Lilly, Schering Plough, Merck Sharp & Dohme, Smithkline-Beecham and Janssen (IPHA, 2005).

What also has to be kept in mind is that during the 1970s, Ireland's membership in the EEC was important as the business plan of major US pharmaceuticals during that time period was based around geographic servicing of markets (IPHA, 2005). Pharmaceutical companies have since reviewed their internal strategies and noted that this geographical and linear organisation contained many inefficiencies and weak lines of communication between manufacturing, R&D and other functions (Egeraat and Breathnach, 2008). As a result, there has been a widespread restructuring of pharmaceutical firms and an integration of various stages of the process R&D cycle, discovery, and

manufacturing functions (ibid). Co-location of many of these functions has followed for the majority of companies, and have impacted the Irish market. As Egaraat and Breathnach (2008) explain, changes in Ireland were driven by the growing number of mergers and acquisitions in the 1990s, and Single European Market and World Trade Organisation have meant that it has not been necessary to have drug plants in different markets. Ireland, partially because of its tax regime, has been an attractive location for strategic sites. The key challenge, however, is to keep those sites in Ireland rather than have them move to less expensive sites or sites with more attractive incentives, and to have them move up the value chain; while China and India are anecdotally sited, much of the public sector literature actually points to Puerto Rico and Singapore as major competitors for the desired pharmaceutical FDI (IPHA, 2005).

The efforts to move Ireland up the value change came during the Celtic Tiger period of the 1990s and early millennium when it was concluded that to remain competitive and keep the gains that had been made in high value employment, Irish firms and subsidiaries would have to engage in greater amounts of R&D as this kind of activity was seen as having deeper roots in an economy. Previously, while FDI was generating employment, the expected stimulus that was to create indigenous firms was slower than expected, prompting IDA Ireland to be divided into IDA Ireland and Enterprise Ireland (EI) in 1998, where EI would be encourage local company growth through business consulting, grants, equity investment, and marketing (The Scientist, 2009; DETE, 1998). Towards the end of the 1990s, not only did the two main development agencies in Ireland begin shifting to encourage higher value-added activity, but Science Foundation Ireland was created in 2001 under the 2000-2005 National Development Plan to oversee public R&D funding in basic research in order to strengthen the Irish research base (site NDP 2000-2005). From a position where little industry was present, Irish agencies managed to attract a critical mass of foreign pharmaceutical firms, begin identifying markets for local Irish firms, create a venture capital industry through EI's Seed and Venture Programme, and begin to systematically increase the country's R&D capacity through SFI programs and funding.

Assessment of Ireland's Strategic Context

Currently, Ireland is in the midst of pursuing the Strategy for Science, Technology and Innovation 2006-2013. The strategy frames its goals in the context of the traditional weakness of the Irish system in depending on the IP and industrial leadership of other countries, and despite its strides forward through EI and SFI, the need to further strengthen local R&D and innovative capacity. Specifically, the SSTI aims to increase the R&D capacity of HEI; capture the IP produced from HEI; create greater involvement of local companies with the R&D structure through encouraging R&D or providing incentives for private-academic collaborations; increase the amount of collaboration between large foreign firms, local firms and HEI; and increase human capital, with the specific goal of doubling the number of PhDs by 2013 (SSTI, Executive Summary). Each of the agencies mentioned previously, EI, IDA, and SFI, have significant roles to play in meeting the targets set by the SSTI.

The intentions of the SSTI can be distilled to making Irish industry less dependent on footloose manufacturers and local firms that can easily be acquired and taken elsewhere – a concern shared by

most small open economies, but whose urgency in Ireland is increased by the limited industrial history in Ireland before the 1980s and the tech boom of the 1990s.

Using foreign pharmaceutical production as an example, Egeraat and Barry (2008) describe the challenge that Ireland has faced moving up the value chain and creating deeper roots amongst foreign subsidiaries. Egeraat and Breathnach (2008) describe how Irish subsidiaries have been trying to take advantage of their experience in manufacturing crucial components such as active ingredients, and try to leverage their experience into an expansion of their role in process R&D along with manufacturing. The challenge is to convince foreign HQs that the skills are available in Ireland and that is it worthwhile for a global pharmaceutical company to consolidate more of its activities in Ireland, increase the value of the activities in Ireland, rather than keep the R&D in the core and risk moving important manufacturing facilities to sites that do not have the experience of quality controlled manufacturing (e.g. China). Moreover, a Forfas report notes that foreign subsidiaries' infrastructure may also pose problems, as many of them originally invested in manufacturing facilities that are not flexible and capable of adjusting to new product demands or functions; part of the challenge is therefore convincing firms to upgrade their facilities in order to aid the co-location of activity.

Despite these challenges, Irish efforts from the SSTI seem to be improving the situation. In the last two years, major investment commitments have been announced by foreign firms to increase their Irish facilities and their R&D activities; there is a growing number of collaborative R&D agreements through the Centres for Science, Engineering and Technology (CSETs), a growing number of indigenous companies positioning themselves in niche markets in biotechnology, medical devices and convergence technologies (the strength of Ireland's IT playing a role), and Irish HEI R&D output has been steadily increasing. Forfas has "taken stock" and noted Ireland's position along the value chain of various life science sub-sectors:

In *Pharmaceuticals*, it states that 9 of the top 10 pharma companies have facilities in Ireland. Ireland's position on the value chain is around manufacturing and development. The sector is predominantly foreign-owned, but does have a few local companies as well. The sub-sector employs 24 800 people and accounts for 24.5% of Ireland's exports. Support for the sector employs a further 24 000. Most of the activities are in the manufacture of active pharmaceutical ingredients, with a slow trend towards including supply chain management, financial management, and moving towards some R&D – especially process R&D. Local firms have begun springing up in drug development targeting niche therapeutic areas led by Elan. Ireland is looking to implement a system that would either keep any facilities, particularly R&D, in Ireland if these companies are acquired, and set up an IP system that facilitates favourable licensing or partnership agreements with global pharma companies.

In *Biopharmaceuticals*, there is more diversity in the industry, according to Forfas, with a mix of SMEs and large multinationals – there are an estimated 60 firms employing 4 000 people. Ireland's position on the value chain reaches from some research, to development, to some manufacturing.

Medical Technologies generates 6.3 billion in exports and employs 24 500 people. 15 of the top 20 global med tech companies are in Ireland, and over 60 of the 140 firms in Ireland are Irish owned. There

is more variety of firms engaged in R&D in med tech than in the previous two sub-sectors, likely due to lower investment requirements, lower risk and shorter timelines. The manufacture of components and contract manufacturing for the sector in Ireland is almost wholly locally owned, and is highly dependent on the foreign companies. Ireland sits mostly along the development and manufacturing parts of the value chain.

Nutraceuticals, while small, seems to be getting quite a bit of attention because of an established Irish presence in the sector, and because most of the companies are and will likely remain Irish. A potential niche market.

It should be noted that the SSTI has very few programs or policies specifically targeted at the life sciences, though it does recognise the importance of health research along with IT, energy, and other areas. Most of the programs run by EI, IDA, and SFI are geared towards improving the broader innovation system, though special rounds of funding or programs may be set aside for the life sciences. Appendix 2 lists the main programs described throughout the literature.

Policy Framework

Each agency has outlined its strategy, and within that strategy some very concrete targets.

EI

EI's strategy is laid out in "Transforming Irish Industry: 2008-2010", which was released in 2007. In it, EI looks to increase Irish export growth (what it sees as a key overarching target), and to develop new innovative business models as well as products. As such, EI has laid out six specific targets for this strategy:

- Achieve €4 billion in new export sales by 2010.
- Increase the number of companies engaged in "meaningful" R&D (defined as €100,000 spend annually) to 800 by 2010, and 1050 by 2013.
- Increase the number of companies engaged in significant R&D (defined as €2 million spend) to 55 by 2010 and to 100 by 2013.
- Create 200 new high potential start0ups, with 50% of these outside the Dublin region.
- Grow companies of scale by increasing the number of EI clients achieving annual global sales of €5 million to 635 (15% increase).
- Grow companies of scale by increasing the number of EI clients achieving annual global sales of €20 million to 225 (20% increase).

While described briefly in Appendix 2, two programs of particular interest in the efforts to strengthen and grow Irish indigenous industry in general, with a strong impact on the life sciences, are EI's venture capital program and the RI&D commercialisation efforts. As mentioned above, EI was tasked with

strengthening indigenous industry and taking advantage of niche markets that were being created by servicing foreign firms or appearing as the local workforce gained experience and skills in the high tech ventures being established. As described by Mastroeni (forthcoming), EI had a lare role to play in establishing the venture capital industry in Ireland. EI did this through a two-pronged approach: by directly investing in equity and by becoming a funder of funds. During its early years as an equity funder, EI would occasionally have to help set the value for enterprises because of the lack of experienced local private investors, though it quickly moved away from this and now strictly follows other investors. More importantly, EI used the Seed and Venture Capital Programme to establish a set of VC funds, where each Euro invested by EI would be matched, and then managed, by private sector partners and invested in Irish firms.

EI has smaller programs and grants that tie in to the VC program and investments. Since its establishment, EI has provided business consultation, marketing and grants to firms to carry out either training or skills acquisition or for feasibility studies, allowing the firms to become attractive enough for private investors to pick up. The new commercialisation efforts being pursued by EI feed into the deal flow for further indigenous company development. The idea behind these efforts is to commit the increased HEI R&D described above into commercialisable ventures, and part of the effort has been the increased professionalisation of the tech transfer offices.

EI's efforts to improve the exploitation of IP were launched in 2008 with a €30 million fund, for which universities and similar institutions would submit tenders for the competitive process. The eligibility criteria allow for single institutions or collaborations between institutions which could demonstrate a significant flow of research funds and can demonstrate how additional resources would lead to a "radical" enhancement of IP protection and transfer of tech to commercial endeavours.

EI has a life sciences and Food Commercialisation group (EI Bio) which forms the key link in the sector efforts for tech transfer as described in the website: "The [Group] forms the crucial link in the commercialisation chain for research: connecting the researchers who conduct the research, and the entrepreneurs, industrialists and companies who apply the fruits of that research. EI Bio works in partnership with all its stakeholders and clients – industrial liaison and technology transfer offices, research funders, research institutions, research teams, bio-entrepreneurs and companies, and with [EI's] other secctoral teams to commercialise the outputs of publicly funded research for Ireland's food, health and life science sectors, " (EI Bio website, 2010). EI Bio enhances some its services by locating staff – commercialisation specialists and patent officers – within campus technology offices. EI Bio supports the Commercialisation fund (Appendix 2), as well as the new Bio-incubator Centres being constructed.

IDA

The IDA recently released its new strategy in March 2010. The IDA's goals will be to continue attracting high value FDI, with a focus on broad areas such as services innovations and convergence technologies, and specific industries with future potential such as health informatics and nanotech surgical implants. Like EI, IDA Ireland has set very specific targets for its strategy and a delivery date of 2014:

- Attract or create 105 000 new jobs
- Attract 640 new investments
- Have 50% of new investments outside of Dublin and Cork
- Have 20% of Greenfield investments originating from high-growth emerging markets by 2014 (BRICS countries – Brazil, Russia, India, China and South Africa)
- And achieve an annual spend in excess of €1.7 billion in research, development and innovation by 2014.

The IDA laid out the four different styles of R&D FDI that they pursue:

- Stand-alone model, where a company establishes an R&D centre or an innovation agenda;
- Development and Manufacturing/Services Delivery model, where R&D is done at a manufacturing of services delivery site to achieve greater productivity and/or efficiency;
- Collaborative model, where RD&I investment is co-dependent on a collaborative agreement with Irish or foreign firms, or academic institutions;
- Development and Commercialisation model, where outputs will be developed and produced in Ireland for export markets (IDA, 53 N 08 W).

A large part of the IDA's ability to attract investment will rest on the RD&I tax credits

SFI

SFI's strategy was launched in July 2009 and focus on four areas:

- Human Capital, and building a mass of internationally competitive research teams in the sciences and engineering
- Quality Output, where SFI teams produce the highest quality output as this acts as an external endorsement of its scientific value
- Global Reputation, in order to attract business creating next-generation products and services
- and Knowledge Transfer, to provide quality inputs to the technology/translational industries in Ireland, increase the national R&D footprint, and exploit Ireland's IP.

As such, the SFI has outlined specific targets for each of the four areas of the strategy. It should also be noted that it continues put an emphasis on the scientific fields of Bio, ICT, Energy, and Convergence research that can bring the three areas together.

The targets for each area are very specific.

Human Capital Targets:

- Retain the 300 SFI teams currently in Ireland, and increase the number of teams so that by 2013 there are 440 PI-led research teams;
- 2000 PhD graduates total, at an on-going average rate of 400 per year;
- 1000 post-doc research training places;
- Create and maintain a core capability that will assist the retention and attraction of high-tech FDI and indigenous innovation.

Quality Output:

- Increase the quantity and quality of Ireland's research publications
- Increase the number of scientific publications from 800 per million of population to over 1200
- Achieve Top 10 placement for Ireland in the leave of international citation performers and citation impact in the fields that it funds (up from its current place of 17th).

Global Reputation:

- Attract to Ireland a cohort of researchers that have been nominated for, or secured, internationally-recognised prizes and honours;
- Recruit 50 new overseas PIs to supplement existing 100 recruited up to 2008;
- Assist IDA Ireland in attracting high tech FDI R&D;
- Conduct five Tier 1 International conferences (e.g. Keystone, WWW, IEEE, EMBO)
- Continually scan science, technology and commercial environments for any developments, challenges or opportunities that may require a change in emphasis in SFI programs.

Knowledge Transfer:

- To continue to contribute to the efforts of EI and IDA by achieving approximately 1000 invention disclosures and 500 patent filing from SFI-funded research;
- 40 revenue-generating licences and 30 high-potential start-ups from SFI research groups;
- Increase the number of distinct multinational corporations and SMEs engaging in formal collaborations with SFI research groups to over 150.

The Centres for Science, Engineering and Technology. These are the main vehicle for moving Ireland up the value chain in terms of human capital, FDI, and local/international collaboration. While these have been described in Appendix 2, it is important to highlight the CSETs because of the attention they have been given both by government literature, the positive initial assessments, and interviewee comments. There are seven official objectives to the CSET program:

- **Create** centres formed by clusters of internationally competitive researchers from the third-level sector and industry, particularly Irish based industry.
- **Support** excellence in research and education as measured by international merit review.
- **Exploit** opportunities in science, engineering and technology where the complexity of the research agenda requires the advantages of scope, scale, dynamism, synergy, duration, equipment, and facilities that a centre can provide.
- **Promote** organisational connections and linkages within and among campuses, industry, other research bodies, private-sector research laboratories, and international collaborators.
- **Support** frontier investigations across disciplines that underpin BioT, ICT, or both, and are essential to developing and strengthening Ireland's industrial base.
- **Engage** intellectual talent within Ireland in advanced research and education.
- **Foster** science and engineering in service to society, especially in research areas that promise to create new technologies.

Along with these objectives, the SFI has certain expectations of each CSET, despite the different science each may engage in. The SFI lists eight of these expectations:

- **Carry** out a unifying research program in any area supported by SFI, including at the interfaces between disciplines.
- **Operate** under the leadership of a director with a record of internationally recognised research achievement who can lead contemporary campus industry partnerships.
- **Form** partnerships with industry to work on challenging problems and facilitate technology transfer among the participants. SFI also encourages co-operation and collaboration across academic institutions.
- **Achieve** strategic goals shared by the host and partnering institutes.
- **Provide** educational and research opportunities and industrial laboratory internships for Irish students and faculty.

- **Stimulate** public understanding and interest in science and discovery through outreach programs. SFI expects centres to help increase participation, particularly by women and other under-represented groups, at all levels of Irish research and education.

- **Work** with Enterprise Ireland to develop R&D in indigenous Irish industry and with IDA Ireland to attract and retain foreign direct investment and participation in the Irish research community.

- **Participate** in the development of the European research area. SFI will provide support to leverage funding from the European Commission's Sixth Framework Programme.

The former chairman of the SFI Board stated the importance of the CSETs to Ireland's research and commercial capacity: "By bringing together researchers from Irish third-level institutions with their counterparts in indigenous and multinational companies, these centres create a force for knowledge and innovation that is greater than the sum of its parts. These are significant resources we invest in these centres, over a time frame that allows world class research to unfold, and we look forward to the contributions to Ireland, as well as to progress in science and engineering, that will emerge from the efforts of these great researchers," (SFI, 2007; pg. 13)

Enterprise Ireland's CEO also notes the importance of the CSETs to Ireland: "Through the CSET Programme, Ireland has a powerful agent for linking indigenous and multinational companies with researchers in Ireland's institutions of higher learning," (SFI, 2007; pg. 16).

Reflections on the Irish Framework/Programs

The goals and targets expressed both in the main SSTI and by the individual agencies are, as noted, very specific. As a result, the measures are very concrete and direct – the number of firms created, amount of money invested and leveraged, etc. They also lend themselves to traditionally innovation measures such as patenting rates and bibliometrics. In contrast to Sweden, the emphasis is less on intangibles than on concrete mechanisms that can be highlighted. However, discussions with Irish agency representatives show that, despite the emphasis on targets expressed in agencies' structures, 'intangibles' are still considered important since the effect of programs ay not only result in concrete measurables, but in network links and processes that strengthen the Irish system of innovation, which is what ultimately the strategy is about. This will be discussed in more detail along with the other cases.

Another thing to note is how the reports that will be discussed below are presented. Each of the reports is a very straightforward, accessible presentation, mostly quantitative data, of program progress. They are presented in a manner that serves as both information but also promotion of Irish strengths, and a discussion of weakness and how they will be overcome. While "intangibles" such as network building are mentioned, the emphasis is on clear cut results and progress towards stated goals.

Irish Program Evaluation

Ireland has commissioned several different evaluations of its programs under Forfas, or the Advisory Council for Science Technology and Innovation, or the individual agencies. While a summary of all relevant evaluations is beyond the scope of this project, key reports are highlighted below along with

the kind of indicators that they use. From this, a brief discussion regarding successful programs will be presented which includes interviewee comments.

SFI Reports and Evaluations

SFI produces an Annual Report and Accounts; An annual Census of Research Report; A report for Bio, ICT, and Energy respectively summarising investment in the areas; and an evaluation of the "Value for Money" of SFI's programs was commissioned and published (Indecon, 2008).

The agency publications are in depth reports of the amount of funding invested by SFI into the different areas of science it supports. Particular importance is given to the number of industrial partners involved with academia in the Centres for Science, Engineering and Technology and the smaller Strategic Research Clusters; publication and research outputs; and the number of researchers (PIs, post-docs, and PhD students) involved. These reports are mostly done by the agency itself, but the Value for Money evaluation was conducted by Indecon consultants.

Briefly, it is interesting to note how the Value for Money report evaluated SFI programs to date. The report, in its executive summary, notes that the programs are well in-line with the national development program and the broad national science and innovation objectives. It states that there has been a major transformation to the Irish R&D system as a direct result of SFI efforts, including impact on business R&D activity, though Ireland still underperforms relative to other EU countries (Indecon, 2008; pg. i-ii). Unfortunately, while the report goes into a detailed analysis of the SFI programs, at the time of review it was too early to make any definitive statements of economic impact, and much of the report projected potential impact. However, a few interesting points were highlighted and are quoted below:

- The funding of Principal Investigators and of the CSETs has acted as a strong reference sell for IDA client companies who have visited Ireland over this period. They have also given the wider industrial community the belief that there will be a steady stream of high quality employees in the future. This confidence in the Irish ecosystem has led to many companies establishing their own in-house R&D centres in Ireland.

- While it is difficult to ascertain the direct impact of SFI on the level of IDA Ireland-funded R&D investment, it should be noted that these researchers have become part of IDA reference itinerary program for new companies.

- While many of these introductions had led to the establishment of industry-academic collaborations, they have also led to new partnerships between companies involved in the CSETs who would not have previously worked together. This could not only be a significant benefit to the companies but should embed their operations further in Ireland as it becomes a preferred location for R&D investments, (Indecon, 2008, pg. 95).

EI Reports and Evaluations

EI produces two annual reports, besides the program brochures which are constantly updated: the EI Annual Report and the Seed and Venture Programme Report. Each of these reports detail the agency's

expenditures and highlight some of its accomplishments. Most of the accomplishments in the Annual Report are described as either case studies or "highlight" examples. The Seed and Venture Capital Programme Report indicates the number of investments, sectoral breakdown, value of investments, and private sector partners involved.

IDA Ireland Reports and Evaluations

The IDA provides annual reports regarding its expenditures and engagement with client firms. Amongst its publications are also included statistical summaries on Ireland for potential investors, and brochures on investing in Ireland and its various sectors, as well as two regular newsletters: "International Finance" and "Business Ireland".

Forfas

As the umbrella organisation coordinating the National Development, and the SSTI, Forfas's publications involve different reports such as local industry conditions, program effectiveness, market forecasts, as well as externally commissioned evaluations such as the 2004 Evaluation of Agency Supports for R&D in the Business Sector.

It would seem that these reports not only update the public stakeholder but are used to inform policy changes and track those changes. For example, Forfas released "Maximising the Environment for Company Research and Development" in March 2010 which highlights some interesting barriers for different science based industries in Ireland, while also outlining suggested remedies and actions.

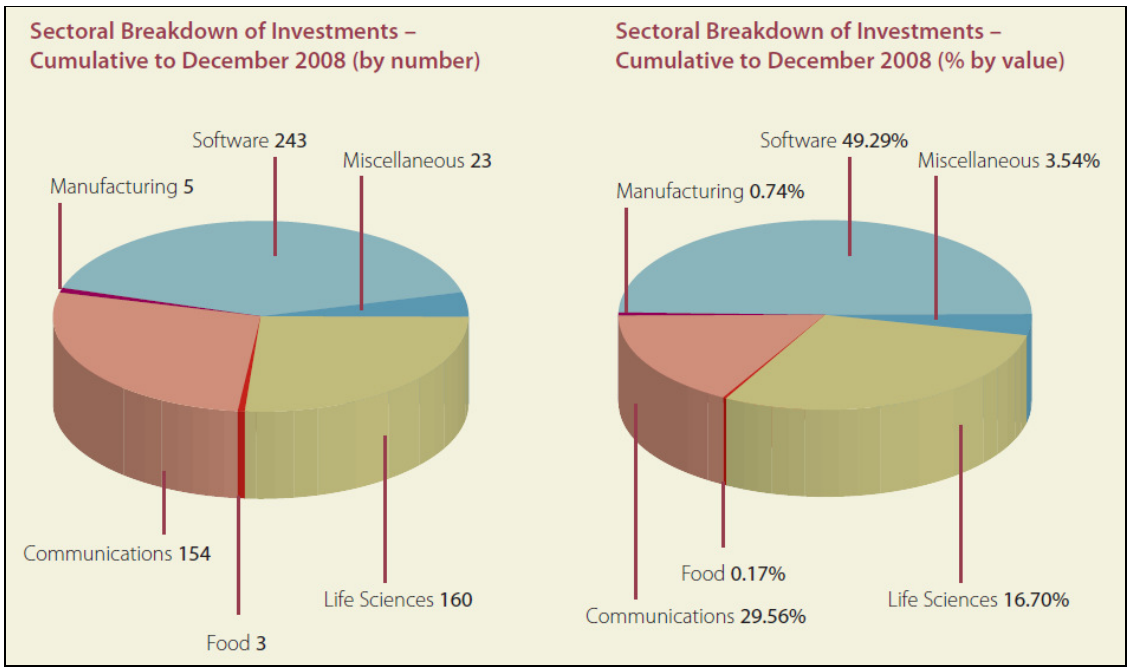
The December 2009 "The Role of PhDs in the Smart Economy" is another illustrative example. It outlines the success of SFI initiatives to increase Ireland's human capital goals, but also helps to refine the approach. The study highlights the industries that hire PhDs and recognise the value of their research skills, primarily the pharmaceutical industry and secondarily the chemicals industry, and those industries which do not express this type of demand (ICT). The report also notes the differentiation between PhD candidates with industrial experience, newly graduated PhDs, and the specific educational portfolio which is in demand (e.g. knowledge of research methodology, specific subject knowledge, etc.). From these conclusions, SFI's approach to building human capital and research oriented workforce will be adjusted, and programs such as Industrial PhDs based on the Danish model are considered.

In discussing Ireland's program review, it is important to mention the role of the Irish Advisory Council for Science, Technology and Innovation. The Advisory Council was established in its present form in 2005, and is a key component in helping Ireland to meet its goals in the SSTI. The Advisory Council is made up of 13 people plus the secretariat (provided by Forfas). The panel members represent industry (including representatives from the IT, food and pharma industries – Ireland's key strategic sectoral focus), as well as representatives from HEI and public agencies. The Advisory Council informs the Chief Scientific Advisor, feeding into the government's science and innovation policy system, which is then turned into part of the mandates pursued by Forfas, IDA, EI, and the SFI. The IDC has been responsible for both evaluative and foresighting reports, including reports cited in the report, which in the last few years have been focused on improving Ireland's R&D environment, its involvement in international

research arenas, and how to translate R&D into commercial strengths. In this manner, Irish policy is strongly informed not only by the council itself which feature industry and HEI representatives, but also draw upon expertise the Council commissions for specific reports, studies and inquiries. The Advisory Council's input forms a crucial part of Ireland's evidence based policy and in outlining the potential changes required by the Irish system.[9]

Performance of Programs mentioned

In terms of the Seed and Venture Capital Programmes progress and performance, to date, a total of 319,771,000 has been invested by the program, with 53,396,000 in the life sciences.



(Seed and Venture Report, EI, 2008)

In 2008, the program had created five new funds and extended one. While no information could be found on the overall effectiveness of the program in terms of GVA, the Seed and Venture Programme has been responsible for literally building a venture capital market in Ireland from scratch. While the majority of investments have gone towards software and IT, Ireland's indigenous strengths, some funds have specialised in the life sciences.

In terms of the incubator program mentioned, according to the EI website, to date 10 institutions have received funding - €17.1 million, and each has had to develop targets regarding their patenting activity, number of licenses they hope to produce, and the number of start-up companies they hope to spin-off. Unfortunately, no data was found regarding the success to date of these centres, nor the bioincubators described by EI Bio.

[9] In fact, the two Forfas given above were prepared by the Council but published under Forfas's banner.

In regards to strengthening Ireland's tech transfer system, and investing in its professionalisation, interviews with SFI and EI representatives have signaled that this is a good step towards strengthening the overall R&D system. According to an SFI representative, the communication between EI, the TTOs and SFI has been steadily improving and, while a review is underway, these relationships have allowed for new research and information to be presented in a manner better suited for commercial use. The TTO investment and the commercialisation funding are both seen as important, but again have not been in place long enough to be reviewed. What is interesting to note, however, is that when asked which of EI's or any other Irish innovation program has been most successful, an EI representative stated the following: "I think it's how all the programs work with each other." The resources have been committed by the government to grow the system and the suite of programs is seen as feeding into each other.

Furthermore, when asked about whether there is a general concern of Irish IP being developed but then acquired and removed to another country, the predominating attitude is that while this is a possibility, the benefits of supporting Irish IP outweigh the loss of its potential exit. The EI representative stated that even if some element of Irish IP were to go elsewhere, it would ultimately "come back" either bundled into some new technology or as future interactions with new investors, clients or R&D partners down the line. The SFI representative noted that "we see it as part of a process, and you can't expect companies coming here to do R&D, you can't expect them to do something right away – but if you start working with a cluster of researchers and they see this is getting them some competitive wines, I think it strengthens Ireland's case for them to be here," besides, even simply being involved in high level R&D activity means that Ireland benefits from skills development and learning by doing.

Key Points Regarding the Irish System for Later Discussion
• Ireland's innovation strategy is well coordinated through Forfas, with EI, IDA and SFI executing program delivery. • Irish strategy is characterised by specific quantitative targets, with each agency defining its targets. Some specific life science programs, and life science specialist teams are notable. • Ireland's main innovation objective is to increase the value added activity, and its R&D capacity in order to keep FDI while strengthening indigenous firms' innovative capacity. Part of its program for increasing high value activity is the use of R&D tax credits. • Ireland has invested in professionalizing the tech transfer system and using it to increase R&D commercialisation. • SFI and EI's programs, beginning with CSETs and then commercialisation funding, help fill gaps and challenges along a company's life cycle. • One explicitly stated goal is to try to encourage more convergence technologies, and their commercialisation. Also looking to develop niche markets such as nutraceuticals, building on Irish strengths. • Ireland's program evaluations and system assessments are used both to promote the Irish system to investors, outline policy progress and next steps, and to demonstrate evidence based policy making.

ONTARIO

Ontario System of Innovation and Context

Ontario is, according to Gertler, Wolfe and Garkut (2000), home to just over a third of Canada's population, with most of the population in the Southern part of the province around Toronto, Hamilton, Ottawa, Kitchener-Waterloo-Cambridge, London and Windsor. During the early millennium, the province was producing 40% of Canadian GDP and approximately the same proportion of country's employment (ibid.). Ontario, in 1996, spent 45% of the total Canadian R&D, with GERD valued at $517 per capita, and 54% of the national total of private business expenditure in R&D. However, since the 1960s, Ontario's manufacturing economy has been dominated by foreign direct investment and, while this has allowed it to become a manufacturing hub in a wide spread of industries, the commitment to R&D activity by foreign companies in Ontario has been historically weaker than their home-grown counterparts (ibid.).

With the advent of the North American Free Trade regime and changes being made within dominant industries such as the automotive sector, the government of Ontario, under various administrations, began making a concerted effort to move the economy away from straightforward manufacturing to a knowledge-based setting. Efforts to create this shift were most notably kicked off in the 1990s. As noted by Gertler and Wolfe (2001):

> Ontario governments have consistently pursued a long-term strategy of investing in its post-secondary education systems, starting in the 1960s. The resulting system of 17 universities and 22 colleges of applied arts and technology can be thought of as the bedrock of Ontario's economic development policy. It has been responsible for a substantial increase in the general level of educational attainment in the province, placing Ontario above or on par with almost every other Canadian province or US State. In the 1980s and 1990s, additional funding was targeted specifically at the research activities of the post-secondary sector, previously regarded as the exclusive responsibility of the federal government (pg. 584-585).

This "bedrock" of university-based R&D forms a major component of the Ontario life sciences sector.

The Ontario Life Sciences System

Canadian Context

As described by Niosi and Bas (2004), the Canadian biotech industry emerged soon after the US industry and in little time began to punch above its weight, ranking second after the US in terms of total number of biotechnology firms in 1999. The role of the federal (national) government must be kept in mind while considering the case of Ontario.

Biotechnology was declared a federal priority in 1983 with the launch of the National Biotechnology Strategy, and was meant to foster industrial, university and public R&D in biotechnology, increase human capital, nurture collaboration, as well to improve the intellectual property environment in

Canada. There are several different aspects to the federal government's efforts to foster the biotech industry. In 1986 seven networks were created across Canada under the Centres of Excellence scheme which brought together researchers from different R&D centres (public, private and HEI). The National Research Council also created 5 different research institutes (19887-1992) across Canada, with one in Ontario (Ottawa), all of which added about one thousand permanent and guest researchers to Canadian biotechnology, and commanded a significant research budget (e.g. in 2001/02 the NRC labs conducted $83 million in research) (Niosi and Bas, 2004).

The National Science and Engineering Research Council, Canadian Institute for Health Research both provide research funding, as well as Genome Canada, which created different centres of research across Canada, including one in Ontario. The Canadian Foundation for Innovation was also created in 1997 which provides university infrastructure funding, and has provided substantial funds for biotech infrastructure (Niosi and Bas, 2004).

IP regulation has been adjusted since 1982 to include patent protection of life forms, following the lead of the US, UK, Australia and Japan. IP protection includes: genetic material, unicellular organisms, nonhuman multicellular organisms (e.g. genetically modified mice) (Niosi and Bas, 2004). This type of IP is seen favourably by investors. While Canada followed the lead of top jurisdictions in its IP laws, the fluid state of IP regulation in the US makes it difficult to rank Canada's efforts. Regardless of this fluidity, according to interviews with Ontario government representatives, Ontario sits in the "middle" tier of IP policies in the OECD in terms of encouraging commercialisation.

Venture capital has been supported through different means, such as the Business Development Bank of Canada's biotechnology fund. In 1996, the federal government also launched the Technology Partnerships Canada, which supported Canadian biotechnology firms with multimillion dollar loans. Tax regulations have been adjusted as well, including a 20% R&D tax credit on all R&D expenditures, that can be carried forward for 10 years (favourable for firms not yet have revenues), and 35% R&D tax credit for more specific expenditures (Niosi and Bas, 2004).

According to Statistics Canada, the number of innovative biotechnology firms had reached 532 in 2005 (Lonmo and McNiven, 2005).[10]

[10] An innovative biotechnology firm is a firm that uses biotechnology for the purpose of developing new products or processes.

Table 1 Number of innovative biotechnology firms, by region

	1999	2001	2003	2005
Total	**358**	**375**	**490**	**532**
Atlantic	19	23	25	25
Quebec	107	130	146	181
Ontario	111	101	129	144
Manitoba	6	11	21	19
Saskatchewan	16	17	34	18
Alberta	28	24	44	51
British Columbia	71	69	91	94

Source: Canadian Trends in Biotechnology
Statistics Canada, Biotechnology Use and Development Survey 2005

Table 2 Growth rates of firm counts, by region

	1999/2001	2001/2003	2003/2005
	percentage growth, rounded to the nearest integer		
Total	**5**	**31**	**9**
Atlantic	21	9	0
Quebec	21	12	24
Ontario	-9	28	12
Manitoba	83	91	-10
Saskatchewan	6	100	-47
Alberta	-14	83	16
British Columbia	-3	32	3

Source: Canadian Trends in Biotechnology
Statistics Canada, Biotechnology Use and Development Survey 2005

Table 3 Number of innovative biotechnology firms, by sector

	1999	2001	2003	2005
Total	**358**	**375**	**490**	**532**
Human health	150	197	262	310
Agriculture and food processing	119	113	138	146
Environment	35	33	38	60
Other	54	32	52	16

Source: Canadian Trends in Biotechnology
Statistics Canada, Biotechnology Use and Development Survey 2005

Table 4 Growth rates of firm counts, by sector

	1999/2001	2001/2003	2003/2005
	percentage growth, rounded to the nearest integer		
Total	**5**	**31**	**9**
Human health	31	33	18
Agriculture and food processing	-5	22	6
Environment	-6	15	58
Other	-41	63	-69

Source: Canadian Trends in Biotechnology
Statistics Canada, Biotechnology Use and Development Survey 2005

Within Canada, the biotechnology industry is concentrated in the provinces of Ontario, Quebec and British Columbia (Lonmo and McNiven, 2005; Gertler and Vinodrai, 2009), basically agglomerating where the largest number of research centres and qualified people had already existed (Gertler and Vinodrai, 2009). What's more, while federal policy should be kept in mind, different pieces of research argue that provincial policies would have a very strong effect on the localised biotech industry (Niosi and Bas, 2004; Lowe and Gertler, 2008; Gerlter and Vinodrai, 2009; Biotechnology Council of Ontario, 2006).

Ontario

The provincial government has undergone many changes from the 1980s through to the present period, with each of the major parties having sat in office. Regardless, each government has worked to address concerns of gaps in the innovation system, benefiting the biotechnology and life science industry. Of early significance was the establishment of the Premier's Council Technology Fund, which funded seven university-based Centres of Excellence to improve research capacity in areas of provincial interest. An explicit mandate of the Centres of Excellence was their engagement in collaborative research with industry partners to help shape research priorities (Biotechnology Council of Ontario, pg. 19).

In 1994, the biotechnology sector was specifically awarded financial support from the province to develop a comprehensive strategy to move the sector to higher value-added activity and international competitiveness – however, recommendations from the strategy that followed were put on hold due to the Conservative party coming into power in 1995 and canceling or winding down all targeted spending policies of predecessor governments. All that remained were the Centres of Excellence, cut down to four, and with reduced funding (ibid.). In 1997, the Conservative government decided to support innovation by establishing the Ontario Research and Development Challenge Fund as a $500 million, 10 year initiative – this was meant to increase R&D capacity of university and other research institutes and grew to become a $1.5 billion fund through matching contributions from academic and private sector partnerships. Tax incentives for R&D were also implemented, the most significant being the Ontario Business-Research Institute credit; 20% refundable tax-credit for corporate sponsored R&D conducted in Ontario by eligible universities or other institutes and associations (ibid.).

Further efforts to support the biotech sector by the Conservative government emerged as reports were received that many start-up companies in the sector were relocating to the US. Following the recommendations of a task force made-up of biotech community representatives, a series of initiatives were implemented:

- Premier's Research Excellence Awards - $85 million, 10 year initiative to attract and retain top researchers (all disciplines, with funding allotted for the Life Sciences as a category).
- Ontario Innovation Trust – a one time $750 million grant to improve research infrastructure at universities, institutes and hospitals.
- Biotechnology Commercialisation Fund to create commercialisation centres (London, Ottawa and Toronto) to nurture new biotech companies spinning off from research institutes; a $20 million, 4 year initiative (ibid.).

- Biotechnology Cluster Innovation Program – a $30 million program which resulted in the creation of 11 regional (regions within the province) biotechnology consortia that have now become the Ontario Regional Innovation Networks (RINs). (ibid)

After the 2003 change in government to the Liberal party, not only did the new government maintain most of the key innovation and biotech initiatives, but emphasised the need to foster innovation, with the Premier also labelling himself the first Minister of Research and Innovation.

As expressed by the Biotechnology Council of Ontario, the different governments in power have placed progressive emphasis on innovation in general and the life sciences specifically, and have all contributed to higher education standards, encouraging R&D, and trying to cultivate an innovative culture (Biotechnology Council, 2006).

Using Porter's cluster analysis method, the Ontario-based Institute for Competitiveness and Prosperity identified "pharmaceuticals and biotechnology" as one of six clusters in which Ontario is continentally competitive, and the only technology-intensive cluster where it has comparable employment rates relative to 15 US states and the province of Quebec. The Broad Biopharma cluster in Ontario includes biological product, medical devices, research organisations, health and science centres, specialty chemicals, lab instruments and equipment, packaging, and distribution. Amongst the key factor endowments identified for the province are the repeatedly mentioned 22 teaching hospitals and five university medical schools located in the province.

Assessment of Ontario's Strategic Context

In 2009, the Premier of Ontario (Head of provincial government) Dalton McGuinty was awarded the Bio International Leader Award in Washington, D.C. (source: Current State of the cluster/industry, May 06 2009). The award recognised his commitment to the development and growth of the industry in Ontario and is an award for aiding biotechnology through policy mechanisms that strengthen a region's innovation framework. Key initiatives and results noted for this award are $3.2 billion dollars for R&D and innovation through Ontario's *Innovation Agenda*, the creation of Ontario's Institute for Cancer Research, programs such as the Biopharmaceutical Investment Program, programs for talent retention and R&D, and $100 million competition for genomics research (Global Leadership Round in Genomics and Life Sciences).

As of 2009 there were 25 research and academic hospitals in the province, with 10 000 researchers, and $850 million worth of research conducted annually. Ontario is the largest hub of biomedical activity in Canada, and the third largest in North America according to this literature. The industry employs 43,000 people, 850 companies, and has $14 billion in revenue (Current State of the cluster/industry, May 06 2009).

In 2008, $550 million in biopharma FDI was received into the province (MaRs, 2008). Sector snapshots from 2007 provided by the Ontario government list the pharmaceutical industry as having over 16,000 employees, sales of $5 billion plus, and the presence of major firms such as Astra Zeneca, Bayer, Lilly, GSK, Pfizer, UCB Pharma, Wyeth, and Ontario's Apotex (a generic manufacturer).; the Medical Devices

industry has 22,000 employees, revenues of $4 billion, and over 600 companies which include Baxter, GE, Johnson and Johnson Medical Devices; Biotech industry has 35,000 employees, $2 billion in revenue and 130 companies including Amgen, Genzyme, Sanofi Pasteur (more than any US state except for MA and CA) (OITS, 2007). $8.5 billion in R&D is spent annually overall in the Life Sciences, with $450 million by pharmaceutical companies alone) (Life Sciences in Ontario).

What emerges in research papers as well as government information regarding the Ontario Life Sciences sector is not only reference to the many cluster of hospitals and universities located in Southern Ontario, and particularly in Toronto, but also the history of research and commercialisation in the region. Part of the history of the region, and a selling point used to attract investors is the discovery in 1921 of insulin, and its later commercialisation, at the University of Toronto by Banting, Best, Macleod and Collip, the creation of Connaught labs, and the initial partnership with Eli Lilly. The Connaught Laboratories were a University of Toronto spin-off company that was created to produce diphtheria and tetanus anti-toxins, and used as a the basis for commercialising the patent Banting and Best had taken out on their discover of insulin. By partnering with Eli Lilly through Connaught, Banting and Best were able to insure the quality of the product that resulted from their discovery. Connaught Laboratories was later sold in 1972, the revenues from which were used to set up a graduate scholarship at the University of Toronto, and the laboratories are now owned by Sanofi Pasteur, the vaccine division of Sanofi Aventis. From the early expertise in research and vaccine production, Sanofi Aventis's site has grown in importance, with increased R&D investment from the company, and support from the provincial government.

Gertler and Vinodrai (2009) note the dual importance of anchor firms for creating entrepreneurial inspiration, and these anchor firms' strong ties to the R&D system. For example, Toronto's Allelix was founded in the 1980s and is considered Canada's pioneering biotech firm. Allelix and Cangore, another significant Canadian biotech firm, both spun-out from Connaught Laboratories at the University of Toronto. Both were supported by public investment which later attracted private sector investment, and both highlight the importance of Ontario's university system in the creation of local life science firms (Gertler and Vinnodrai, 2009).

Other companies such as GSK have maintained a strong presence in Ontario, co-locating manufacturing and development activities in facilities that can take drugs from early development through clinical trials to manufacturing (MaRs, 2008; pg, 7-9). From interviews and statements made by industry leaders, a large part of the attraction of Ontario rests on its ability to provide world class research skills and a proximity to the US market. Lowe and Gertler (2009) also note the importance of the university research system for medical technology device firms. They cite the example of the Greater Toronto Med Tech companies building on earlier educational links to local universities and colleges, with cases where entrepreneurs would turn to college or universal mentors for assistance in product development. Some of these examples have included entrepreneurs formalising the link with the university by securing grants to support collaborative research and testing (Lowe and Gertler, 2009).

The overall impression garnered from government literature, academic studies and the interviews conducted is that a large part of the commercialisation of Ontario science begins as small university

spin-offs, later to be picked up by multinational firms. As one interviewee noted, Ontario SMEs are incubators for the international industry, and it may therefore be worthwhile to try to see how Ontario can benefit from operating in this niche. Alternatively, the interviewee notes that for Ontario firms to be able to grow competitively, venture finance is needed to take firms beyond the start-up phase into serious growth. This opinion is echoed by the other Ontario-based interviewees. Without a better functioning venture system, Ontario will have to accept its position as a creator of incubator firms which are candidates for acquisition. The issue of venture finance will be discussed further below.

Impact of procurement

Ontario's profile is also influenced by its health procurement strategies, according to Gertler and Vinodrai (2009). Canada is the eighth largest market in the world for pharmaceuticals, therefore the procurement of drugs and medical devices by one of the largest provinces and centres of population in Canada becomes important. Gertler and Vinodrai note that since the 1970s, Ontario has required that medicare patients must purchase generic version of drugs wherever available, in contrast to Quebec which gave a 15-year exclusive approval guarantee to brand name drugs in order to attract multinational firm research and manufacturing. Lowe and Gertler (2009) echo this, explaining how Canadian federal legislation since the 1960s requires brand name corporations to licence their products to Canadian generic drug-manufacturers, which combined with Ontario's health care policy favouring the purchase of generic drugs. As a result, Gertler and Vinodrai claim that Ontario's pharmaceutical production profile features greater prominence of generic manufacturers (Gertler and Vinodrai, 2009). The Canadian Generic Pharmaceutical Association (CGPA) notes that Ontario is home to one of the world's largest concentrations of generic pharma research, development and manufacturing, with 8000 people employed in Ontario and $400 million in salaries and benefits. According to the CGPA, its members spend $300 million in R&D in Ontario, or 15% of their sales revenue. Interestingly, Apotex is the largest generic company and largest spender of pharma R&D in Ontario (using 2006-2007 data, CGPA website). Generic drug R&D has reinforced demand for R&D skills in the area, especially as many prefer to contract their R&D efforts out (Lowe and Gertler, 2009).

The importance of procurement is also noticeable in the med tech industry. Referring back to Lowe and Gertler's study (2009), they note that a significant number of med tech firms, characterised by their hybrid business plans, would use initial procurement of services to then establish a product supply relationship. The process depends on the fact that service provision and technical product provision depends on individuals within hospitals, or other potential purchasers, rather than on a wider system. Once a regular relationship was established for services, it became easier for these same service providers to present their product and conclude a sale.

Impact of Clinical Trials

While the strength in basic R&D and skills development stemming from the public and university sector has been discussed in term of making Ontario an attractive destination to do research for life science firms, another area of strength is that found in clinical trials, which creates a further incentive for firms to locate operations in Ontario and also creates a sub-industry in the province. An interview with a representative from GSK Canada highlighted this as a source of attraction for having keeping different

facilities in the region (MaRs, 2008). As noted in the table above pointing out research strengths in the province, at least five regions in Ontario have clinical trial facilities, skilled personal tied to the universities and hospitals to conduct the trials, as well as an ethnically diverse population from which to draw upon. Queen's University has the National Cancer Institute of Canada Cancer Trials Group; the University of Western Ontario has the Robarts Clinical Trial group which is the world leader in trials for inflammatory bowel diseases; and McMaster University has the Population Health Research Institute. The latter is particularly noted for the large number of clinical trials it has conducted, and the fact that it is home to CANNeCTIN, a network that will eventually join every teaching hospital in Canada, as well as smaller community hospitals and, eventually, 1500 hospitals world wide (MaRs, 2008).

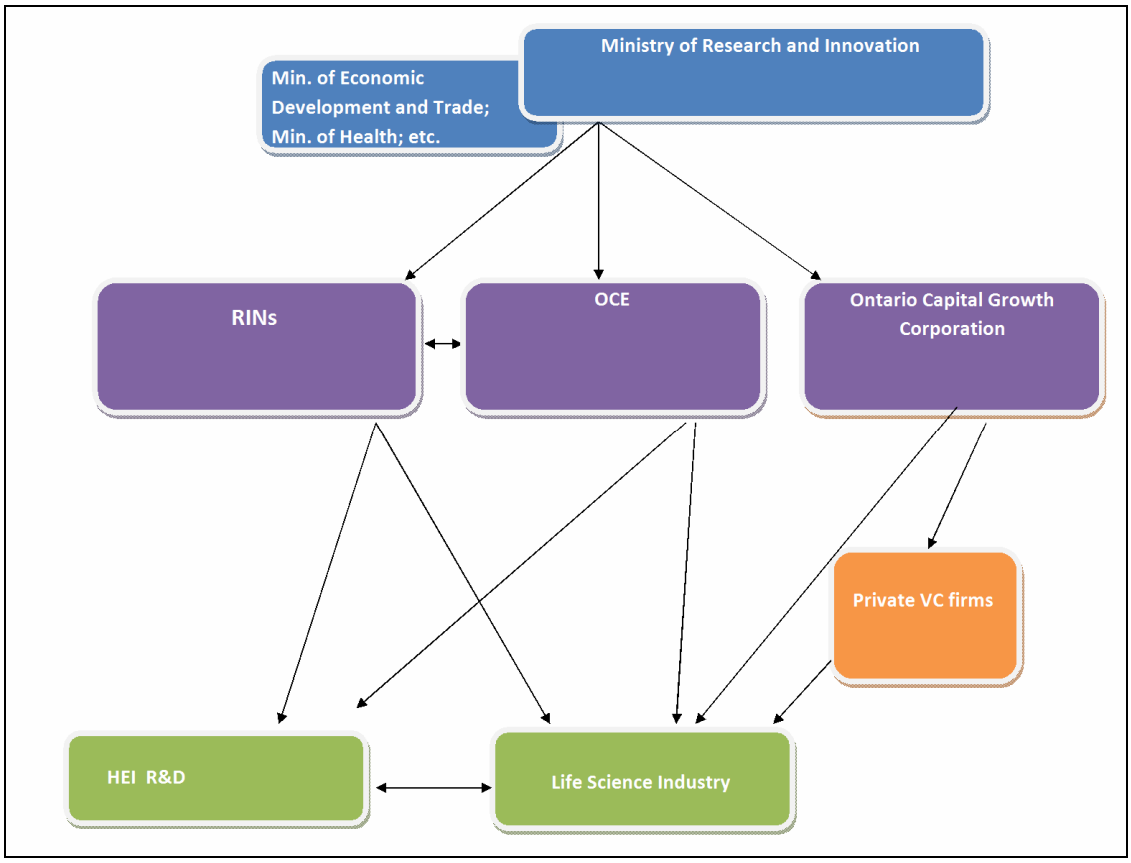
Policy Framework

The Province of Ontario's policies and programs aimed at growing the Life Science industry are centred around further increasing the R&D capacity in the province, both public and private, as well as increasing the output of commercialisation in the province particularly through the creation of Ontario-based companies. Since its creation in 2005, the Ministry of Research and Innovation has taken the lead on the majority of these programs, though a variety of programs are carried out or administered by the Ontario Centres of Excellence, Regional Innovation Networks, or the MaRS Discovery District. As will be discussed below, the evaluation of these programs has been rudimentary, but the general feeling is that programs geared towards R&D have been more successful than those focused on commercialisation. The Ontario programs discussed are summarised in Appendix 3.

Of the programs in place through 2009 and 2010, only four can be considered to be directly targeted towards the life sciences, and two of those take the form of institutes funded by the government and running sub-programs for their stakeholders: the Global Leadership round in Genomics and Life Sciences for the Ontario Research Fund, the Ontario Institute for Cancer, the Biopharmaceutical Investment Program (discontinued in 2010), and the Health Technology Exchange. The remaining programs listed have a broader remit to support the innovation and commercialisation environment in Ontario. However, this remit is defined in such a way that the life sciences are recognised as a key sector, as stated in the Ontario Innovation Agenda:

> Through the innovation agenda Ontario's government has highlighted specific areas of the economy – bio –economy and clean technologies, advanced health technologies, pharmaceutical research and manufacturing and digital media and information and communications technology – for initial strategic investment. These are areas of strong growth where Ontario already holds a position of global importance or can quickly mobilise existing resources and skills to do so (Ontario Innovation Agenda).

Particularly for the university research funding programs, evaluation and peer review committees are set-up so that disciplines are assessed separately, with the life sciences representing one or two committees in the evaluation process (committees may be divided between medical/clinical and basic life sciences, depending on the size of the application pool).



Program Evaluation

The province of Ontario has not carried out any in-depth assessments of its policy programs in terms of impact or contribution to the economy. Unlike Sweden, Scotland, or Ireland, to some extent, there have been no commissioned evaluations made available to the public and stored in a publicly available site. From discussions with representatives of industry associations, regional innovation networks and the provincial government, the reasons for the lack of evaluation seems to stem from a lack of political will for a large scale evaluation; the difficulty of assessing innovation programs, especially those aimed at creating network linkages and raising the provincial profile internationally, i.e. “intangibles”; and a sense that many of the programs are “new”, with the current government’s efforts stemming from the 2005 founding of the Ministry of Research and Innovation. Most of the communication efforts surrounding the impact of policies and programs involves the amount of funds released to researchers or firms for each program, the number of awards of given, and if explicitly part of the program (i.e. the program requires matching funding), the amount of funds leveraged. However, below a rough evaluation of the Ontario’s programs will be discussed based on interview data, academic papers, and publicly available information available released by the government or industry bodies.

The R&D programs in Ontario have been successful in increasing the R&D infrastructure and attracting and retaining research talent to the province. As described below, these programs have enabled Ontario to not only maintain its strong HEI research base, but increase its international recognition and take the

lead in international projects in the life sciences. In May 2008, Nature magazine noted Toronto, Ontario as a research hub based around the University of Toronto, nine research hospitals, 5000 principal investigators, and research budgets totaling $1 billion in the city region alone, which creates an atmosphere to which other researchers want to travel (Nature, 2008). Gertler and Vinodrai (2009) note that Ontario centres such as MaRS, and the university setting have allowed the province to attract "star" researchers; they give the example of the Ontario Cancer Institute being able to attract a star researcher from Boston to do stem cell research based on the funding commitment and commitment to independent research. Another star researcher was recruited from New York in 2006; he was recognised by the New York Magazine as one of the six researchers New York could ill afford to lose, but he decided to move to Toronto because of the quality of the stem cell research and quality of research talent (MaRs, 2008).

In addition, Ontario institutes have been selected for leadership roles for international life science projects. Ontario was selected as the site for the secretariat of the International Regulome Consortium, which consists of 60 investigators from 34 institutions in 12 countries conducting genome research. Ontario was also chosen to lead the International Cancer Genome Consortium, a partnership with Boston's Broad Institute, Harvard University, MIT and Whitehead. Ontario institutions also lead the Structural Genome Consortium, a research partnership between the University of Toronto, Oxford and the Karolinska Institue.

Commercialisation in Ontario

In regards to commercialisation programs, Ontario is relatively weak and has been underperforming considering the level of IP that is produced in the province. An article in Nature magazine covering the Toronto region of Ontario, states that while Ontario has one of the largest concentrations of biotech companies in North America following California or Massachusetts, it only produces "half the opportunities it should" when looking at the relative R&D investment to commercial output. Part of the reasons for this, according to the article, is that Ontario has "a research culture that values basic research more than entrepreneurship; lack of government funding for applied research; and a shortage of venture capital for early stage companies," (Nature, 2008; pg. 253).

In terms of venture capital funding, in Canada, Ontario and Quebec compete with each other in regards to venture capital activity. Overall, venture capital investment in the life sciences in Canada has been similar to that in the US, in terms of the proportions set aside (17% in the US from 1996-2002, compared to 19% in Canada). From 1999-2002, the amount invested in Canadian life sciences increased 103%, behind ICT investment with a growth of 368% (which subsequently suffered in the early millennium). Part of this steady growth, according to a Canadian government report, is a result of specialised investors forming. Most of the investments were in biotechnology, but with the highest rate of growth in medical devices (192%), followed by medical and biological software (163%), biopharmaceutical investment (76%), and healthcare (65%).

Interestingly, while Ontario managed to attract the most venture capital in terms of money invested, the majority of investments were focused on high profile IT firms in the Ottawa region. However, from

1996-2002, life science investments in Ontario were declining and falling below the average Canadian rates (from $248 million in 2000 to $158 million in 2001 and $134 million in 2002). According to the report, this has affected the development of Ontario's life science sector. Lowe and Gertler (2009) pick up on the effect that investors have had on the Ontario life science industry, particularly around the Greater Toronto region. Firstly, they note that most of the VC investment in Ontario has been from private sector sources, and that it has been reactive to risk and to the varying economic environment. As a result, Lowe and Gertler have noted that as a result of 'punitive' actions taken by VC investors in the new millennium, which ties into the drop in investment described by the Federal government, Ontario life science firms deploy hybrid business plans which seek to diversify income sources and lower their risk exposure from concentrating on only drug discovery or new product marketing. Hybrid business plans involve everything from therapeutic and drug discover accompanied by contract research, genetic consulting or blood banking, to more straightforward medical device creation, service and repair.

It is useful to contrast Ontario's VC investment with that of Quebec. Quebec's VC system has mostly been, in contrast to Ontario's, publicly financed. They key investors in Quebec have been either public VC (Innovatech, BDC), labour-sponsored funds heavily favoured by government tax credits, or private VC that has spun-out of public sector VC (i.e. former public VC managers started their own firms). Part of the system influence of the system is that many of the Quebec funds are evergreen and must invest a minimum fixed percentage of the capital in order to continue receiving tax benefits or continue to function by government mandate. As a result, while Ontario has had more overall VC investment in terms of money, there have been a greater number of deals of smaller amount in Quebec. Furthermore, because of the need to invest, Quebecois VC are more likely to accept risks that private sector Ontario VC would not support. While this means that Quebec life sciences has received a constantly increasing amount of VC, whether it is better or not for firms in terms of productivity and market impact has not been explored.

In 2008, the Ontario introduced three venture capital programs to try to fill funding gaps that were perceived in the system. The first program is the Investment Accelerator Fund launched in 2008 and managed for the Ontario government by the Ontario Centres of Excellence. According to Ministry of Research and Innovation, the fund's goals are:

- The Investment Accelerator Fund finances eligible knowledge-based companies to test and develop their new technology in the early stages, and gain entrepreneurial know-how to take the idea closer to the marketplace.
- Investments between $250,000 and $500,000 help companies with technology development, market potential analysis, prototype development, early customer trials, promotion and patenting costs.
- IAF will also provide companies with business mentorship until a skilled management team is in place, either temporarily or permanently. The fund also supports assistance to attract later-stage venture capital.

To date, the website shows 20 new firms in the Fund's portfolio, and seems to be making a positive impact, though it has been slow to take-off. As one entrepreneur (in one of the few life science companies in the portfolio) is quoted as saying:

> "IAF has been a major catalyst to the early and continued success of Atreo Medical. The financial support has enabled Atreo to secure a Canadian medical device engineering firm to assist in product design, testing and manufacturing. Additionally, the managerial expertise brought to the table by IAF has been instrumental in helping Atreo skillfully navigate the medical device industry. We are extremely grateful to IAF for providing a strong and stable foundation upon which Atreo has not only been able to grow, but thrive." (CEO Atreo Medical, accessed 2010).

Two other programs are run through the newly formed Ontario Capital Growth Corporation, an agency of the provincial government. The first fund is Ontario Emerging Technologies Fund. It is a $250 million 5-year fund, designed to co-invest with qualified investors. One of the models for the fund was the Scottish Co-investment fund. According to the website, the goals and objectives for the fund are:

- Market-based investment decisions – identification of investment opportunities will be undertaken by qualified investors that have a proven track record of success and have been pre-qualified by Ontario
- Rapid deployment of capital – the Fund will have the ability to make investments directly into companies within a short time frame
- Focus on key industry sectors for Ontario – the Fund will focus its investments on sectors of strategic importance to the province
- Government's role as a catalyst – Ontario will act as a catalyst to leverage private sector capital.
- Ability to make additional investments into an investee company – the Fund will be able to make both initial and follow-on investments to support the ongoing growth of high potential, innovative companies.

The administration and monitoring of the fund has been assigned to Covington Capital Corporation, a private company.

The second fund coming from the Ontario Capital Growth Corporation is the Ontario Venture Capital Fund. Unlike the co-investment fund above, the OVCF is a $205 million fund of funds, with $90 million of the money committed by the government, and the balance of the money coming from its partners: TD Bank, OMERS Capital Partners, RBC Capital Partners, Business Development Corporation and Manulife Financial. The fund is managed by Northleaf Capital, formerly the private equity arm of TD Bank, but now an independent VC fund manager in charge of portfolio made of up of various funds of funds. The key principles guiding the fund are as follows:

- OVCF's primary objective will be to generate long-term returns for its Lead Investors.

- In order to maximise its investment returns, OVCF will leverage the resources of TD Capital and the Lead Investors to promote industry development initiatives and the ongoing adoption of global best practices across the Ontario venture capital industry.
- OVCF will seek to construct a focused portfolio of high-potential fund managers with sufficient scale and resources to effectively execute on their investment strategy and deliver world-class returns.
- OVCF will play a proactive role as an anchor investor, but will not seek to represent a majority of the total capital commitments of any single fund.
- OVCF will invest selectively and opportunistically in direct co-investments alongside leading fund managers in high-potential Ontario-based portfolio companies.

Despite the launch of these funds, the current state of private VC investment in Ontario has become worrisome, with 2009 showing the lowest record of VC investment in all sectors in 13 years (CVCA, 2009). The Canadian Venture Capital Association has called upon the government of Ontario to increase its activities in creating a strengthenened a fund of funds, improve the R&D tax structure, and create a more attractive environment for retail investors (CVCA, 2009b). While the Ontario government, through the creation of the Ontario Capital Growth Corporation in 2008, has potentially addressed this by creating a co-investment fund as well as a fund of funds, and through the Investment Accelerator Fund which is managed by the Ontario Centres of Excellence, the results of the efforts have not yet been determined and therefore the call for action remains in the public domain.

Anecdotally, according to interviewees, the above venture capital program has been slow to take-off. One reason which may be put forward for this is that, because the funds are managed privately, private sector investors may still not have sufficient motivation to invest in higher risk life sciences. Such investment patterns, focusing on IT and med-tech, would follow the investment strengths of the province as described in the federal government study in venture capital. In fact, to date, no life science firm is in either of the programs portfolios. A second reason for the slow take-up of the venture capital fund may be the process of vetting private investors for co-investment with the Ontario fund, a process seen as too onerous and intrusive by some. The position is held by representatives of the CVCA (CVCA blog, 2009), but has also been echoed by a biotechnology industry association representative. According to the CVCA blog, most of the Ontario VC investment to date has been done by angel investors, however, the guidelines for co-investment introduced in 2009 made it challenging for angel investors to be able to quickly participate in the process.

Besides the challenges faced in the area of venture investment, part of the commercialisation problem in Ontario was a lack of coherent structures that facilitate communication between the various public and private sector stakeholders. The RIN program was implemented in 2004 to address this, and has received fairly good reviews, though an in-depth assessment and evaluation of the program was not available.

RINs have been given consistently positive reviews by both government representatives and the literature which describes the Ontario system of Innovation. While the RINs are described in Appendix 3, it is useful to note how they were programs created by the Ontario government, initially conceived by the Ministry of Economic Development and Trade and then executed by the Ministry of Research and Innovation, to solve the problem of "extreme program, policy, and communication silos" in Ontario (RIN, 2007). The RINs were therefore created to help Ontario's commercialisation, initially in biotech, though it has spread to other sectors in later years. The RINs are multi-stakeholder organisations that are meant to facilitate a wide range of commercialisation activities, focusing on the need of entrepreneurs, researchers and growing companies. The main way they do this is by facilitating network communications that previously were not there. As noted in a RIN publication, their paradigm for activity involves creating relevant innovation pathways, providing clarity around commercialisation programs, and providing improved access to critical resources for entrepreneurs, researchers and SMEs (RIN, 2007). In 2006, the president of Sanofi-Pasteur in Ontario stated that:

> "[The RIN] has facilitated relationship among large companies and institutions in the area, enhanced awareness about the strong medical device presence in the region, and led to concrete proposals such as the National Centre for Medical Device Development. It has brough together regional and municipal governments, universities and colleges, large companies and SMEs, all operating in a collaborative spirit and for the greater good of the sector," (RIN, 2007).

Changes that are currently being implemented is a reorganisation of the regional innovation networks and their structure in regards to dealing with identifying viable IP for commercialisation and then helping researchers and research institutions gather the resources necessary to commercialise it. One of the changes occurring is an amalgamation of BioDiscovery Toronto RIN and the MaRs Centre, which is located in Toronto. As an interviewee explained, the amalgamation is meant to better facilitate a system of cooperation amongst the cluster of hospitals and universities in the Toronto to pool resources and opportunities of their various individual TTOs, in order to identify more commercialisation opportunities and use the wider resources to get them off the ground. A second group of universities have done something similar, creating a network of TTOs to promote their research. The second group is made up of TTOs from small universities which have been successfully building their research profile over the last few years: Ryerson University, Brock University, Lakehead University, Laurentian University, Nippissing University, Trent University, and UOIT. Again, the results of these changes remain to be seen.

Unfortunately, despite anecdotal evidence of success and "highlights" published by stakeholders, there does not appear to be a comprehensive evaluation of the RINS, or of the Ontario Centres of Excellence, another program credited with furthering the Ontario innovation system. In terms of the OCEs, part of the success may be assumed to come from its Business Mentorship and Entrepreneurship Program (see Appendix 3), run jointly with MaRs Discovery District. Interview data indicates the OCEs' activity helps new firms not only access resources but learn how to access and use them more effectively.

One final note regarding Ontario's program performance is the changes that were made to the Ontario Biopharmaceutical Investment Program. This program, as described by a Ministry of Research and

Innovation representative, was mostly aimed at attracting deeper foreign investment with more involvement in R&D activity. The program was discontinued in March 2010, and while it is still considering proposals submitted before that date, it has only posted three successful investments: Purdue Pharma Canada, Sanofi Pasteur, and a collaborative project between Pfizer, the Ontario Institute for Cancer Research and the Ontario Cancer Institute. According to interview data, the few notable successful projects coming out of this approach of targeting large multinational companies has prompted the government to fold up the program early and re-invest its resources into other programs, such as those targeting SME and venture funding.

Key Points Regarding the Ontario System for Later Discussion

- Ontario's innovation policy is driven by the Ministry of Research and Innovation, but overall coordination with key stakeholders is challenging.
- Ontario's innovation strategy is horizontal, with vague overall objectives. It does have some specific life science programs, and a new forthcoming life science strategy.
- Ontario is characterised by a strong R&D environment, but a struggle to commercialise relative the amount of knowledge created. It has introduced tax credits favouring local IP developed by new local firms.
- Universities and research hospitals play a major role in Ontario's life science industry, with most local companies made up of university spin-offs. TTOs are independently adjusting their practices and using RIN program for commercialisation.
- MRI's academic funding helps progress university research through various career stages – new programs have been added to address commercialisation gaps.
- Ontario has an advantage in clinical trials which is interesting, and many firms are characterised by hybrid business plans. Ontario's procurement strategy seems to have had an effect on the life sciences industry.
- Ontario does not have publicly available program or policy evaluations. This is mostly a matter of the material not having been gathered, either by government or industry organisations.

Key Lessons

Some key lessons for Scotland are presented in this section. These lessons can be summarised as follows:

1) The importance of a focus on systemic correction, rather than targeted BERD improvement. To include:
    g. The need to focus on creating discrete platforms to link basic R&D with industrial R&D and technology use.
    h. Policy ideas on how to improve the translational platform.
    i. Increase the utility of incubator programs.
2) Funding gaps and investor preferences – some food for thought on different investor preferences, and the long-term value of drug discovery and therapeutics investment.
3) The importance of Evidence-based policies and evaluation processes.
    a. Useful evaluation processes.
    b. The importance of long-term commitment to programs.
4) Ideas on effective program design – building a cascade of programs.
5) Getting the most out of local knowledge and technology.
    a. Build on the growing interest in convergence technologies and develop ways of commercialising them
    b. The impact of procurement strategies on local supply capacity.
    c. Clinical trials, markets and market effects

To begin the discussion, the tables from each of the cases listing points of discussion are summarised below:

Discussion Points from Sweden	Discussion Points from Ireland	Discussion Points from Ontario
The Swedish innovation system is characterised by a strategic coordinating body, Vinnova, but independent units manage the innovation programs.	Ireland's innovation strategy is well coordinated through Forfas, with EI, IDA and SFI executing program delivery.	Ontario's innovation policy is driven by the Ministry of Research and Innovation, but overall coordination with key stakeholders is a challenge.
Sweden's innovation policy is horizontal, with programs applied the innovation system, though the life sciences are seen as an important part of the technology landscape. The Innovation strategy is characterised by qualitative goals and measures.	Irish strategy is horizontal, characterised by specific quantitative targets, with each agency defining its targets. Some specific life science programs, and life science specialist teams are notable.	Ontario's innovation strategy is horizontal, with vague overall objectives. It does have some specific life science programs, and a new forthcoming life science strategy.
Sweden has strong BERD performance, but is attempting to grow its local firm population from Swedish IP sources. It does not have an R&D tax credit, which is different compared with other jurisdictions considering its goals.	Ireland's main innovation objective is to increase the value added activity, and its R&D capacity in order to keep FDI while strengthening indigenous firms' innovative capacity. Part of its program for increasing high value activity is the use of R&D tax credits.	Ontario is characterised by a strong R&D environment, but a struggle to commercialise relative the amount of knowledge created. It has introduced tax credits favouring local IP developed by new local firms.
There has been a strong emphasis on incubators in the Swedish system, and professionalisation of TTOs.	Ireland has invested in professionalising the tech transfer system and using it to increase R&D commercialisation.	Universities and research hospitals play a major role in Ontario's life science industry, with most local companies made up of university spin-offs. TTOs are independently adjusting their practices and using RIN program for commercialisation.
Innovationsbron, ALMI and Industrifonden programs fill gaps and challenges along a company's life cycle.	SFI and EI's programs, beginning with CSETs and then commercialisation funding, help fill gaps and challenges along a company's life cycle.	MRI's academic funding helps progress university research through various career stages – new programs have been added to address commercialisation gaps.
Sweden has strength in clinical trials and research. Therapeutics and drug discovery suffer from funding shortages, particularly if performed within SMEs, but institutional investors are recalculating their long-term benefit.	One explicitly stated goal is to try to encourage more convergence technologies, and their commercialisation. Also looking to develop niche markets such as nutraceuticals, building on Irish strengths.	Ontario has an advantage in clinical trials which is interesting, and many firms are characterised by hybrid business plans. Ontario's procurement strategy seems to have had an effect on the life sciences industry.
Program evaluation, specifically Sweden's Fokus Analysis tool, is seen as an important component to a well-functioning, evidence-based system for innovation policy.	Ireland's program evaluations and system assessments are used both to promote the Irish system to investors, outline policy progress and next steps, and to demonstrate evidence based policy making.	Ontario does not have publicly available program or policy evaluations. This is mostly a matter of the material not having been gathered, either by government or industry organisations.

1(a) Focusing on needs based research and creating platforms to link basic R&D with industrial R&D and technology use.

The lifecycle of an innovation strategy is generally composed of the assessment of local endowments; comparison with other jurisdictions; the identification of key stakeholders; setting goals; identification of the kind of programs and support structures desired, and their specification; and the launch and operationalisation of the strategy. One of the current concerns in Scotland, based on comparisons with competing economies, is the necessity to increase Business Expenditure on R&D. BERD is a measure typically used to confirm whether the private sector is engaging in high value added activities, and as a proxy to determine how rooted business are within economies, the reasoning being that with more R&D and high value investments in a region, a firm would be more reluctant to pull up stakes and move somewhere else. In Scotland, most of the R&D is public, conducted through universities and public research institutes, and there is, as a result, an interest to try to increase BERD. Looking at the three cases presented here helps to put this goal into perspective, as well as to introduce a more systemic view of R&D and innovation policy as applied to the life sciences, and in general.

While different jurisdictions have differing emphasis and approaches to attracting foreign direct investment in R&D, each of them seek to strengthen the overall R&D system. This tendency makes sense for Sweden since it already has a high level of BERD, where most of the R&D activity is carried out by the private sector, particularly large multinational companies such as Astra Zeneca. The strength in Swedish BERD is used to explain why there is no R&D tax credit system in Sweden, something which the other cases have. Looking at the other two cases, however, it becomes evident that the R&D policies are moving more towards strengthening the overall R&D system, its funding and later application. Ontario's Biopharmaceutical Investment Program has been folded up; the only program specifically targeted at attracting large scale R&D investment by multinational corporations. The large scale commitment of funds has been shifted to strengthening venture investment and programs for helping indigenous companies grow. In Ireland, while the IDA still plays a crucial role in building the innovation system, Irish activities are becoming more focused on promoting the growing strength and expertise of Irish industry in process R&D, and in the CSETs – both of these elements are key showpieces to show potential foreign investors why Ireland is an attractive jurisdiction for investment.

Efforts to grow BERD for both Ontario and Ireland are more and more focused on encouraging indigenous companies to become more R&D active, or to grow to a point where they can continue commercialising new innovation. Both Ontario and Ireland have R&D tax credits which can be applied to all companies in the jurisdiction, with Ontario specifically favouring local firms using local IP in the tax scheme. More importantly, for all three cases the main policy and program efforts are geared towards strengthening local firms' capacity to grow, increase the management skills in these companies, and providing the networks and opportunities to link with service providers, investors and other companies to strengthen their position. In other words, the platform which helps to translate basic and public sector R&D to the private sector, and create a ramp from which future research can be commercialised, is being created and strengthened.

1 (b) Some Ideas on how to improve the translational platform, and the utility of incubator programs and professional TTOs

Some specific programs can be indicated in the case studies that are being used to help improve this translational platform. Sweden has leveraged its institutional economic history and drawn upon its culture of collaboration and coordination between the private sector, universities and government agencies to put together a coherent system of programs to enhance its entrepreneurial culture. Such strategy is in line with the general aim of solving what is known as the 'Swedish Paradox' via a more effective allocation and exploitation of its high rate of R&D investment. First, this involves focusing on areas of scientific excellence to maintain a leading position, scale up the supply of much required skills and promote the translation of ideas into products and services. Thus, massive investment in the 'professionalisation' of Swedish TTOs, the creation of a national programme for incubators (NIP), the setting up of supportive organisations such as Innovationsbron and ALMI, and the provision of grants (Research & Growth) to innovative start-ups. Finally, its culture of cooperation has also allowed it to open an effective dialogue with MNCs in order to come to a mutual understanding of what kind of skills need to be developed in the innovation system, funding necessary, and what other programs would make it a desirable place to invest in. Also, by focusing more on strengthening the general innovation system rather than BERD, Sweden is alleviating the concern of having large multinationals leave along with their R&D activity and leaving the country in a significantly weaker position in terms of R&D – their efforts are effectively helping to create new sources of BERD with deeper roots in the system.

In Ireland, the efforts to improve the translational platform rest firmly on the CSETs, centres where HEIs, local firms and foreign firms work together to come up with new IP with long-term market implications all partners can then utilise. These efforts are also supplemented by EI's commercialisation grant program, helping new companies to build up their commercialisation capacity through three stages of funding. The deal flow or pipeline for new ideas for either spin-off or commercialisation through existing companies is being strengthened through EI's investment in professionalising the TTOs in different universities and their partner institutions (e.g. hospitals, colleges).

In Ontario, the efforts to improve the translational platform are based around new government investments to strengthen provincial venture capital. Also, and perhaps more successfully, Ontario's RINs and OCEs which help new companies access resources and become stronger and more independent, hopefully leading to them becoming companies of scale.

Also key to note is that Ontario has been building on its traditional strengths very successfully, namely leveraging, growing, and gaining recognition for the public and academic R&D in the life sciences. Ontario's academic and research funding and programs are well coordinated and are being maintained despite federal funding cuts to research, which helps Ontario remain an attractive location for not only conducting research, but for high level researchers to continue moving to. A statement from the Minister of Research and Innovation in 2009 highlights:

> At a time when economic challenges are tempting some governments to scale back on their innovation spending, Ontario is more committed than ever to its vision of global

> leadership through collaboration. The McGuinty government is committed to growing an innovation economy that supports the groundbreaking work of our leading scientists and their teams. New discoveries and breakthroughs will continue to be made - and we want those people, those ideas, and those jobs right here in Ontario," By focusing on its research strength, it has managed to not only garner international recognition for its discoveries, but to remain an attractive location for foreign private R&D in the life sciences. (Press release, 2009)

This assessment was echoed in Nature magazine, "Scientists say the new funding is timely and could help offset cuts at the federal level. In January, the federal budget called for Canada's three granting councils to scale back their budgets by Can$148 million over three years, starting this year [2009]," (Nature, 2009).

Finally, what should be noted is that each of the cases have implemented some sort of incubation or mentoring policies. Whereas both Sweden and Ireland have outright incubation, Ontario uses the RINs and MaRs to provide mentoring, particularly in the form of the Business Mentorship and Entrepreneurship program. Moreover, while the programs have been received positively, it should be noted that their results require time to develop – consider that the Swedish NIP predicts a minimum of five years before any results are seen – something which is useful to keep in mind when considering Scotland's BioQuarter.

Overall, therefore, recommendations to put in place effective system improvements, rather than short term, reactionary solutions, consist of:

- Strengthening and maintaining the science base, ranging from basic research as well as applied research
- Ensuring that resources are readily available for local firms and entrepreneurs to commercialise locally produced IP
- Improving the managerial and business skill set of local entrepreneurs and firms to more effectively develop their IP and interact with investors and other firms.
- Retaining R&D tax relieves/credits, which constitute a key tool to promote investments in higher-risk but often strategically vital activities.
- If we look at the Swedish experience, large scale efforts to invest in the professionalisation of TTOs and infrastructure - in the Swedish case, incubators - seem to pay back. However, the process can take several years and it is characterised by an initial increase in the number of 'disclosed' ideas, followed by the applications for patents, then obtained patents and start-ups being incubated, finally (a few years later) an increase in the number of new jobs and new products/services that reach the market.

As an interviewee from Sweden's Industrifonden stated: "in order to have a viable business proposition you need strong science as well as good management and a strategic plan… in today's market you see

that only 1-2% of the cases fulfill that criteria, as a result we are currently only making 4-5 investments a year".

2 (a) Funding gaps and investor preferences – some food for thought

The second point which is of interest is more food for thought than a clear lesson, as it involves a difference in interpretation between policymakers and analysts in Sweden and Ontario in regards to the types of life science technologies supported. In Scotland, the tendency for public funding support seems to be trending towards medical technologies and diagnostics as they are seen as shorter term, lower risk investments. In Sweden, interview data reveals that this attitude may be short-sighted when considering market capacity for the different life science products that may be produced. A representative from Industrifonden noted the following:

> Around 2003-05 we saw a very clear shift from drug R&D towards med tech… some investors got burned with drug R&D and they had the naïve belief that once you get approval for a medical device, the risk is eliminated. In fact, the economic risk associated with med-tech remains very high. In 2007 there were 30,000 new products approved by the FDA and an estimated market of 25 billion USD. When you start to play with the statistics, you see that the probability of achieving peak sales of 30 million USD [a level you would need to guarantee profitability] is lower than 4%, which is similar to the probability of launching a new drug at the beginning of a clinical program.

He goes on to state how their preference is investment in companies with focused business models: "[companies] had to adjust their business models to rough conditions [during the most recent crisis] in order to de-risk investments… that is, by becoming very much product oriented, sometimes a one product company, and by running a virtual-type organisation." This statement contrasts to the advice mentioned in the Ontario discussion by Lowe and Gertler (2009), where they note the strength in hybrid business models and usefulness of incorporating medical devices, or services in order to reduce risk. However, a representative of one of the RINs in Ontario noted that drug discovery companies hold a lot of potential value, they can leverage a lot of investment and funding throughout their life cycle – the challenge is to find how to minimise the dilution and be able to capture value and create investment returns more effectively at each stage of its development.

With such contrasting views, it is difficult to determine what the best business plan is for local ventures to adapt, but it would seem that a shift away from drug discovery and therapeutics means potentially losing value in the future.

3 (a) A useful evaluation process

The importance of program evaluations became apparent from this project in terms of benefiting the life sciences industry and broader system of research and support. What do comprehensive, publicly available evaluations provide?

A good system of evaluation provides feedback data for policy adjustment, system of innovation assessment and next steps. This is evident in both Ireland and Sweden, as both commission and publish regular reports on specific programs, progress in reaching the goals expressed in their innovation strategies, and on the specific impact on the life sciences sector.

A system of evaluation also provides a reduction of the information asymmetries for potential investors and participants. Ireland's reports are perhaps most framed to achieve this effect as they are published in a format that also works as an investment brochure or promotion of the Irish system. Sweden's reports also serve this purpose, though they more closely resemble academic analysis of the life science sector; of course, this analysis is still likely accessed by potential investors, entrepreneurs and other stakeholders in helping them determine whether to engage with particular programs. Sweden's evaluations are a requirement set by the government of the agencies carrying out individual programs. Typically, each program undergoes a mid-term review, a final review and a 'post-mortem' review (i.e. 2 years from the conclusion of the program). The purpose of each review is different. Mid-term reviews focus on organisational and managerial issues, final reviews on achieved/missed objectives and 'post-mortem' ones economic impacts. Concerning the review process, each review employs 'ad-hoc' indicators and criteria to assess the effectives of the program. Each review entails a project-specific mix of qualitative and quantitative measures. International experts are often employed to ensure high standards and neutrality.

Ontario is the weakest of the cases on this front, and the lack of publications is reflected in interviews with representatives from industry associations as well as arm's length regional innovation networks: it is generally believed that the Ontario government, specifically MRI does not want to collect such information both because of a lack of political will and the difficulty of the exercise. As one interviewee stated, "the [Ontario] government is more interested in sound bytes and nice stories. They would rather point to an individual example of an award," than an assessment report. While highlighting success stories is common practice across the cases studied, as a stand-alone method of demonstrating success, it is more likely to create a weaker sense of confidence in efforts to strengthen and promote the sector, thereby weakening potential collaboration from other stakeholders.

3(b) The importance of long-term commitment to programs

While it can be confidently concluded that regular evaluations are beneficial and should be carried out by a regional government, especially one looking to strengthen a sector characterised by knowledge investment and risk such as the life sciences, the benefit of patient program management must be observed alongside such evaluations. Successful programs are those maintained consistently and *known* by participants in all three jurisdictions. A potential "con" of regular evaluations is a short-term reactivism that alters programs before they've had a chance to impact. An awareness and commitment to the long-term, relatively high-risk nature of the life sciences sector is therefore important. This seems to be the case in Sweden, where key programs such as Competence/Excellence Centres last for 10 years, agencies such as Vinnova and Innovationsbron enjoy substantial independence from government, and the various evaluation exercises focus on the programs' stage of development.

It should also be noted that assessments are characterised by the types of goals, objectives and targets set out in each case's strategy. Ontario's strategy does not involve specific targets, but rather a vague set of objectives regarding achieving a competitive system of innovation and creating a basis for long term employment creation. However, as Ontario does not have regular policy assessments in regards to RI&D policy, or the life sciences, we can look to Sweden and Ireland as examples. In Sweden, Vinnova does not set specific quantitative targets for its strategy, but rather general objectives which, while it issues regular policy assessments through tools such as Fokus Analysis, means that its evaluation must emphasis qualitative analysis. In contrast, Ireland's specific quantitative targets mean that it can rely to a large extent on quantitative measures from firm numbers across the range to bibliometric studies in order to determine whether it is meeting its targets. However, it should be noted that in interviews with the different Irish representatives, qualitative aspects which are difficult to measure are also given weight – determining the effectiveness of networks, and knowing that a communication pathway has been open between firms and investors, or HEI and industry, or even between public agencies, cannot be easily captured by quantitative data and yet are crucial elements of a functioning system of innovation.

In regards to local assessment, jurisdictional comparison, and foresighting, Scotland's own experience shows an in-depth approach. For example, in the early 1990s various reports were commissioned and circulated to stakeholders, identifying both the limitations and strengths of the system, but also detailing the path to developing the system of innovation that was to be taken. The results were first operationalised in the Framework for Action and targets for innovation, which have since been adjusted (specific targets have since been set aside as an annual practice). However, Scotland also shows potentially reactionary behaviour when it comes to program and policy analysis, where strategies and programs are altered at what some argue is a premature time. This tension between evidence-based policy and programming and long-term strategic commitment is something that must be addressed and resolved for Scotland's policies towards R&D and the life sciences to be effective, especially considering the long-term nature of the life sciences.

4 Effective program design – a cascade of programs

While awareness of a region's development path and regular progress evaluations are important for success a the strategic level, at the program level the case analysis indicates that how well a program is tied into other programs helps its overall effectiveness. Cascading programs, with either cascading benefits, or tie-ins to other programs, are the most obvious examples of successful programs that came up during the research.

In Ontario, an example of successful cascading programs is made up of the post-doctoral fellowship, Early Researcher Awards, Ontario Research Fund Research Infrastructure and Research Excellence Awards, and Premier's Discovery program. These programs all create a set of funds that Ontario researchers can move through as they build up their career from post-doctoral researcher to late-stage career. More importantly, because many of these programs require other peer-review funding to qualify for application, they tie-in to federal level research council funding and create effective mechanisms to

leverage funds into the system of innovation. Ontario's life science research draws heavily from these programs, despite their not being specifically targeted to the life sciences.

The Ontario Institute for Cancer Research is another example of a sort of cascade program as it plugs in to a whole set of activities and further funding, and logical ties to other programs both inside and outside of Ontario. Its unified structure allows it to facilitate collaboration with international R&D efforts and attract the attention of international research "stars".

In Ireland, the most obvious examples of cascade effect programs are the CSETS, SFI grants, EI commercialisation grants and funding, and IDA use of CSETs as FDI showpieces. CSETS are the main source of IP creation and exploitation; they are a cornerstone program for moving Ireland to a higher level of value creation. CSETs tie in and are supported by other programs from the three agencies, from funding to skills provision. One representative from Enterprise Ireland stated in an interview that there is not one specific program he would point to as the most successful or effective in moving Ireland up the life science value chain – rather it is the set of programs that allow an entrepreneur to move from obtaining his IP, testing it

Sweden's commercialisation programs cascade into each other much as Ireland's, where firms - now start-ups are generated at a much higher rate than before thanks to the 'professionalisation' of the TTOs and NIP -can go through part of their life cycle seeking funding and incubation support from the incubation centres, Innovationsbron, and Industrifonden. For instance, over the past 5 years the Karolinska Institute has spun out 44 new ventures. Some of them have entered its incubator and moved forward in the development process. In comparison, during the same period has generated only 3 ventures within the domain of the life sciences. There seems to be a direct and positive relationship among number of new ideas that are 'disclosed' by scientists to TTOs and, later on, number of patents obtained and number of companies that are incubated. In Sweden, number of requests to enter incubators picked up in 2007/08. However, admissions began to decrease in 2008, which may indicate that incubators are reaching full capacity and they have become more selective.

In fact, some of our interviewees suggested that the entire system is becoming more selective. A comparison with the Danish sectoral innovation system (Gestrelius 2008) showed that Swedish ventures tend to grow slower and fail more frequently. Being able to operate a more effective selection from the very early stages (i.e. which ideas is worth patenting? which ones could be successfully commercialised? through which channels?) and the provision of a stronger and more professionalised infrastructure of support (TTOs, NIP, Research & Growth, and Innovationsbron) appear to be critical factors in solving such problem.

A final thing to note is the shift in the commercialisation emphasis in all three cases: all three are shifting to companies of scale rather than a large quantity of firms. The challenge, of course, is that no agency wants to pick winners. The solution is therefore the introduction of more difficult criteria for obtaining support. Representatives from Sweden, Ireland and Ontario seem to have a relaxed attitude to small firms being involved with larger MNCs and risk acquisition. They accept and even encourage involvement of large firms – as one representative from an Ontario Innovation Network stated, you

have to view small firms as incubators: while you would prefer to encourage mergers over acquisition, and if acquired, then would encourage them to stay in-country through various incentives. But the risk of acquisition should not discourage the intermingling of smaller local firms with larger firms.

5(a) The growing interest in convergence technologies and how to get them, and the attractiveness of niche markets

Convergence technologies are worth mentioning in this report as they represent a new, common focus for all three cases in their life science strategies. All three cases are seeking to find the next life science innovation at the junction between different technologies. Ontario, for example, has been looking to benefit from its expertise in imaging technologies and medical research in the areas of cancer. The increase in multidisciplinary research funding by the province also highlights the attractiveness of this technological junction.

Ireland's pursuit of convergence technologies is officially declared in its strategy documents. The hope lies in Ireland's strengths in IT, specifically software, and the various life science projects supported by SFI.

Sweden's programs promote multidisciplinarity, and dedicated centres (e.g. structural genomics, system biology and bioinformatics) and/pr programs (e.g. VINN Excellence Centres and VINNVÄXT) for this kind of research have been created in order try and accelerate the creation of merged technologies. Depending on the configuration and goals of the different programs, the benefits of convergent technologies are exploited (frequently in collaboration with local HEIs) by either local players or newly established businesses.

Linked to the pursuit of convergence technologies, at least two of the cases, Ontario and Ireland, explicitly promote and seek to grow what can be considered niche markets. The benefit of this for both cases is that it creates not only a relatively unique market strength for them, but also helps to strengthen or engage other parts of the life sciences system along with the direct producers. For Ireland, 'nutraceuticals' has been pursued which not only involves life science R&D capabilities in its universities, but also food and drink manufacturers, one of the only sectors in which Ireland had considerable strength before the Celtic Tiger phenomenon.

As far as Sweden is concerned, a strategic focus on niche markets is not mentioned in any of the examined documents. However, our interviews show that organisations such as Industrifonden judge positively (and invest in) companies (especially those working on drug-R&D) that show the potential to bring new products to niche markets - perhaps by exploiting regulatory provisions that facilitate clinical advancement and approval of orphan and/or 'fast-trackable' innovative therapies. An Industrifonden representative stated the following:

> Today we like to invest in opportunities where we have a clear understanding of the business rationale and the "value triggers". We are not so eager to invest in "classical drug discovery" where you're developing a molecule up to phase 2 and then it is crucial that you find a partner (i.e. pharmaceutical company). Instead, we like to invest in

> business plans that involve a "niche-type inclination", combining a good market opportunity with a real chance to complete development on your own.

This defies common wisdom, which recently portrays other types of investments (especially in diagnostics) as lower risk and/or shorter-term.

In Ontario, one niche market is clinical testing. As discussed above, Ontario has several well-respected clinical trial organisations run by universities. By helping to grow these organisations, not only do they benefit from the income generated by conducting clinical trial, but it creates a research environment that is attractive to pharmaceutical firms looking to co-locate R&D functions across a wider spectrum of development, including clinical trials.

5(b) Impact of Procurement

Both the Swedish organisation Vinnova and the Ontario Ministry of Research and Innovation recognise the importance of procurement on the local life sciences industry. Vinnova's report, which was sited above (Vinnova, 2007), highlights the impact of procurement on local industry, and it is something which is being built in to future strategy. The sector's development in Ontario has been shaped by procurement requirements, such as the health systems requirement that Ontario residents use generic drugs creating a local manufacturing sub-sector. Furthermore, Ontario's med-tech companies use the one-to-one relationships that they are allowed to develop with hospitals or laboratories in terms of service procurement, to develop future markets for product sales. Ontario's forthcoming life science strategy is also meant to incorporate procurement in a more conscious way to grow the industry.

5(c) Clinical trials

The benefit of clinical trials noted for the Ontario life science sector is significant for Scotland. As noted above, the Ontario government has recognised the local strengths in clinical trials across a number of universities and hospitals in the province, and has helped to highlight this strength as well as to further fund trials and network development between centres. Pharmaceutical companies have commented positively regarding having such research strengths present in the province and that they offer reasons for maintaining operations in the province, rather than moving abroad. The specific strengths noted were the capacity of centres to conduct large clinical trials, the data management capabilities, and the ethnically divers population of the province which allows for a multiplicity of trials to be possible.

Sweden's strength in clinical trials is also notable, and both Ontario and Sweden demonstrate how developing and maintaining a strength in clinical trials may be beneficial for Scotland. Sweden's health registry and epidemiological capacity is noted as a particular strength, as are the presence of a high proportion of high quality clinical researchers. Amongst others, Michael Porter has noted the significance of clinical trials to Sweden's overall life science industry:

> With its strong tradition of quality registries, Sweden is poised to become the world's most advanced nation in measuring the actual outcomes of care across many diseases. This represents a major opportunity for Sweden to lead a global shift toward a new, value-based

approach to health care delivery focused on improving patient health outcomes relative to cost, (DCCR, 2009).

Scottish policymakers and industry representatives should note how strength in clinical trials translates to a more complete life sciences system of innovation. For both of the above cases, clinical trials has meant that large pharmaceutical firms are persuaded to maintain an R&D presence or at least remain clients of the organisation's responsible for conducting trials. Furthermore, such strength also benefits local R&D efforts to develop drugs or therapeutics which may prove to be beneficial later. Scotland already benefits from the presence of two large contract research organisations as well as a host of smaller ones, and a health registry which is attractive to firms looking to conduct trials. Scotland's status as a "sick man" of Europe, with a high proportion of cardiovascular disease and other conditions, means it presents an opportunity for the development of these kinds of drugs to be undertaken within Scotland. While contract research itself does not create great GVA impact, it seems to provide a level of research expertise within the region, clinical research skills which are essential to a functioning biopharma industry, and provides a niche market which can act as a node from which to build networks that may help grow the broader life science sector.

Appendix 1: Swedish Programs

Programs Directly Supporting Life Sciences	Money invested through program	Description of program
Pharmaceuticals and diagnostic reagents	€1.5 M program	The programme finances multidisciplinary research projects around molecular biology, with the objective to exploit forms of techno-scientific convergence such as bio-informatics, system biology, bio-processing etc.
Multi-disciplinary Bio	€150K per collaboration per year	The program sponsors international and multi-disciplinary collaborations
Swedish Brain Power	€10M	Funds to be invested in collaborative research among Swedish HEIs in research, diagnosis and treatment of neurodegenerative diseases.
Innovations for Future Health	€55M	A very recent initiative that aims to finance the full translations of a limited number of ideas (450 applications have been submitted but only 15 of them are expected to be funded) into new products and/or services.
Collaborative Projects for personnel mobility between HEIs and Industry	€3.5M	Established in 2006 to finance post-graduate appointments from academia to industry.
Programs Indirectly Supporting Lifesciences		
Competence Centres, 1st Generation (under Nutek)	€550 million over first 10 years, ending in 2005	Launched in 1995 as a new kind of initiative in university-industry collaboration. Features included a very high level of subsidy (up to two thirds), so that the centres could perform comparatively long-term research; and the long period for which the centres are funded, namely 10 years. These features, which were borrowed from traditional intra-academic research centres of excellence, allowed the centres time to establish their reputations and some critical mass, and enabled two whole generations of doctorands to be educated and encouraged industry to take a long-term view that extends beyond single product generations. In the specific Swedish context of the early-mid 1990s, the centres were also important as contributions to the large supply of new PhDs needed by industry.
Berzelii Centres (Competence Centres, 2nd Generation)	€ 75 million over 10 years	Joint funding from Vinnova and the Swedish Research Council to set up four centres of excellence in basic research. They are assigned to maintain high international scientific quality, cooperate with the private sector and support the translation of science into innovation. For example, Uppsala Barzelii Centre - 'second generation Competence Research Centres': identify biomarkers for use in neuro-related diseases including Alzheimer's, Parkinson's, Amyotrophic Lateral Sclerosis (ALS) or chronic pain.
VINNVÄXT	Each successful region is awarded a yearly grant worth €1M	The programme supports needs-driven research and development of innovation systems. It focuses on regions characterised by an active contribution from actors in industry, research and the public sector. Objective is to create 12 centres, 4 of which already financed in 2008. Based on the initial plan, within 3 years has to achieve the following objectives: 1. establishment of effective management/governance structures at a the regional level 2. ability to influence the process of decision-making within the triple-helix model 3. show potential to stimulate growth at a regional level 4. contribution to regional/national learning. Example: Biomedical Development in Western Sweden (www.goteborgbio.se); Uppsala BIO (www.uppsalabio.com)
VINN Excellence Centres	€300M Euros over 10 years to create 25 centre of excellences	Create 25 centre of excellences via the collaboration among HEIs, local authorities/other public organisations (e.g. medical hospitals) and the private sector. The objective is to create research platforms that will allow translation into products and services. Each centre will receive an annual grant of €2.2M (40% from Vinnova - expected 30% from the private sector). Two of the 19 existing centres are related to the life sciences. The AlbaNova Centre at the Royal Institute of Technology conducts R&D in the area of protein technology based on proteome information. The Biomatacell centre at the University of Gothenburg utilizes (stem) cell technology to produce new materials for implants and prostheses.
Research & Growth	The programme is worth €185 M	These are grants designed to support pilot studies or needs identification for companies that have little and/or no experience in the domain of R&D activities. The main beneficiary of the grants will be Swedish SMEs. Up to 2009, Vinnova had already received 1,116 applications.
VINNU NU (and VINN Verification)		VINN NU is a competition for research-intensive start-ups. The goal of VINN NU is to help these companies to develop commercially-viable plans at a very early stage so that they can move forwards, receive financial support and, in the long term, evolve into sustainable businesses. VINN Verification: proof of concept.
National Incubator Programme (NIP)	Initial investment of €3M, plus an additional 10 years worth of funding provided by Vinnova	Launched in 2003. Main aim was to provide each industrial centre with seed money to invest in start-ups, like a new proof-of-concept fund. The pilot programme started with 12 incubators and provides premises for a defined period of time, access to infrastructure such as labs, professional support in nurturing the business idea, access to lawyers and accountants, contacts with potential investors and - where appropriate - financial support via the above-mentioned channels. Some of the incubators have their own small investment funds.

Appendix 2: Irish Programs

Programs Directly Supporting Life Sciences	Money invested through program	Description of program
NIBRT		The National Institute for Bioprocessing Research and Training (NIBRT) provides training and research solutions for the bioprocessing industry. Located in Dublin and is based on a collaboration between University College Dublin, Trinity College Dublin, Dublin City University and Institute of Technology Sligo
HRB-SFI Translational Research Award	Each award €250 000 a year for a max. of 4 years. Milesonte based.	The Translational Research Award (TRA) is specifically focussed on the following areas of strategic importance, and only in early research: Patient-Oriented Research; Medical devices; Diagnostics; E-Health.
Programs Indirectly Supporting Lifesciences		
Innovation Vouchers	Value of €5000	The Innovation Voucher objecitve is to build links between public knowledge providers and SMEs, and create a cultural shift in SME approach to innovation. Voucher allows SMEs to approach HEIs or FEIs with a problem and have the knowledge providers come up with a solution. Knowledge providers are generally institutions of higher or further education with expertise in the field. Innovation vouchers are for product, service or process innovations, and exclude activities such as marketing.
Commercialization Fund	Differing amounts of funding depending on phase of project: e.g.€ 50 to 100K, and €100 to 400K.	A range of supports to publicly funded researchers to encourage the commercialization of knowledge. Three phases: Proof of Concept phase, Technology Development, Commercialization Plus, and an Intellectual Property fund for use in addition to these. - Proof of Concept for researchers to explore innovative scientific concepts with commercial potential. - Technology Development for researchers to accomplish substantive applied research projects based on a reasonable prospect of serving an identifiable market. - Commercialisation Plus provides funding for completed projects that have reached advanced commercialisation discussions with potential industrial partners, but need to specific market
Campus Incubation Centres	€50 million invested by EI across HEIs	8 university and 16 further education incubation centres.
Business Partners Program	€20 000 grant	Give entrepreneurs access to HEI projects and ideas in order to create start-ups and spin-offs to experienced entrepreneurs. Set up in a way that entrepreneurs and university projects are matched through application process.
Technology Transfer Strengthening Initiative	€30 million budget from 2007-2011	Technology Transfer Strengthening Initiative (TTSI) objective is to increase the level IP transferred to industry from research in HEIs and facilitate development of effective systems to identify, protect and transfer IP, where possible into companies in Ireland. Goes to the installation of trained professionals in to HEI TTOs.
Innovation Partnerships	Maximum of €250 000 for a project, up to 80% of R&D expenses	The Innovation Partnership Initiative offers financial support to companies who engage in collaborative research projects with Irish universities and institutes of technology. The proposal process and administration of the project is managed by the participating third level research institution
Industry-Led Research Programmes	€10 million, with individual projects of €150K to 1.5 million.	Designed to deliver pre-competitive strategic research activity on a research agenda set by the industry partners, which is to be used as background to open up wider opportunities for Industry. Groups of companies which are in manufacturing or international traded services may apply to participate in an Industry Led Research Programme. Successful submissions can drive a call for research provision to meet the research needs of the group. Research specified by the group will be performed by a Research Performing Organisation (RPO) in close collaboration with the companies to ensure its relevance and to build and sustain strong links between the participants. Three out of Seven projects supported to date in the Life Sciences.
Competence Centres	€56 million, announced March 2010	The Competence Centres are delivered jointly by EI and IDA. Clusters of companies to work together to overcome common research challenges and drive opportunities for innovation. Competence Centres are collaborative entities established and led by industry that are resourced by researchers associated with research institutions empowered to do market focussed R&D. The objective is to achieve competitive advantage for industry in Ireland by accessing the innovative capacity of the research community.
SFI Centres for Science, Engineering & Technology campus-industry partnerships	Grants normally ranging from €1 to €5 million per year for up to five years.	CSETs link scientists and engineers across academia and industry to address crucial research questions, foster the development of new and existing Irish-based techn companies, attract industry to Ireland.Current relevant CSETs: Alimentary Pharmabiotic Centre; Regenerative Medicine Institute; Biomedical Diagnostic Institute (BDI); Systems Biology Ireland (S.B.I.).
Strategic Research Clusters		SFI Strategic Research Clusters Programme(SRCs) link scientists and engineers across academia and industry to address crucial research questions, foster the development of new and existing Irish-based techn companies, attract industry to Ireland. SRC designed to facilitate clustering of researchers to carry out joint research activities in areas of strategic importance to Ireland, and attract and cultivate strong industry partnerships. SRCs in Life Sciences: Reproductive Biology Research Cluster; The Irish Drug Delivery Research Network (IDDN); Network of Excellence for Functional Biomaterials (NFB); Solid State Pharmaceuticals Cluster; Immunology Research Centre (IRC); Advanced Biomimetics for Solar Energy Conversion; BioNanoInteract; Alimentary Glycoscience Research Cluster (AGRC); Irish Separation Science Cluster.
SFI Principal Investigator Award	From €100,000 to €500,000 direct costs per year, 3-5 years in duration.	SFI provides grants for researcherswho wish to relocate to Ireland and those already based in Ireland, for outstanding investigators, for conferences and symposia, and for collaboration with industry. The main program, SFI Principal Investigator (PI) Programme, supports those fields of science and engineering that underpin biotechnology, information and communications technology, and sustainable energy and energy-efficient technologies.
Research Development and Innovation funding, support and grants	€500 million scheme to support R&D initiatives	Support for 1st time R&D work involves funding for feasibility studies, training and a pilot R&D project. Support for companies with existing R&D also involves training, capital expedndiutre support and consultancy.

Appendix 3: Ontario Programs

Programs Directly Supporting Life Sciences	Money invested through program	Description of program
Global Leadership Round in Genomics and Lifesciences (Ontario Research Fund)	Minimum support to a project is $3.5million, part of a the ORF which provides 730 milion over 4 years	The Ontario Research Fund - Global Leadership Round in Genomics & Life Sciences (GL2) supports transformative, internationally significant research in genomics and gene-related areas of research. International collaboration is encouraged for projects, along with collaborative, transformational projects across institutions from areas such as:
Ontario Institute for Cancer and affiliated programs	Multiple programs with various levels of funding	The Government of Ontario established the Ontario Institute for Cancer Research (OICR) to undertake research in prevention, early detection, diagnosis, treatment and control of cancer, and to translate research findings into programs, technologies and therapies. The institute brings together multi-disciplinary, multi-institutional collaborations, and looks to foster commercialization and private sector partnerships. The institute will support more than 50 internationally recognized principal investigators. The institute will leverage the current research excellence at universities, research hospitals and health research institutes across Ontario. Objectives: - Ontario as a leading jurisdiction for cancer research. - Ontario more competitive in attracting research funds. - Attract outstanding cancer researchers to Ontario, and trainnext generation of clinician/scientists. - Contribute to a coordinated cancer system in Ontario. - link clinical practice to support enhanced patient outcomes.
Biopharmaceutical Investment Program	$150 M over 5 years	Biopharmaceutical Investment Program (BIP) was aimed at attracting new or enhanced biopharm investments in Ontario. $150 million for 5 years. Wouldl fund up to 20% of total eligible project costs. BIP Objectives: - increase the level of new biopharmaceutical Research and Development and advanced manufacturing in Ontario - expand local footprints, and create a generation of new high value jobs for Ontarians - increase "deal flow" in Ontario's biotech cluster, build capacity through collaborations with public research institutions. The eligibility criteria were generalized, but better suited to large foreign firms.
Health Technology Exchange		Established in 2004 to accelerate innovation, commercialization and the growth of Ontario's medical and assistive technologies sector. The organization helps Ontario's scientists, engineers, and entrepreneurs commercialize their ideas through three main program areas: Medical and Assistive Technology R&D Program: provides funding on a competitive basis for the commercialization of med tech by Ontario researchers. The Medical and Assistive Technology Commercialization and Market Development Program: fosters collaborations among researchers, entrepreneurs and start-up companies. Provides information resources such as technology development roadmaps, market research and intelligence, and seminars. - The "HTX.ca" Business-to-Business Web Portal: provides a database on opportunities for innovators and investors; products under development or available for licensing or distribution; and general industry information.
Programs Indirectly Supporting Lifesciences		
International Strategic Opportunities Program	Each award is max. $150,000 over three years.	The International Strategic Opportunities Program (ISOP) provides funding for strategic international collaborations between Ontario institutions and the global research community. The program has been developed to: - Facilitate research of scientific importance - Increase Ontario's long-term economic potential - Attract and retain top international research talent - Enhance Ontario's profile in the international research community - Priority given to collaborations with researchers in the United States, the United Kingdom, Germany, France, Japan, China and India.
Early Researcher Awards	$140,000 per award, $11.5 million to date, $51 million over 5 years (but check budget to make sure). Each award is 140K from MRI plus 50K matching funds from the host institution or private partners.	The Early Researcher Award (ERA) program helps promising, recently-appointed Ontario researchers build their research teams, and train the next generation of researchers. The goal of the program is to improve Ontario's ability to attract and retain the best and brightest research talent. Funding Provided
Premiere's Discovery Awards	one award per discipline, with Life Sciences counted as a discipline. $500K value for LS award.	The Premier's Discovery Awards celebrate the research excellence of Ontario's most accomplished researchers. The Discovery Award consists of five awards recognizing excellence in research for either a single discovery or a body of work: - $500,000 Life Sciences and Medicine award (for the study of human health and/or biological/ecological systems) - $500,000 Natural Sciences and Engineering (physical sciences and/or engineering processes) - $250,000 Social Sciences award - $250,000 Arts and Humanities award
Premiere's Catalyst Awards	5 awards of $200K	The Premier's Catalyst Awards help build a culture of innovation and entrepreneurship in Ontario by recognizing excellence and leadership in innovation. Awards for developing an innovation that is a commercially successful new, or significantly improved, product or service based on a breakthrough technology that impact Ontario's economy. They consist of the Best Young Innovator Award; Innovator of the Year Award; Lifetime Achievement Award; Start-Up Company; Best Company.
Post-Doctoral Programme	$25,000 per year for two years from government, to be matched by universities	The Post-Doctoral Fellowship (PDF) program provides outstanding scientists with two-year fellowships at Ontario's Universities. PDFs are open to scientists in all disciplines. PDFs are managed solely by the universities participating in the program, based on a competitive process.

Regional Innovation Networks		RINs are multi-stakeholder, regional development organizations that support partnerships among business, institutions and local governments to promote innovation. Initially focused on the life sciences, now expanding into information technology, energy conservation, and advanced materials. The RINs are: Southwestern Ontario Bioproducts Innovation Network (SOBIN); Guelph Partnership for Innovation; Waterloo Research and Technology Park Accelerator; Golden Horseshoe Biosciences Network; Research, Innovation, Commercialization Centre (R.I.C. Centre); London Regional Innovation Network; BioDiscovery Toronto; York Biotech; Greater Peterborough Area DNA Cluster; Eastern Lake Ontario Regional Innovation Network (ELORIN); Ottawa and Eastern Ontario Regional Innovation Network (OCRI Life Sciences); Innovation Initiatives Ontario North (IION).
Ontario Tax Exemption	N/A	OTEC encourages the commercialization of intellectual property which has been developed by qualifying Canadian universities or colleges. OTEC offers a refund of corporate income tax for a qualifying corporation's first ten taxation years. OTEC Objectives: - To encourage business start-ups that commercialize Canadian IP developed at a qualifying institute. - To encourage new entrepreneurs to transfer research to the market - To foster economic growth in advanced health, bioeconomy, telecommunications, computer, and digital
Ontario Research Commercialization program	total of 31.4 million committed so far (check math from on-line table	The Ontario Research Commercialization Program (ORCP) funding to public research institutions and not-for-profit organizations to help identify promising research and shape ideas into innovative products or services. Includes funding for medical discoveries and devices, and environmental and energy-related technologies. ORCP is providing support for four important commercialization goals: 1. Linking research institutions to companies 2. Linking companies to researchers 3. Building regional and province-wide networks 4. Developing Ontario's next generation of innovative thinkers
Innovation Accelerator Fund	$29 million over four years, investments between $250K and 500K.	The IAF finances knowledge-based companies to test and develop their new technology in the early stages, and gain entrepreneurial know-how to take the idea closer to the marketplace. Fund helps companies with technology development, market potential analysis, prototype development, early customer trials, promotion and patenting costs. IAF will also provide companies with business mentorship until a skilled management team is in place, either temporarily or permanently.
Ontario Venture Capital Fund	$165 million (first closing in June 2008 of $205 million, of which $90 million from ON government	OVCF is structured as a fund of funds that makes investments primarily in qualified underlying venture capital and growth equity funds. These underlying funds subsequently make investments into high-growth companies. The Lead Investors have selected Northleaf Capital Partners (formerly TD Capital Private Equity Investors) to manage OVCF. Investment decisions will be market-based and returns focused, with the aim of generating attractive investment returns and significantly advancing the long-term prospects for venture capital investing in
Business Mentorship and Entrepreneurship program	$17 million program over four years	Entrepreneurs can apply to the Business Mentorship and Entrepreneurship program for help in getting the necessary management skills to take their new high-tech product or service through to the marketplace. The program has four parts: Entrepreneur Training; Business Mentorship; Serial Entrepreneur/Business Executive Program network creation; Angel Network Links
Ontario Emerging Technologies Fund	$250 million available; $50 million per year, for five years available for investment	The Ontario Emerging Technologies Fund will co-invest into companies working within: - Clean technologies - Life sciences and advanced health technologies - Digital media and information and communications technologies.

Glossary

ALMI – Swedish development and funding agency with a regional structure

BERD – Business Expenditure on Research and Development

CSET – Centre for Science, Engineering and Technology

CVCA – Canadian Venture Capital Association

DETE – Department of Enterprise, Technology and Employment (Ireland)

EI – Enterprise Ireland – Agency responsible for local enterprise development and support

FDI – Foreign Direct Investment

FEI – Further Education Institution

Forfas – Umbrella organisation coordinating Ireland Science, Technology and Innovation Strategy

GDP – Gross Domestic Product

GERD – Gross Expenditure on R&D

GVA – Gross Value Added

HEI – Higher Education Institution

IDA – IDA Ireland – Agency responsible for attracting and retaining high value foreign investment

Innovationsbron – Swedish innovation development agency

IP – Intellectual Property

MNC – Multinational Corporation

MRI – Ministry of Research and Innovation

NIP – National Incubator Program (Sweden)

Nutek – National Swedish Board for Technical Development

OCE – Ontario Centre of Excellence

OCGC – Ontario Capital Growth Corporation

OVCF – Ontario Venture Capital Fund

PRO – Public Research Organisation

R&D – Research and Development

R&IP – Regional Innovation Policy

RIN – Regional Innovation Network (Ontario)

SFI – Science Foundation Ireland – Agency responsible for increasing Ireland's R&D capacity

SME – Small and Medium sized Enterprise

SSTI – Strategy for Science, Technology and Innovation (Ireland)

TTO – Technology Transfer Office

VC – Venture Capital

Vinnova – Swedish Agency for Innovation Systems

Interviews

Sweden
2 Representatives from Vinnova
1 Representative from Innovationsbron
1 Representative from Industrifonden
Ireland
Department Manager from Enterprise Ireland
2 Directors from Science Foundation Ireland
Ontario
Head of a provincial industry Association
2 directors of different Ontario area Regional Innovation Networks
Representative from Ministry of Research and Innovation

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